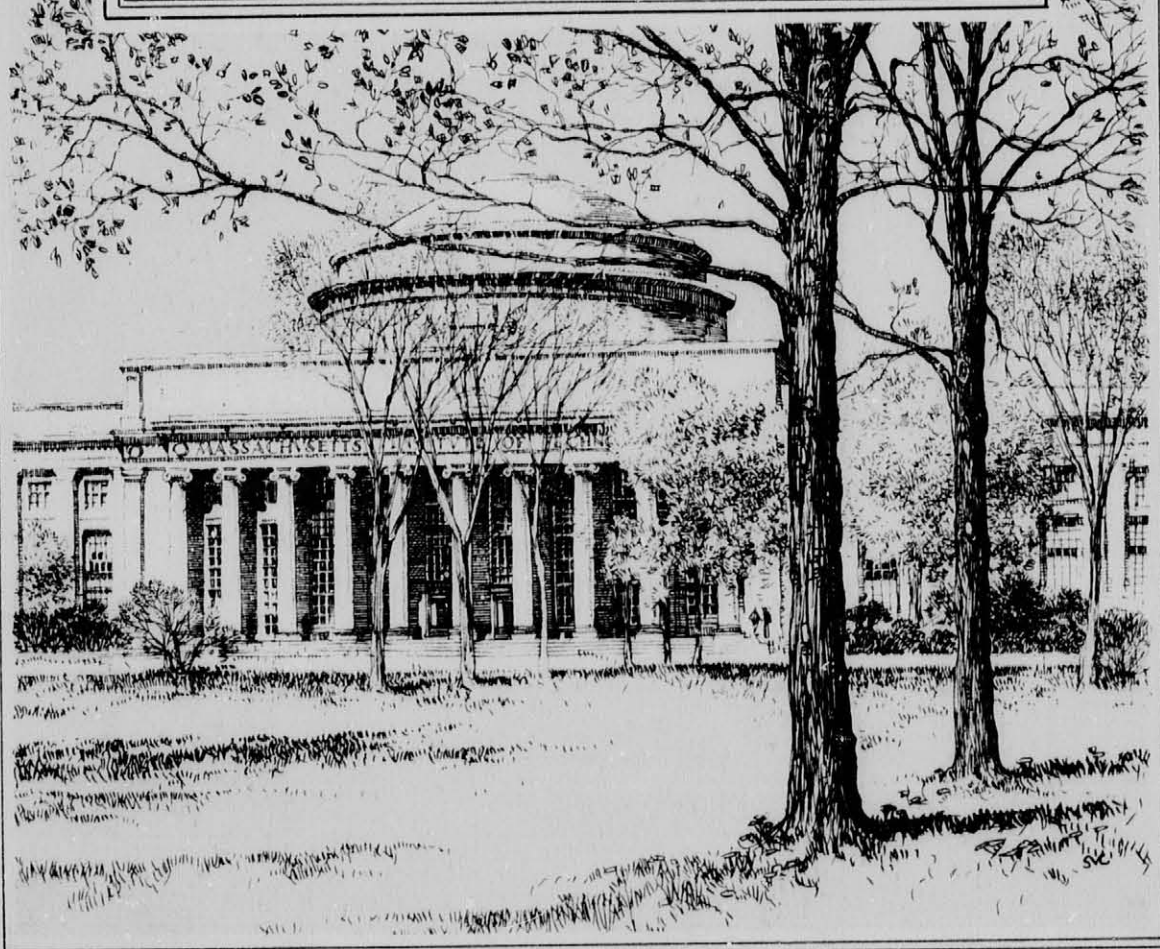
M.I.T. ANNUAL CATALOGUES AND BULLETINS
1956/57

01
OF
03

MASSACHUSETTS INSTITUTE OF TECHNOLOGY BULLETIN



GENERAL CATALOGUE ISSUE FOR 1956-1957

PUBLISHED BY THE INSTITUTE CAMBRIDGE, MASSACHUSETTS

JULY, 1956

Entered July 3, 1933, at the Post Office, Boston, Massachusetts, as second-class matter, under Act of Congress of August 24, 1912

Published six times yearly by the MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Cambridge Station, Boston, Massachusetts, in March, May, July, September, October, and November.

Issues of the Bulletin include the reports of the President and of the Treasurer, the Summer Session Catalogue, the General Catalogue, and the Undergraduate Catalogue.

The Institute reserves the right to make changes in the regulations and courses announced in this Bulletin

MASSACHUSETTS INSTITUTE OF TECHNOLOGY BULLETIN

VOLUME 91 JULY, 1956 NUMBER 6

GENERAL CATALOGUE ISSUE

1956–1957 SESSION

A Bulletin of Information
About the Institute, Its Government, Staff, Regulations,
Requirements for Admission, Facilities, and Courses of Instruction,
Both Undergraduate and Graduate

TABLE OF CONTENTS

	Page
Table of Contents	2
Calendar	4
Corporation	5
Officers	6
Officers of Instruction and Instructing Staff	11
Faculty Committees	29
Committees on Joint Projects	30
Committees on Interdepartmental Laboratories	30
Other Committees and Boards	30
General Information	
Government and Administration	31
Degrees Granted	32
Educational Resources	32
Estimated Cost of a College Year	33
Financial Aids	33
Fees, Deposits, Payments, Expenses	34
Health of Students	36
General Regulations	36
Recreational Facilities	38
Undergraduate Activities	38
Premedical Students	40
Placement	40
The Technology Dames	40
The Society of Arts	40
The Lowell Institute School	40

UNDERGRADUATE COURSES

Requirements for Admission	
Entrance Dates	41
Admission from Secondary Schools	41
Admission with Advanced Standing	42
Combined Plan of Study with Liberal Arts Colleges	43
Special Students	44
Foreign Students	44
Undergraduate Courses of Study	
Selection of Course of Study	45
Modifications in Courses of Study	45
Requirements for the Bachelor's Degree	45
Physical Education Program	45
System of Credits	45
The Courses	
School of Architecture and Planning	46
School of Engineering	46
School of Science	46
School of Humanities and Social Studies	46
School of Industrial Management	46
The Undergraduate Program in Humanities and Social Sciences	46
Undergraduate Course Schedules	
First Year	49
Civil Engineering (I)	50
Mechanical Engineering (II)	52
Mechanical Engineering, Cooperative (II-B)	55
Metallurgy (III)	56
Architecture (IV-A)	58
City Planning (IV-B)	59
Chemistry (V)	59
Electrical Engineering (VI)	60
Electrical Engineering, Cooperative (VI-A)	61
Quantitative Biology (VII)	65
Physics (VIII)	65
General Science (IX-A)	66
General Engineering (IX-B)	67
Science Teaching (IX-C)	68
Chemical Engineering (X)	69
Chemical Engineering Practice (X-B)	70
Sanitary Engineering (XI)	70
Geology and Geophysics (XII)	70
Geology and Geophysics (XII-A)	71
Naval Architecture and Marine Engineering (XIII)	72
Shipping and Shipbuilding Management (XIII-B)	73
Economics, Politics, and Engineering (XIV-A)	74
Economics, Politics, and Science (XIV-B)	74
Business and Engineering Administration (XV-A, XV-B)	76
Aeronautical Engineering (XVI)	78
Aeronautical Engineering, Cooperative (XVI-B)	79
Building Engineering and Construction (XVII)	80
Mathematics (XVIII)	81
Meteorology (XIX)	81
Food Technology (XX)	82
Food Technology (XX-A)	83
Biochemical Engineering (XX-B)	83
Humanities and Engineering (XXI-A)	84
Humanities and Science (XXI-B)	84
Reserve Officers' Training Corps	87

THE GRADUATE SCHOOL

	Page
The Graduate School	
Administration of the Graduate School	89
Committee on Graduate School Policy	89
Chairmen of Department Committees on Graduate Students	89
General Information	90
Admission	91
Undergraduate Preparation for Advanced Degrees	92
Residence	92
The Degrees Master of Science, Master in Architecture, and Master in City Planning	93
Engineering Degrees	93
The Doctorates	93
Cooperative Arrangement with Harvard University	94
Cooperative Arrangement with Lowell Technological Institute	95
Graduate Programs Offered	
Civil Engineering	95
Mechanical Engineering	95
Metallurgy (Including Mineral Engineering and Ceramics)	97
Architecture	97
City Planning	98
Chemistry	98
Electrical Engineering	100
Biology	102
Physics	103
Chemical Engineering	104
Chemical Engineering Practice	104
Sanitary Engineering	106
Geology and Geophysics	107
Naval Architecture and Marine Engineering	107
Naval Construction and Engineering (XIII-A)	108
Economics and Social Science	109
Industrial Management	110
Aeronautical Engineering	110
Building Engineering and Construction	111
Mathematics	112
Meteorology	112
Food Technology	113
Biochemical Engineering (XX-B)	114

SUBJECTS OF INSTRUCTION

Description of Subjects	115
Tabulation of Subjects	170

APPENDICES

Appendix A — Student Aid and Prizes	
Freshman Scholarships	198
Undergraduate Scholarship Aid for Upperclassmen	200
Technology Loan Fund	205
Other Loan Funds	205
Prizes	205
Graduate Assistantships	207
Graduate Fellowships	207
Graduate Scholarships	209
Appendix B — Student Housing	210

INDICES

Index to Subjects of Instruction	223
Alphabetical Index	229

CALENDAR

ACADEMIC YEAR 1956–1957

1956

First Term Begins for Freshmen 1 P.M.,	Sept. 12
First Term Begins for Upperclassmen and Graduate School	Sept. 17
Columbus Day (*Holiday*)	Oct. 12
Field Day (*Exercises omitted*)	Oct. 27
Veterans' Day (*Holiday*) (Exercises omitted Monday, Nov. 12)	Nov. 11
Thanksgiving Vacation	Nov. 22 through Nov. 25
Christmas Vacation	Dec. 22 through Jan. 6

1957

Last Exercises, First Term	Jan. 16
Reading Period	Jan. 17 through Jan. 19
Examination Period	Jan. 21 through Jan. 25
Second Term Begins	Feb. 4
Washington's Birthday (*Holiday*)	Feb. 22
Spring Vacation	March 25 through March 31
Patriots' Day (*Holiday*)	April 19
Last Exercises, Second Term	May 21
Reading Period	May 22 through May 24
Examination Period	May 25 through May 31
Memorial Day (*Holiday*)	May 30
Commencement Day	June 7
Summer Session 1957 Begins	June 17
First Term 1957 Begins	Sept. 23

1956

JANUARY

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

FEBRUARY

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29			

MARCH

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

APRIL

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

MAY

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

JUNE

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

JULY

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

AUGUST

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

SEPTEMBER

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

OCTOBER

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

NOVEMBER

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

DECEMBER

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

1957

JANUARY

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

FEBRUARY

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28		

MARCH

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

APRIL

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

MAY

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

JUNE

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

JULY

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

AUGUST

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

SEPTEMBER

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

OCTOBER

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

NOVEMBER

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

DECEMBER

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

THE CORPORATION

President
JAMES RHYNE KILLIAN, JR.

Chancellor
JULIUS ADAMS STRATTON

Vice-President for Industrial and Governmental Relations
EDWARD LULL COCHRANE

Vice-President and Treasurer
JOSEPH JULIEN SNYDER

Secretary[1]
WALTER HUMPHREYS

LIFE MEMBERS

WALTER HUMPHREYS
ALFRED LEE LOOMIS
HARLOW SHAPLEY
ALFRED PRITCHARD SLOAN, JR.
REDFIELD PROCTOR
GODFREY LOWELL CABOT
BRADLEY DEWEY
FRANCIS JOHN CHESTERMAN
VANNEVAR BUSH
WILLIAM EMERSON
RALPH EDWARD FLANDERS
JAMES MADISON BARKER
THOMAS CHARLES DESMOND
MARSHALL BERTRAND DALTON
ROBERT ERASTUS WILSON
DONALD FELL CARPENTER
HORACE SAYFORD FORD
WALTER JAY BEADLE
B. EDWIN HUTCHINSON
IRVING WHITE WILSON
DUNCAN ROBERTSON LINSLEY
THOMAS DUDLEY CABOT
CRAWFORD HALLOCK GREENEWALT
JAMES MCGOWAN, JR.
HAROLD BOURS RICHMOND
LLOYD DEWITT BRACE
THOMAS D'ARCY BROPHY
WILLIAM APPLETON COOLIDGE
MERVIN J. KELLY
ROBERT THOMAS HASLAM
RALPH LOWELL
ROBERT CHAPMAN SPRAGUE
CHARLES ALLEN THOMAS
GWILYM ALEXANDER PRICE
DAVID ALLAN SHEPARD

LIFE MEMBERS, EMERITI

WILLIAM CAMERON FORBES
GERARD SWOPE
WILLIAM CHAPMAN POTTER
LOUIS SHATTUCK CATES
HARRY JOHAN CARLSON
WILLIS RODNEY WHITNEY

SPECIAL TERM MEMBERS

Term expires June, 1957
GEORGE WILHELM MERCK

Term expires June, 1958
THEODORE PARKER FERRIS

Term expires June, 1959
THEODORE V. HOUSER

Term expires June, 1960
ROBERT ABERCROMBIE LOVETT

Term expires June, 1961
JAMES PHINNEY BAXTER III

PRESIDENT OF THE ALUMNI ASSOCIATION

THEODORE THOMAS MILLER

ALUMNI TERM MEMBERS

Term expires June, 1957
EVERETT SHARPLES COLDWELL
ALFRED THOMAS GLASSETT
WILLIAM LYMAN STEWART, JR.

Term expires June, 1958
JAMES HAROLD DOOLITTLE
CLARENCE DECATUR HOWE
EDWIN DELAMATER RYER

Term expires June, 1959
HORATIO LOCKERBY BOND
RAY PUTNAM DINSMORE
WILLIAM JAMES SHERRY

Term expires June, 1960
HUGH SEARS FERGUSON
FRED CHASE KOCH
MAX LEON WATERMAN

Term expires June, 1961
DWIGHT COBB ARNOLD
EDWARD JAMES HANLEY
AUGUSTUS BRAUN KINZEL

REPRESENTATIVES OF THE COMMONWEALTH

HIS EXCELLENCY, CHRISTIAN ARCHIBALD HERTER, *Governor*
HONORABLE STANLEY ELROY QUA, *Chief Justice of the Supreme Judicial Court*
JOHN JOSEPH DESMOND, JR., *Commissioner of Education*

[1] Address correspondence to Massachusetts Institute of Technology.

OFFICERS

President

James Rhyne Killian, Jr., Sc.D., LL.D., D.Eng.

Julius Adams Stratton, Sc.D., D.Eng.
Chancellor

Carl Richard Soderberg, Tekn.D.
Dean of the School of Engineering

George Russell Harrison, Ph.D., D.Sc., LL.D., D.Eng.
Dean of the School of Science

Pietro Belluschi, Dott.Ing., LL.D.
Dean of the School of Architecture and Planning

John Ely Burchard, L.H.D.
Dean of the School of Humanities and Social Studies

Edward Pennell Brooks, S.B.
Dean of the School of Industrial Management

Harold Locke Hazen, Sc.D.
Dean of the Graduate School

John Thomas Rule, S.B.
Dean of Students

Eli Shapiro, Ph.D.
Associate Dean of the School of Industrial Management

Horton Guyford Stever, Ph.D.
Associate Dean of the School of Engineering

James McCormack, Jr., S.M.
Special Adviser to the President

Robert Merriman Kimball, S.B.
Secretary of the Institute

Ebenezer Francis Bowditch, A.B.
Special Adviser to the President

Malcolm Gordon Kispert, S.M.
Executive Assistant to the President

Thomas Palm Pitré, B A.
Associate Dean of Students;
Director of Student Aid

Joe Jefferson, A.B.
Assistant Director of Student Aid

Frederick Gardiner Fassett, Jr., M.A.
Associate Dean of Students;
Director of Technology Press

William Speer, A.B.
Associate Dean of Students

Robert Earl Hewes, S.B.
Registrar

Warren Davis Wells, S.B.
Assistant Registrar

Carl Louis Svenson, S.M.
Executive Officer, Committee on Academic Regulations

William Nash Locke, Ph.D.
Director of Libraries

Ernest Hamlin Huntress, Ph.D.
Director of Summer Session;
Secretary of the Graduate School

John Wymond Miller Bunker, Ph.D., Sc.D.
Dean of the Graduate School, Emeritus;
Special Adviser to the President

Joseph Chrisman MacKinnon, S.B.
Registrar Emeritus;
Special Adviser to Director of Physical Plant

Robert Martin Briber, S.M.
Administrative Assistant to the President

ADMISSIONS

Brainerd Alden Thresher, S.B., A.M.
Director of Admissions

Paul Maynard Chalmers, A.M.
Associate Director of Admissions;
Adviser to Foreign Students

David Augustus Dudley, S.B.
Associate Director of Admissions

Eugene Randolph Chamberlain, A.B.
Assistant Director of Admissions

Matthew Bryce Leggett, A.B., S.M.
Assistant Director of Admissions

Richard Walck Willard, S.B., Ed.M.
Assistant to Director of Admissions

John Peter Anderson, B.S.
Assistant to Director of Admissions

MEDICAL

James Morison Faulkner, M.D.
Medical Director

John Winslow Chamberlain, M.D.
Associate Medical Director

RESEARCH ADMINISTRATION

EDWARD LULL COCHRANE, LL.D., D.ENG., Sc.D.
Vice-President for Industrial and Governmental Relations

CARL FREDERICK FLOE, Sc.D.
Assistant Provost

DIVISION OF SPONSORED RESEARCH

FRANKLIN LEROY FOSTER, Sc.D.
Director

Lincoln Laboratory
MARSHALL GLECKLER HOLLOWAY, PH.D.
Director

Instrumentation Laboratory
CHARLES STARK DRAPER, Sc.D.
Director

Operations Evaluation Group
JACINTO STEINHARDT, PH.D.
Director

INDUSTRIAL LIAISON

WILLIAM RUPERT WEEMS, S.M.
Director, Industrial Liaison Office

VINCENT ANTHONY FULMER, B.A.
Assistant Director, Industrial Liaison Office

MERRILL JOHN BAUMANN, B.A., S.B.
Industrial Liaison Officer

ROBERT DIETRICH HABERSTROH, MECH.E.
Industrial Liaison Officer

HAROLD ROBERT LAWRENCE, S.M.
Industrial Liaison Officer

RALPH LUDEMANN WENTWORTH, S.M.
Industrial Liaison Officer

PLACEMENT

JAMES GERALD KELSO, PH.D.
Placement Officer

EVELYN BARTLETT YATES, B.A.
Associate Placement Officer

MARY DALY HOWE, M.A.
Assistant Placement Officer

FINANCIAL AND BUSINESS ADMINISTRATION

JOSEPH JULIEN SNYDER, B.S., M.B.A.
Vice-President and Treasurer

PAUL VINCENT CUSICK
Assistant Treasurer

PHILIP ARNOLD STODDARD, S.B.
Assistant Treasurer

FINANCIAL ADMINISTRATION

WOLCOTT ANDERS HOKANSON
Bursar

JOHN ALBERT LITTLE, A.B., M.C.S.
Accounting Officer

THOMAS JOSEPH CRANE, M.B.A.
Manager of Research Fiscal Office

FREDERIC WHITNEY WATRISS, S.B.
Assistant to the Treasurer

ARTHUR EDWARD MITSCH
Chief Accountant

FRANCIS JOSEPH FARRY, B.S.B.A., LL.B.
Assistant to Accounting Officer

GEORGE EDWARD NEALAND, S.B.
Director of Purchasing

CHARLES EDWARD SLYE
Manager of Office of Laboratory Supplies

FRANK HERBERT CONANT
Manager of Photographic Service

BUSINESS ADMINISTRATION

CARL MAGNUS FRITHIOF PETERSON, S.M.
Director of Physical Plant

DONALD WHISTON, S.B.
Executive Officer to Director of Physical Plant

RICHARD COLIN MACLAURIN, S.B.
Director of General Services

ALBERT FLEETWOOD SISE
Personnel Officer

WILLIAM MACKINTOSH, B.S.
Assistant Director of General Services

JEROME HAZELTON BARRAFORD, B.S.
Assistant Superintendent of Buildings and Power

EDWARD THOMAS PIEPER, B.A., S.B.
Assistant Superintendent of Buildings and Power

MILES PAYNE COWEN
Assistant to Superintendent of Buildings and Power

THEODORE JORDAN
Assistant to Superintendent of Buildings and Power

MARK JOHN DONDERO, B.S.
Safety Engineer

HAROLD EMIL DREYER, PH.D.
Associate Personnel Officer

JAMES JOSEPH FANDEL, B.A., M.S.
Assistant to Personnel Officer

FRANK MOFFETT BALDWIN, A.B.
Director of Dining Services

HENRY KENNETH DOW, A.B.
Manager of the Dormitories

OTHER OFFICERS

FRANCIS ERNEST WYLIE, A.B.
Director of Public Relations

RALPH THEODORE JOPE, S.B.
Director, Development Office

WALTER HENRY GALE, S.M.
Special Assistant

JOHN WESLEY SHEETZ, III, S.M.
Executive Secretary for Development

JOHN JAMES ROWLANDS
Director of News Service

JOHN ISHAM MATTILL, M.A.
Director of Publications;
Assistant Director of News Service

BRUCE FOWLE KINGSBURY, S.B.
Executive Secretary of Educational Council

WALTER LING MILNE, A.M.
Administrative Assistant

WILLIAM HAMILTON CARLISLE, JR.
Manager of Student Personnel

RUTH LOUISE BEAN, S.B., ED.M.
Assistant Dean of Students

ROBERT KAREL WEATHERALL, B.A.
Assistant to Dean of Students

ARTHUR LAWRENCE TOWNSEND, S.B.
Director of the Lowell Institute School

ROBERT JOHNSON HOLDEN, A.B., S.T.B.
General Secretary, Technology Christian Association

FRANK MATTHEW VERZUH, SC.D.
Director of Statistical Services

HEADS OF DEPARTMENTS AND PROFESSIONAL COURSES

Aeronautical Engineering
CHARLES STARK DRAPER, Sc.D.
WALTER MCKAY, S.M., *Executive Officer*

Air Science
HAROLD LAMPLEY, JR., B.S.
COLONEL, U. S. AIR FORCE

Architecture
LAWRENCE BERNHART ANDERSON, M.ARCH.

Biology
IRWIN WHITING SIZER, PH.D., *Acting Head*

Building Engineering and Construction
ALBERT GEORGE HENRY DIETZ, Sc.D., *Acting Head*

Chemical Engineering
WALTER GORDON WHITMAN, Sc.D.

Chemistry
ARTHUR CLAY COPE, PH.D., Sc.D.
LEICESTER FORSYTH HAMILTON, S.B., *Executive Officer*

City and Regional Planning
FREDERICK JOHNSTONE ADAMS, B.ARCH.

Civil and Sanitary Engineering
JOHN BENSON WILBUR, Sc.D.
HARL PRESLAR ALDRICH, JR., Sc.D., *Executive Officer*

Economics and Social Science
RALPH EVANS FREEMAN, M.A., B.LITT.

Electrical Engineering
GORDON STANLEY BROWN, Sc.D.
CARLTON EVERETT TUCKER, S.B., *Executive Officer*

Food Technology
BERNARD EMERSON PROCTOR, PH.D.
SAMUEL ABRAHAM GOLDBLITH, PH.D., *Executive Officer*

General Science, General Engineering
JOHN THOMAS RULE, S.B.

Geology and Geophysics
ROBERT RAKES SHROCK, PH.D.
PATRICK MASON HURLEY, PH.D., *Executive Officer*

Humanities
HOWARD RUSSELL BARTLETT, B.S., A.M.

Mathematics
WILLIAM TED MARTIN, PH.D.
GEORGE BRINTON THOMAS, JR., PH.D. (*Absent*), *Executive Officer*

Mechanical Engineering
JACOB PIETER DEN HARTOG, PH.D.
JAMES HOLT, S.B., *Executive Officer*

Medical
JAMES MORISON FAULKNER, M.D.

Metallurgy
JOHN CHIPMAN, PH.D., Sc.D.

Meteorology
HENRY GARRETT HOUGHTON, Sc.D.

Military Science and Tactics
CHARLES MOSES MCAFEE, JR., M.S.
COLONEL, U.S.A.

Modern Languages
WILLIAM NASH LOCKE, PH.D.

Naval Architecture and Marine Engineering
LAURENS TROOST, IR.

Physics
NATHANIEL HERMAN FRANK, Sc.D.
GEORGE GRAHAM HARVEY, PH.D., *Executive Officer*

COUNCILS

ACADEMIC COUNCIL

President (*Chairman*)
Chancellor (*Vice-Chairman*)
Vice-President for Industrial and Governmental Relations
Vice-President and Treasurer
Dean of the School of Engineering
Dean of the School of Science
Dean of the School of Architecture and Planning
Dean of the School of Humanities and Social Studies
Dean of the School of Industrial Management
Dean of the Graduate School
Dean of Students
Chairman of the Faculty
Executive Assistant to the President

ADMINISTRATIVE COUNCIL

President
Chancellor
Vice-President for Industrial and Governmental Relations
Vice-President and Treasurer
Dean of the School of Engineering
Dean of the School of Science
Dean of the School of Architecture and Planning
Dean of the School of Humanities and Social Studies
Dean of the School of Industrial Management
Dean of the Graduate School
Dean of Students
Assistant Provost
Assistant Treasurers
Chairman of the Faculty
Director of Admissions
Director of Division of Sponsored Research
Director of Industrial Liaison Office
Director of Libraries
Director of News Service
Director of Public Relations
Director of Student Aid
Director of Summer Session
Executive Assistant to the President
Executive Vice-President of the Alumni Association
Medical Director
President of the Alumni Association
Registrar
Secretary of the Institute
Special Adviser to the President

FACULTY COUNCIL

Chairman of the Corporation
President
Chancellor
Vice-President for Industrial and Governmental Relations
Dean of the School of Engineering
Dean of the School of Science
Dean of the School of Architecture and Planning
Dean of the School of Humanities and Social Studies
Dean of the School of Industrial Management
Dean of the Graduate School
Dean of Students
Chairman of Committee on Undergraduate Courses
Director of Division of Sponsored Research
Chairman of Faculty
Secretary of Faculty
Director of Libraries
Registrar
Director of Admissions
Director of the Acoustics Laboratory
Director of the Research Laboratory of Electronics
Chairman of Directing Committee, Laboratory for Nuclear Science
Director of the Spectroscopy Laboratory
Director of Lincoln Laboratory
Director of Summer Session
Heads of Departments and Professional Courses
Chairman of Committee on Undergraduate Policy

OFFICERS OF INSTRUCTION AND INSTRUCTING STAFF

JAMES R. KILLIAN, JR., Sc.D., LL.D., D.ENG., *President*
JULIUS A. STRATTON, Sc.D., D.ENG., *Chancellor*
JOHN T. NORTON, Sc.D., *Chairman of the Faculty*
LEICESTER F. HAMILTON, S.B., *Secretary of the Faculty*
ALVIN SLOANE, B.S., *Assistant Secretary of the Faculty*

MEMBERS OF FACULTY EX-OFFICIIS

JAMES R. KILLIAN, JR., *President*
JULIUS A. STRATTON, *Chancellor*
EDWARD L. COCHRANE, *Vice-President for Industrial and Governmental Relations*
C. RICHARD SODERBERG, *Dean of the School of Engineering*
GEORGE R. HARRISON, *Dean of the School of Science*
PIETRO BELLUSCHI, *Dean of the School of Architecture and Planning*
JOHN E. BURCHARD, *Dean of the School of Humanities and Social Studies*
EDWARD P. BROOKS, *Dean of the School of Industrial Management*
HAROLD L. HAZEN, *Dean of the Graduate School*
JOHN T. RULE, *Dean of Students*
THOMAS P. PITRÉ, *Associate Dean of Students*
FREDERICK G. FASSETT, JR., *Associate Dean of Students*
WILLIAM SPEER, *Associate Dean of Students*
ROBERT E. HEWES, *Registrar*
WARREN D. WELLS, *Assistant Registrar*
B. ALDEN THRESHER, *Director of Admissions*
PAUL M. CHALMERS, *Associate Director of Admissions*
DAVID A. DUDLEY, *Associate Director of Admissions*
EUGENE R. CHAMBERLAIN, *Assistant Director of Admissions*
M. BRYCE LEGGETT, *Assistant Director of Admissions*
WILLIAM N. LOCKE, *Director of Libraries*
RICHARD L. BALCH, *Director of Athletics*

INSTITUTE PROFESSORS

MARTIN JULIAN BUERGER, PH.D.
EDWIN HERBERT LAND, LL.D., Sc.D. (*Visiting*)
ISADOR ISSAC RABI, PH.D. (*Visiting*)
FRANCIS OTTO SCHMITT, PH.D., Sc.D.
JOHN CLARKE SLATER, PH.D., Sc.D.

AERONAUTICAL ENGINEERING

CHARLES STARK DRAPER, Sc.D.
Professor of Aeronautical Engineering; in charge of the Department; Director of Instrumentation Laboratory

WALTER MCKAY, S.M.
Associate Professor of Aeronautical Engineering; Executive Officer

JEROME CLARKE HUNSAKER, Sc.D., ENG.D.
Professor of Aeronautical Engineering, Emeritus; Lecturer

OTTO CARL KOPPEN, S.B.
Professor of Aeronautical Engineering

EDWARD STORY TAYLOR, S.B.
Professor of Aircraft Engines

JOHN RAYMOND MARKHAM
Professor of Aeronautical Engineering

SHATSWELL OBER, S.B.
Professor of Aeronautical Engineering

RAYMOND LEWIS BISPLINGHOFF, M.Sc.
Professor of Aeronautical Engineering

ISADORE EDWARD GARRICK, B.S.
Jerome Clarke Hunsaker Professor of Aeronautical Engineering (Visiting)

HORTON GUYFORD STEVER, PH.D.
Professor of Aeronautical Engineering
Associate Dean of the School of Engineering

WALTER WRIGLEY, Sc.D.
Professor of Aeronautical Engineering

WALTER HENRY GALE, S.M.
Associate Professor of Aeronautical Engineering; Special Assistant

JOSEPH BICKNELL, S.M.
Associate Professor of Aeronautical Engineering

Lecturers

RICHARD HORACE BATTIN, PH.D.
HENRY PHILIP WHITAKER, S.B.

RENÉ HARCOURT MILLER, B.A.
Associate Professor of Aeronautical Engineering

PAUL EDWIN SANDORFF, S.B.
Associate Professor of Aeronautical Engineering

ROBERT KARL MUELLER, Sc.D.
Associate Professor of Aeronautical Engineering

HOLT ASHLEY, Sc.D.
Associate Professor of Aeronautical Engineering

ROBERT LOUIS HALFMAN, S.M.
Associate Professor of Aeronautical Engineering

YAO TZU LI, Sc.D.
Associate Professor of Aeronautical Engineering

FRANK KINGSLEY BENTLEY
Assistant Professor of Aeronautical Engineering

SIDNEY LEES, Sc.D.
Assistant Professor of Aeronautical Engineering

JAMES WAH MAR, Sc.D.
Assistant Professor of Aeronautical Engineering

ELMER EUGENE LARRABEE, S.M.
Assistant Professor of Aeronautical Engineering

MORTON FINSTON, PH.D.
Assistant Professor of Aeronautical Engineering

THEODORE HSUEH-HUANG PIAN, Sc.D.
Assistant Professor of Aeronautical Engineering

LEON TRILLING, PH.D.
Assistant Professor of Aeronautical Engineering

MYRON ARNOLD HOFFMAN, Sc.D. (*Absent*)
Assistant Professor of Aeronautical Engineering

ERIK LEONARD MOLLÖ-CHRISTENSEN, Sc.D.
Assistant Professor of Aeronautical Engineering

Research Associate

JOHN DUGUNDJI, Sc.D.

INSTRUCTING STAFF

AIR SCIENCE

HARMON LAMPLEY, JR., B.S., COLONEL, U. S. AIR FORCE
Professor of Air Science; in charge of the Department

SIDNEY F. WOGAN, LL.B., LIEUTENANT COLONEL, U. S. AIR FORCE
Associate Professor of Air Science

JOHN ARENT VANDERPOEL, S.B., MAJOR, U. S. AIR FORCE
Associate Professor of Air Science

FREDERICK WILLIAM DEDERICH, B.S., CAPTAIN, U. S. AIR FORCE
Assistant Professor of Air Science

WILLARD DISSTON TEASE, B.S., CAPTAIN, U. S. AIR FORCE
Assistant Professor of Air Science

THEODORE ROBERT YORK, B.S., CAPTAIN, U. S. AIR FORCE
Assistant Professor of Air Science

ALAN DEXTER WHEELER, B.B.A., CAPTAIN, U. S. AIR FORCE
Assistant Professor of Air Science

HARRY JOSEPH CROOK JR., B.S., 1ST LIEUTENANT, U. S. AIR FORCE
Assistant Professor of Air Science

Instructors

FLOYD RIDGELY YOUNG, JR., MASTER SERGEANT, U. S. AIR FORCE
ROBERT LEROY PAGE, JR., STAFF SERGEANT, U. S. AIR FORCE
HARRISON LEE DONOVANT, STAFF SERGEANT, U. S. AIR FORCE
VICTOR CARL MINICH, MASTER SERGEANT, U. S. AIR FORCE
JERE SARGENT MCCARTHY, STAFF SERGEANT, U. S. AIR FORCE
LOUIS EDWARD SCHWEINFURTH, TECHNICAL SERGEANT, U. S. AIR FORCE
DONALD T. TATTERFIELD, STAFF SERGEANT, U. S. AIR FORCE

ARCHITECTURE

LAWRENCE BERNHART ANDERSON, M.ARCH.
Professor of Architecture; in charge of the Department

HERBERT LYNES BECKWITH, M.ARCH.
Professor of Architecture

GYORGY KEPES, M.A.
Professor of Visual Design

PIETRO BELLUSCHI, DOTT. ING., LL.D.
Professor of Architecture;
Dean of the School of Architecture and Planning

ROBIN GERARD PENLEIGH BOYD
Bemis Professor of Architecture (Visiting)

EDUARDO FERNANDO CATALANO, M.ARCH.
Professor of Architecture

KAY FISKER
Professor of Architecture (Visiting)

ERNEST NAPOLEON GELOTTE, S.B.
Associate Professor of Construction

WILLIAM HOSKINS BROWN, M.ARCH.
Associate Professor of Architecture

RICHARD FILIPOWSKI, B.A.
Associate Professor of Visual Design

ROBERT BRADFORD NEWMAN, M.A., M.ARCH.
Associate Professor of Architecture

ALBERT BUSH-BROWN, M.F.A.
Assistant Professor of Architectural History

MARVIN EDWARD GOODY, M.ARCH., M.C.P.
Assistant Professor of Architecture

Lecturers

JOSEPH HUDNUT
CARL KOCH, M. ARCH.
ROBERT ORMEROD PREUSSER
ALEXANDER SYLVAN REED
PAUL WEIDLINGER, M.S.

Instructors

WILLIAM ARTHUR BAGNALL, B.A., B.S.
HENRY ARMAND MILLON, A.M., M.ARCH.
BERNARD POLMER SPRING, A.B., M.ARCH.
SANFORD RAYMOND GREENFIELD, M.ARCH.

Technical Instructor

NISHAN BICHAJIAN

Research Associate

RICHARD WINFIELD HAMILTON, M.ARCH.

BIOLOGY

Irwin Whiting Sizer, Ph.D.
Professor of Biochemistry; acting in charge of the Department

Francis Otto Schmitt, Ph.D., Sc.D.
Institute Professor; Professor of Biology

Richard Scott Bear, Ph.D.
Professor of Biophysics

John Machlin Buchanan, Ph.D.
Professor of Biochemistry; in charge of the Division of Biochemistry

David Floyd Waugh, Ph.D.
Professor of Biophysics

Paul A. Weiss, Ph.D., M.D.
Professor of Biology (Visiting)

Bernard Sidney Gould, Ph.D.
Associate Professor of Biochemistry

Kurt Siegfried Lion, D.Eng. (*Absent*)
Associate Professor of Applied Biophysics

Cecil Edwin Hall, Ph.D.
Associate Professor of Biophysics

Richard Carl Sanborn, Ph.D.
Assistant Professor of Zoology

Howard Peter Jenerick, Ph.D.
Assistant Professor of General Physiology

Herman William Lewis, Ph.D.
Assistant Professor of Biology

Gene Monte Brown, Ph.D.
Assistant Professor of Biochemistry

Instructors

Edward Herbert, Ph.D.

Lewis Nelson Lukens, III, A.B.

Research Associates

Rose Robyns Coelho, Ph.D.
Carolyn Cohen, A.B.
Gottfried Deffner, D.Sc.
Josef Fellig, Ph.D.
Norman Jacob Geschwind, M.D.
Marcus C. Goodall
Christine Kris, Ph.D.
Richard Sherley Morgan, M.D.
Jesse Friend Scott, M.D.
David Spiro, Ph.D.
Betty Geren Uzman, M.D.
Bert Lester Vallee, M.D.

CHEMICAL ENGINEERING

(Including the School of Chemical Engineering Practice)

Walter Gordon Whitman, Sc.D.
Professor of Chemical Engineering; in charge of the Department

Warren Kendall Lewis, Ph.D., D.Sc., D.Eng.
Professor of Chemical Engineering, Emeritus

William Henry McAdams, D.Sc.
Professor of Chemical Engineering

Hoyt Clarke Hottel, A.B., S.M.
Professor of Fuel Engineering; Director of Fuels Research Laboratory

Thomas Kilgore Sherwood, Sc.D., Eng.D.
Professor of Chemical Engineering

Harold Christian Weber, D.Sc.
Professor of Chemical Engineering

Edwin Richard Gilliland, Sc.D., D.Eng.
Professor of Chemical Engineering

Manson Benedict, Ph.D.
Professor of Nuclear Engineering

Herman Paul Meissner, D.Sc.
Professor of Chemical Engineering

Glenn Carber Williams, Sc.D.
Professor of Chemical Engineering

Johnson Edward Vivian, Sc.D.
Professor of Chemical Engineering; Director of School of Chemical Engineering Practice; Director of Oak Ridge Engineering Practice School

Harold Somers Mickley, Sc.D.
Associate Professor of Chemical Engineering

Charles Nelson Satterfield, Sc.D.
Associate Professor of Chemical Engineering

Theos Jardin Thompson, Ph.D.
Associate Professor of Nuclear Engineering

Thomas Harrington Pigford, Sc.D.
Associate Professor of Nuclear Engineering

Alan Sherman Michaels, Sc.D.
Associate Professor of Chemical Engineering

Edward Wilson Merrill, Sc.D.
Assistant Professor of Chemical Engineering

Raymond Frederick Baddour, Sc.D.
Assistant Professor of Chemical Engineering; United Engineers and Constructors, Inc., Preceptor

Daniel Furth Fairbanks, Sc.D.
Assistant Professor of Chemical Engineering

Norman Beecher, S.M.
Assistant Professor of Chemical Engineering

Robert Clark Reid, Sc.D.
Assistant Professor of Chemical Engineering

Pierre Leonc Thibaut Brian, B.S.
Assistant Professor of Chemical Engineering Director, Bangor Station, School of Chemical Engineering Practice

Edward S. Cohen, Sc.D.
Assistant Professor of Chemical Engineering; Director, Parlin Station, School of Chemical Engineering Practice

Melville Clark, Jr., Ph.D.
Assistant Professor of Nuclear Engineering

Gordon Lee Brownell, Ph.D.
Assistant Professor of Nuclear Engineering

William Herbert Ceckler, S.B.
Assistant Professor of Chemical Engineering; Director, Buffalo Station, School of Chemical Engineering Practice

Thomas William Mix, S.M.
Assistant Professor of Chemical Engineering; Director Engineering Practice School at Oak Ridge

INSTRUCTING STAFF

Instructors

ALBERT ROBINSON COLVILLE, JR., M.Sc.
ROBERT G. SHAVER, S.M.

Technical Instructors

HENRY CHASEN
HAROLD HAVNER CARTER

Research Associates

THOMAS CANTWELL, S.M., M.B.A.
FRANK FEAKES, Sc.D.
WILLIAM PAUL JENSEN, S.M.
CHARLES WILLIAM SHIPMAN, Sc.D.

STAFF OF THE STATIONS OF THE SCHOOL OF CHEMICAL ENGINEERING PRACTICE

Directors

EDWARD S. COHEN, Sc.D., *Parlin*
PIERRE LEONC THIBAUT BRIAN, B.S., *Bangor*
WILLIAM HERBERT CECKLER, S.B., *Buffalo*

CHEMISTRY

ARTHUR CLAY COPE, PH.D., SC.D.
Professor of Organic Chemistry; in charge of the Department

LEICESTER FORSYTH HAMILTON, S.B.
Professor of Analytical Chemistry; Executive Officer; Secretary of the Faculty

WALTER CECIL SCHUMB, PH.D.
Professor of Inorganic Chemistry

GEORGE SCATCHARD, PH.D., SC.D.
Professor of Physical Chemistry

JAMES ALEXANDER BEATTIE, PH.D.
Professor of Physical Chemistry

AVERY ADRIAN MORTON, PH.D.
Professor of Organic Chemistry

CHARLES DUBOIS CORYELL, PH.D.
Professor of Chemistry

ISADORE AMDUR, PH.D.
Professor of Physical Chemistry

JOHN CLARK SHEEHAN, PH.D.
Professor of Organic Chemistry

WALTER HUGO STOCKMAYER, PH.D.
Professor of Physical Chemistry

RICHARD COLLINS LORD, PH.D.
Professor of Chemistry; Director of Spectroscopy Laboratory

CLARK CONKLING STEPHENSON, PH.D.
Professor of Chemistry

LARS GUNNAR SILLEN, PH.D.
Arthur D. Little Professor of Chemistry (Visiting)

LOUIS HARRIS, PH.D.
Associate Professor of Physical Chemistry

AVERY ALLEN ASHDOWN, PH.D.
Associate Professor of Organic Chemistry; Secretary of the Society of Arts

STEPHEN GERSHOM SIMPSON, PH.D.
Associate Professor of Analytical Chemistry

RALPH CHILLINGWORTH YOUNG, PH.D.
Associate Professor of Inorganic Chemistry, Emeritus; Lecturer

ARTHUR RANDALL DAVIS, PH.D.
Associate Professor of Inorganic Chemistry

NICHOLAS ATHANASIUS MILAS, PH.D.
Associate Professor of Organic Chemistry

CHARLES MONTGOMERY WAREHAM, S.B.
Associate Professor of Inorganic Chemistry

EDMUND LEE GAMBLE, PH.D.
Associate Professor of Inorganic Chemistry

LAWRENCE JOSEPH HEIDT, PH.D.
Associate Professor of Physical Chemistry

JOHN WITHERS IRVINE, JR., PH.D., SC.D.
Associate Professor of Chemistry

DAVID NEWTON HUME, PH.D.
Associate Professor of Chemistry

LOCKHART BURGESS ROGERS, PH.D.
Associate Professor of Chemistry

CHARLES GARDNER SWAIN, PH.D.
Associate Professor of Chemistry

GEORGE HERMANN BÜCHI, D.Sc.
Associate Professor of Chemistry

DAVID POWELL SHOEMAKER, PH.D.
Associate Professor of Chemistry

CARL WESLEY GARLAND, PH.D.
Assistant Professor of Chemistry

FREDERICK DAVIS GREENE, II, PH.D.
Assistant Professor of Chemistry

HERBERT OTIS HOUSE, PH.D.
Assistant Professor of Chemistry

NORMAN ALLAN NELSON, PH.D.
Assistant Professor of Chemistry

JOHN STEWART WAUGH, PH.D.
Assistant Professor of Chemistry

Instructors

WILLIAM ROBERT MOORE, PH.D.
FRANK ALBERT COTTON, PH.D.
ROY ARCHIE WHITEKER, PH.D.

Research Associates

KLAUS BIEMANN, DR. PH.C.
ALBERT EMILE CLAEYS, DR. CHEM.
RALPH ALBERT HORNE, PH.D.
STEPHEN MEARS NAGY, SC.D.
LISELOTTE ELSE POHMER, D.SC.
HANS HEINRICH RENNHARD, D.SC.
ULRICH LOTHAR SCHINDEWOLF, DR. RER. NAT.
FELIX SERRATOSA, D.SC.
RENE FRITZ ZÜRCHER, D.SC.

CITY AND REGIONAL PLANNING

FREDERICK JOHNSTONE ADAMS, B.ARCH.
Professor of City Planning; in charge of the Department

ROLAND BRADFORD GREELEY, A.B.
Associate Professor of Regional Planning

JOHN TASKER HOWARD, M.C.P.
Associate Professor of City Planning; Director of Section of Urban and Regional Studies

BURNHAM KELLY, A.B., LL.B., M.C.P.
Associate Professor of City Planning

LLOYD RODWIN, PH.D.
Associate Professor of Land Economics

KEVIN ANDREW LYNCH, B.C.P.
Associate Professor of City Planning

Lecturers

LAWRENCE KELSO FRANK, A.B.
WALTER ISARD, PH.D.

CIVIL AND SANITARY ENGINEERING

JOHN BENSON WILBUR, SC.D.
Professor of Civil Engineering; in charge of the Department

HARL PRESLAR ALDRICH, JR., SC.D.
Assistant Professor of Soil Mechanics; Executive Officer

JOHN BRAZER BABCOCK, 3D, S.B.
Professor of Railway Engineering, Emeritus; Lecturer

WALTER CHARLES VOSS, S.M.
Professor of Building Construction, Emeritus; Lecturer

WILLIAM EDWARD STANLEY, C.E.
Professor of Sanitary Engineering

ARTHUR THOMAS IPPEN, PH.D.
Professor of Hydraulics

ROLF ELIASSEN, SC.D.
Professor of Sanitary Engineering

ALBERT GEORGE HENRY DIETZ, SC.D.
Professor of Building Engineering; acting in charge of Course XVII

CLAIR NATHAN SAWYER, PH.D.
Professor of Sanitary Chemistry

CHARLES HEAD NORRIS, SC.D.
Professor of Structural Engineering

JAMES WALLACE DAILY, PH.D.
Professor of Hydraulics

GORDON RYERSON WILLIAMS, S.B.
Professor of Hydraulic Engineering

EUGENE MIRABELLI, S.B.
Associate Professor of Structural Design

ALEXANDER JAMIESON BONE, S.M.
Associate Professor of Highway and Airport Engineering

JAMES ALBERT MURRAY, S.B.
Associate Professor of Materials

ROBERT JOSEPH HANSEN, SC.D.
Associate Professor of Structural Engineering

MYLE JOSEPH HOLLEY, JR., S.M.
Associate Professor of Structural Engineering

THOMAS WILLIAM LAMBE, SC.D.
Associate Professor of Soil Mechanics

JOHN MELVIN BIGGS, S.M.
Associate Professor of Structural Engineering

HOWARD SIMPSON, S.M.
Associate Professor of Structural Engineering

DONALD ROBERT FERGUSSON HARLEMAN, SC.D.
Associate Professor of Hydraulics

WERNER HERBERT GUMPERTZ, BLDG. E.
Assistant Professor of Building Construction

ROBERT VAN DUYNE WHITMAN, SC.D.
Assistant Professor of Soil Mechanics

ROSS ERWIN MCKINNEY, SC.D.
Assistant Professor of Sanitary Engineering

VINCENT JACOB ROGGEVEEN, M.B.A., S.M.
Assistant Professor of Transportation Engineering

PETER STURGES EAGLESON, SC.D.
Assistant Professor of Hydraulic Engineering

FRANK JOSEPH HEGER, JR., S.M.
Assistant Professor of Structural Design

FREDERICK JEROME MCGARRY, A.B., S.M.
Assistant Professor of Materials

CHARLES LESLIE MILLER, S.B.
Assistant Professor of Surveying

SAUL NAMYET, S.B.
Assistant Professor of Structural Engineering

ALBERT SCHEFFER LANG, S.B.
Assistant Professor of Transportation Engineering

RONALD ELLIOTT NECE, M.S.
Assistant Professor of Hydraulics

Lecturer

KARL TERZAGHI, DR. ING., *Soil Mechanics*

Instructor

JAMES EDWIN ROBERTS, S.B.

Technical Instructor

ALBERT JOSEPH O'NEILL, S.B.

Research Associates

JACOB JOSEPH BIKERMAN, M.SC.
ROBERT AMIS LAUDERDALE, JR., M.S.
ROBERT JOSEPH PELLETIER, B.ARCH., BLDG.E.

INSTRUCTING STAFF

ECONOMICS AND SOCIAL SCIENCE

Ralph Evans Freeman, M.A., B.Litt.
Professor of Economics; in charge of the Department

William Rupert Maclaurin, D.C.S.
Professor of Economics

Norman Judson Padelford, Ph.D., LL.D.
Professor of Political Science

Paul Anthony Samuelson, Ph.D.
Professor of Economics

Charles Andrew Myers, Ph.D.
Professor of Industrial Relations

Harold Adolph Freeman, S.B.
Professor of Statistics

Charles Poor Kindleberger, Ph.D.
Professor of Economics

Max Franklin Millikan, Ph.D.
Professor of Economics

Daniel Lerner, Ph.D.
Professor of Sociology (Visiting)

Paul Rosenstein-Rodan, Ph.D.
Professor of Economics (Visiting)

Wilfred Malenbaum, Ph.D.
Professor of Economics (Visiting)

Everett Einar Hagen, Ph.D.
Professor of Economics (Visiting)

Benjamin Howard Higgins, Ph.D.
Professor of Economics (Visiting)

Frank Horace Hahn, Ph.D.
Professor of Economics (Visiting)

Derwent Whittlesey
Professor of Economics (Visiting)

Evsey D. Domar, Ph.D.
Professor of Economics (Visiting)

Paul Pigors, Ph.D.
Associate Professor of Industrial Relations

Joseph Carl Robnett Licklider, Ph.D.
Associate Professor of Psychology

Robert Lyle Bishop, Ph.D.
Associate Professor of Economics

Edgar Cary Brown, Ph.D. (*Absent*)
Associate Professor of Economics

Ithiel de Sola Pool, Ph.D.
Associate Professor of Political Science

Morris Albert Adelman, Ph.D.
Associate Professor of Economics

Robert Merton Solow, Ph.D.
Associate Professor of Statistics

Raymond Augustine Bauer, Ph.D.
Associate Professor of Social Psychology

George Pratt Shultz, Ph.D.
Associate Professor of Industrial Relations

Herbert Allen Shepard, Ph.D.
Assistant Professor of Sociology

Elspeth Davies Rostow, A.M.
Assistant Professor of History

Roy Olton, Ph.D.
Assistant Professor of Political Science

Herbert Miles Jenkins, Ph.D.
Assistant Professor of Psychology

Lawrence W. Martin, Ph.D.
Assistant Professor of Political Science

Lucian Wilmot Pye, Ph.D.
Assistant Professor of Political Science

Abraham J. Siegel, M.A.
Assistant Professor of Industrial Relations

Lecturer

Frederick J. Lesieur

Instructors

Richard-John Kruizenga, Ph.D.
Maurice McManus, B.Com.
Edwin Smith Mills, B.A.
Arnold Robert Weber, M.A.
Egon Sohmen, Ph.D.
Keith J. Norman, M.S.
Claus William Ruser, M.A.
Henry Binford Steele, B.A.
Seth P. Tillman, M.A.
Maynard Norman Toussaint, M.A.

ELECTRICAL ENGINEERING

Gordon Stanley Brown, Sc.D.
Professor of Electrical Engineering; in charge of the Department

Carlton Everett Tucker, S.B.
Professor of Electrical Engineering; Executive Officer

Harold Locke Hazen, Sc.D.
Professor of Electrical Engineering; Dean of the Graduate School

Murray Frank Gardner, S.M.
Professor of Electrical Engineering

Ernst Adolph Guillemin, Ph.D.
Professor of Electrical Communications

Samuel Hawks Caldwell, Sc.D.
Professor of Electrical Engineering

Arthur Robert von Hippel, Ph.D.
Professor of Electrophysics

Harold Eugene Edgerton, Sc.D., D.Eng.
Professor of Electrical Measurements

EUGENE WHEELOCK BOEHNE, D.ENG.
Professor of Electrical Engineering

JEROME BERT WIESNER, PH.D.
Professor of Electrical Engineering;
Director of Research Laboratory of Electronics

WILLIAM HENRY RADFORD, S.M.
Professor of Electrical Communications;
Division Head, Lincoln Laboratory

LAN JEN CHU, SC.D.
Professor of Electrical Engineering

JOHN GEORGE TRUMP, SC.D.
Professor of Electrical Engineering

RICHARD HENRY BOLT, PH.D.
Professor of Acoustics;
Director of Acoustics Laboratory

KARL LELAND WILDES, S.M.
Professor of Electrical Engineering

HENRY JOSEPH ZIMMERMANN, S.M.
Professor of Electrical Engineering;
Associate Director of Research Laboratory of Electronics

CLAUDE ELWOOD SHANNON, PH.D.
Professor of Communications (Visiting)

ROBERT MARIO FANO, SC.D.
Professor of Electrical Communications

RICHARD DUDLEY FAY, A.B., S.B.
Associate Professor of Electrical Communications, Emeritus;
Lecturer

RICHARD HENRY FRAZIER, S.M.
Associate Professor of Electrical Engineering

PARRY MOON, S.M.
Associate Professor of Electrical Engineering

TRUMAN STRETCHER GRAY, SC.D.
Associate Professor of Engineering Electronics

CHARLES KINGSLEY, JR., S.M.
Associate Professor of Electrical Engineering

LEO LEROY BERANEK, SC.D.
Associate Professor of Communications Engineering

YUK-WING LEE, SC.D.
Associate Professor of Electrical Engineering

WALTER ALTER ROSENBLITH, ING.RAD.
Associate Professor of Communications Biophysics

GEORGE CHENEY NEWTON, JR., SC.D.
Associate Professor of Electrical Engineering

ALEXANDER KUSKO, SC.D.
Associate Professor of Electrical Engineering

WILLIAM KIRBY LINVILL, SC.D. (*Absent*)
Associate Professor of Electrical Engineering

JOHN FRANCIS REINTJES, M.E.E.
Associate Professor of Electrical Communications

THOMAS FRANKLIN JONES, JR., SC.D.
Associate Professor of Electrical Engineering

SAMUEL JEFFERSON MASON, SC.D.
Associate Professor of Electrical Engineering

DAVID CALVIN WHITE, PH.D.
Associate Professor of Electrical Engineering

RICHARD BROOKS ADLER, SC.D.
Associate Professor of Electrical Communications

LOUIS DIJOUR SMULLIN, S.M.
Associate Professor of Electrical Engineering

PETER ELIAS, PH.D.
Associate Professor of Electrical Engineering

EWAN WATTS FLETCHER, PH.D.
Associate Professor of Electrical Engineering

ROBERT LOUIS KYHL, PH.D.
Associate Professor of Electrical Engineering

OSMAN KAMEL MAWARDI, PH.D.
Associate Professor of Communications Engineering

ALBERT BERNHARDI VAN RENNES, SC.D.
Associate Professor of Electrical Engineering

MARCY EAGER, S.B.
Assistant Professor of Electrical Communications

ELERY FRANK BUCKLEY, S.M.
Assistant Professor of Electrical Engineering

WILLIAM MCCONWAY SIEBERT, SC.D.
Assistant Professor of Electrical Engineering

DAVID JACOB EPSTEIN, SC.D.
Assistant Professor of Electrical Engineering

PAUL EUGENE SMITH, JR., E.E.
Assistant Professor of Electrical Engineering

LEONARD ABRAHAM GOULD, SC.D.
Assistant Professor of Electrical Engineering

DAVID ALBERT HUFFMAN, SC.D.
Assistant Professor of Electrical Engineering

RICHARD CRITTENDEN BOOTON, JR., SC.D.
Assistant Professor of Electrical Engineering

KENNETH NOBLE STEVENS, SC.D.
Assistant Professor of Electrical Communications

HERMANN ANTON HAUS, SC.D.
Assistant Professor of Electrical Engineering

MAHMOUD RIAZ, SC.D.
Assistant Professor of Electrical Engineering

ALFRED KRISS SUSSKIND, S.M.
Assistant Professor of Electrical Engineering

DEAN NORMAN ARDEN, S.B.
Assistant Professor of Electrical Engineering

MAX EDWARD CASPARI, PH.D.
Assistant Professor of Electrical Engineering

ELIE JOSEPH BAGHDADY, SC.D.
Assistant Professor of Electrical Engineering

PHILIP M LEWIS, II, SC.D.
Assistant Professor of Electrical Engineering

FREDERICK WILLIAM NESLINE, JR., PH.D.
Assistant Professor of Electrical Engineering

BERNARD WIDROW, SC.D.
Assistant Professor of Electrical Engineering

HERBERT HORACE WOODSON, SC.D
Assistant Professor of Electrical Engineering

AMAR GOPAL BOSE, SC.D. (*Absent*)
Assistant Professor of Electrical Engineering

Lecturers

DENYS OSMUND AKHURST, PH.D.

JORDAN JAY BARUCH, SC.D.

WILLIAM DAVID JACKSON, A.R.T.C.

ARTHUR LEE LOEB, PH.D.

INSTRUCTING STAFF

Instructors

William Alfred Youngblood, B.A., M.S.
George Wendell Hughes, E.E.
Richard Douglas Thornton, S.M.
Roger Henri Baumann, S.M. (*Absent*)
Moise Herbert Goldstein, Jr., S.M.
Elias Panagiotis Gyftopoulos, Dipl.
Herbert Martin Teager, Sc.D. (*Absent*)
Dudley Allen Buck, S.M.
Owen William Kennedy, Jr., M.S. (*Absent*)
Norman Howard Meyers, S.M.
Thomas Harold Putman, S.M.
William Tower Peake, S.M.
Krishin Hashmatrai Bhavnani, S.M.
Paul Romberg Johannessen, S.M.
James Frederick Kaiser, S.M.
Allan Joseph Lichtenberg, A.B., S.M.
Charles Wolcott Merriam, III, S.M.
Robert Frank Nease, S.M.
Campbell Leach Searle, S.M.
Amiya Kumar Sen, D.Sc.
David Rempfer Whitehouse, S.M.

Assistant to Head of Department
John Avery Tucker, M.Eng.

Non-Resident Instructors

Theodore Carl Anderson, S.M.
Eugene Huff Beach, Ph.D.
Edward Kenneth Blum, Ph.D.
John Alden Bradshaw, Ph.D.
Garland Marion Branch, Jr., Ph.D.
William Smith Cramer, Ph.D.
Jackson Estes Fowler, B.Sc.
Anthony Francis Gabrielle, S.M.
Sorab K. Ghandi, Ph.D.
Stanford Goldman, Ph.D.
Edward Isaac Hawthorne, Ph.D.
Lloyd Oscar Krause, B.S.
Pietro Paolo Lombardini, Ph.D.
John Carl Mairhuber, M.S.
Albert Downing Perry, Jr., Ph.D.
Bernard Rider, D.E.E.
John Parker Runyon, M.E.
Bernard Donald Steinberg, S.M.
Arthur P. Stern, M.S.
Jerome J. Suran, B.S.
Joseph Tellier, B.S.
Paul Frederick Zweifel, Ph.D.

Research Associates

Manuel Valdivia Cerrillo, Ph.D.
Albert Denver Frost, Sc.D.
Kenneth Joseph Germeshausen, S.B.
Alexander Smakula, A.B., S.M.
Patrick Youtz, A.B., S.M.

FOOD TECHNOLOGY

Bernard Emerson Proctor, Ph.D.
Professor of Food Technology; in charge of the Department; Director of the Samuel Cate Prescott Laboratories of Food Technology

Samuel Abraham Goldblith, Ph.D.
Associate Professor of Food Technology; Executive Officer

Robert Samuel Harris, Ph.D.
Professor of Biochemistry of Nutrition

Cecil Gordon Dunn, Ph.D.
Associate Professor of Industrial Microbiology

John Theodore Roosevelt Nickerson, Ph.D.
Associate Professor of Food Processing

Henry Sherman, Ph.D.
Assistant Professor of Biochemistry of Nutrition

Lecturers

Charles N. Frey, Ph.D., D.Sc.
William Geisler
James Robert Wilson, M.D.

Instructors

Stanley Ely Charm, M.S.
George Joseph Fuld, B.S.

Research Associates

Carol Lois Campbell, Ph.D.
Charles Woodbury Fifield, Ph.D.
Joseph John Licciardello, M.S.
Mabel Crawford Merritt, B.S.
Abraham Edward Nizel, D.M.D., M.S.D.
Robert Louis Wanner, Ph.D.
John Hans Wertheim, Ing.Chem.
Elsie Amelia Wilson, A.B.

GEOLOGY AND GEOPHYSICS

ROBERT RAKES SHROCK, PH.D.
Professor of Geology; in charge of the Department

PATRICK MASON HURLEY, PH.D.
Professor of Geology; Executive Officer

MARTIN JULIAN BUERGER, PH.D.
Institute Professor: Professor of Mineralogy and Crystallography; Director of School for Advanced Studies

HAROLD WILLIAMS FAIRBAIRN, PH.D.
Professor of Geology

ROLAND DANE PARKS, E.M., M.S.
Associate Professor of Mineral Industry

WALTER LUCIUS WHITEHEAD, PH.D.
Associate Professor of Geology

ELY MENCHER, PH.D.
Associate Professor of Geology

GORDON JAMES FRASER MACDONALD, PH.D.
Associate Professor of Geology

WILLIAM HENRY DENNEN, PH.D.
Assistant Professor of Geology

STEPHEN MILTON SIMPSON, JR., PH.D.
Assistant Professor of Geophysics

WILLIAM FRANCIS BRACE, PH.D.
Assistant Professor of Geology

RICHARD RAYMAN DOELL, PH.D.
Assistant Professor of Geophysics

WILLIAM HAMET PINSON, PH.D.
Assistant Professor of Geology

JOHN WIDMER WINCHESTER, PH.D.
Assistant Professor of Geochemistry

Lecturers
HERBERT EDWIN HAWKES, JR., PH.D.
DONALD JONATHAN MACNEIL, PH.D.
THEODORE RICHARD MADDEN, S.B.

Research Associate
NORMAN ABRAHAM HASKELL, PH.D.

HUMANITIES

HOWARD RUSSELL BARTLETT, B.S., A.M.
Professor of English and History; in charge of the Department

JOHN ELY BURCHARD, L.H.D.
Professor of Humanities; Dean of the School of Humanities and Social Studies

WILLIAM CHACE GREENE, M.A.
Professor of English

KARL WOLFGANG DEUTSCH, PH.D. (*Absent*)
Professor of History and Political Science

GIORGIO DIAZ DE SANTILLANA, PH.D.
Professor of the History of Philosophy and Science

WALT WHITMAN ROSTOW, PH.D.
Professor of History

ERNST LEVY, B.A.
Professor of Music

CARVEL COLLINS, PH.D.
Professor of English

KLAUS LIEPMANN
Professor of Music

LYNWOOD SILVESTER BRYANT, A.M.
Associate Professor of English and History

JOHN BELL RAE, PH.D. (*Absent*)
Associate Professor of History

THOMAS HENRY DONALD MAHONEY, PH.D.
Associate Professor of History

THEODORE WOOD, JR., S.B., A.M.
Associate Professor of English

JOHN MORTON BLUM, PH.D.
Associate Professor of History

EDWARD NEAL HARTLEY, A.M.
Associate Professor of History

ROBERT SMITH WOODBURY, S.B., A.M.
Assistant Professor of English and History

WALTER FRANCIS URBACH, A.M.
Assistant Professor of English

STUART EDGERLY, A.M.
Assistant Professor of English and History

JAMES GERALD KELSO, PH.D.
Assistant Professor of History

ROBERT ELLSWORTH MACMASTER, PH.D.
Assistant Professor of History

ALFRED DUPONT CHANDLER, JR., PH.D.
Assistant Professor of History

ROBERT REYNOLDS RATHBONE, A.M.
Assistant Professor of English

IRVING HENRY BARTLETT, PH.D.
Assistant Professor of History

JOSEPH DEE EVERINGHAM, A.M.
Assistant Professor of English

THEODORE STEVENSON BAER, PH.D.
Assistant Professor of Political Science; Carnegie Fellow

JAMES DAVID KOERNER, PH.D. (*Absent*)
Assistant Professor of English

THEODORE DAVIDGE LOCKWOOD, PH.D.
Assistant Professor of History

HAROLD ANTON THRAP OLSEN REICHE, PH.D.
Assistant Professor of Classics

WILLIAM DUANE STAHLMAN, S.B., M.A.
Assistant Professor of History of Science

MARTIN LICHTERMAN, PH.D.
Assistant Professor of History

ROWLAND LIPPINCOTT MITCHELL, JR., PH.D.
Assistant Professor of History

NORMAN NORWOOD HOLLAND, JR., PH.D.
Assistant Professor of English

BRUCE MAZLISH, PH.D.
Assistant Professor of History

STANLEY P. WASSON, PH.D.
Assistant Professor of History (Visiting)

Lecturer
GREGORY TUCKER

INSTRUCTING STAFF

Instructors

George Robert Healy, M.A.
Charles Seymour Alden, A.M.
Brison Dowling Gooch, Ph.D. (*Absent*)
Andrew Winchester Turnbull, Ph.D.
Roger Warren Prouty, Ph.D.

Walter Faw Cannon, Ph.D.
William Van Grimes, Jr., A.M.
Charles Robert Niehaus, M.A.
Charles Kavanaugh Warner, M.A.
Henry Ashton Crosby Forbes, A.M.

Rudolph Binion, B.A.
Charles Montgomery Gray, Ph.D.
Gordon Maurice Jensen, Ph.D.
Richard Lee Schoenwald, Ph.D.
William Theodore Krasnow, A.B.

SCHOOL OF INDUSTRIAL MANAGEMENT

(Including the Undergraduate Course in Business and Engineering Administration)

Edward Pennell Brooks, S.B.
Professor of Industrial Management; Dean

Eli Shapiro, Ph.D.
Professor of Finance; Associate Dean

Erwin Haskell Schell, S.B.
Professor of Industrial Management, Emeritus, Lecturer

Douglass Vincent Brown, Ph.D.
Alfred P. Sloan Professor of Industrial Management

Douglas Murray McGregor, Ph.D., LL.D.
Professor of Industrial Management

Elting Elmore Morison, A.M.
Professor of Industrial History

Billy Earl Goetz, Ph.D.
Professor of Industrial Management

Houlder Hudgins, B.A.
Professor of Industrial Management

Sidney Stuart Alexander, Ph.D.
Professor of Industrial Management

Jay Wright Forrester, D.Eng.
Professor of Industrial Management

Ross MacDuffee Cunningham, D.C.S.
Associate Professor of Marketing

Gerald Bruce Tallman, Ph.D.
Associate Professor of Marketing

Thomas Mason Hill, A.B., M.B.A.
Associate Professor of Industrial Management

William Van Alan Clark, Jr., B.A., S.M.
Associate Professor of Industrial Management

David Durand, Ph.D.
Associate Professor of Industrial Management

Myron Jules Gordon, Ph.D.
Associate Professor of Industrial Management

Howard Wesley Johnson, M.A.
Associate Professor of Industrial Management
Director, Executive Development Programs

Marvin E. Shaw
Associate Professor of Industrial Management

Thomson McLintock Whitin, Ph.D. (*Absent*)
Associate Professor of Industrial Management

Herbert Franklin Goodwin, S.B.
Assistant Professor of Industrial Management

Leo Benjamin Moore, S.M.
Assistant Professor of Industrial Management

Robert Barclay Fetter, D.C.S.
Assistant Professor of Industrial Management

Robert Henry Gregory, Ph.D.
Assistant Professor of Industrial Management

Edward Harry Bowman, Ph.D.
Assistant Professor of Industrial Management

Andrew Barrie Jack, M.A.
Assistant Professor of Marketing

Albert Harold Rubenstein, Ph.D.
Assistant Professor of Industrial Management

Gregory Chi-Chong Chow, Ph.D.
Assistant Professor of Industrial Management

Ingo Ingenohl, Ph.D.
Assistant Professor of Industrial Management

Peter Savois King, B.S., M.B.A.
Assistant Professor of Marketing

Edwin Kuh, Ph.D.
Assistant Professor of Finance

William Louis Letwin, Ph.D.
Assistant Professor of Industrial History

Richard Blaise Maffei, Ph.D.
Assistant Professor of Industrial Management

Warren Stanley Torgerson, Ph.D.
Assistant Professor of Industrial Management

John Lawrence Enos, S.B., M.A.
Assistant Professor of Marketing

Gordon Shillinglaw, Ph.D.
Assistant Professor of Industrial Management

Floyd Eugene Gillis, Jr., M.A.
Assistant Professor of Industrial Management

Edgar Henry Schein, Ph.D.
Assistant Professor of Industrial Management

Edward Lindley Bowles, D.Sc.
Consulting Professor of Industrial Management

William A. Wallace Krebs, Jr., A.B., LL.B.
Visiting Associate Professor of Law

Lecturers

Donald Alvin Corbin, Ph.D.
Daniel Holland, Ph.D.

Stanley Martin Jacks, A.M., LL.B.
Stuart Macmillan, Ph.B., LL.B.
Bernard J. Muller-Thym, Ph.D., LL.D.

Mason Smith, B.S., M.B.A.
Erlind Hjalmar Thorsteinson

Instructors

William Beranek, B.S., M.B.A.

Earl Scott Nielsen, A.B., M.B.A.
Zenon Soteriou Zannetos, S.M.

Harvey Maurice Wacner, M.S.

Administrative Assistant
Theodore Mark Alfred, M.B.A.

MATHEMATICS

WILLIAM TED MARTIN, PH.D.
Professor of Mathematics; in charge of the Department

GEORGE BRINTON THOMAS, JR., PH.D. (*Absent*)
Associate Professor of Mathematics; Executive Officer

NORBERT WIENER, PH.D., SC.D.
Professor of Mathematics

PHILIP FRANKLIN, PH.D.
Professor of Mathematics

RAYMOND DONALD DOUGLASS, PH.D., SC.D.
Professor of Mathematics

DIRK JAN STRUIK, PH.D. (*Absent*)
Professor of Mathematics

WITOLD HUREWICZ, PH.D.
Professor of Mathematics

NORMAN LEVINSON, SC.D.
Professor of Mathematics

ERIC REISSNER, DR. ING., PH.D.
Professor of Mathematics

CHIA-CHIAO LIN, PH.D.
Professor of Mathematics

JOAQUIN B. DIAZ, PH.D.
Professor of Mathematics (Visiting)

STANISLAW MARCIN ULAM, PH.D.
Professor of Mathematics (Visiting)

PRESCOTT DURAND CROUT, PH.D.
Associate Professor of Mathematics

GEORGE PROCTOR WADSWORTH, PH.D.
Associate Professor of Mathematics

SAMUEL DEMITRY ZELDIN, PH.D.
Associate Professor of Mathematics

WARREN AMBROSE, PH.D.
Associate Professor of Mathematics

FRANCIS BEGNAUD HILDEBRAND, PH.D.
Associate Professor of Mathematics

GEORGE WILLIAM WHITEHEAD, PH.D.
Associate Professor of Mathematics

ALBERTO PEDRO CALDERON, PH.D.
Associate Professor of Mathematics

KENKICHI IWASAWA, DR.SCI.
Associate Professor of Mathematics

JOHN FORBES NASH, JR., PH.D. (*Absent*)
Assistant Professor of Mathematics

NESMITH CORNETT ANKENY, PH.D.
Assistant Professor of Mathematics

LOUIS NORBERG HOWARD, PH.D.
Assistant Professor of Mathematics

HARTLEY ROGERS, JR., PH.D.
Assistant Professor of Mathematics

ISADORE MANUAL SINGER, PH.D.
Assistant Professor of Mathematics

ROBERT ARTHUR CLARK, PH.D.
Assistant Professor of Mathematics (Visiting)

Lecturers

MICHEL ANDRE KERVAIRE, DR.SC.MATH. — KLAUS F. ROTH, PH.D. — J. T. STUART

Instructors

NOEL JUSTIN HICKS, B.S.
ROBERT RICHARD DINGLE KEMP, PH.D.
JAMES KENYON KNOWLES, S.B.
DONALD LESTER KREIDER, B.S.
ARTHUR PAUL MATTUCK, PH.D.
ALBERT LOUIS RABENSTEIN, JR., A.B., M.S.
WILLIAM FRANCIS REYNOLDS, PH.D.
WALTER LEWIS BAILY, JR., PH.D.
OMA VEIKKO HAMARA, B.A.
KENNETH MYRON HOFFMAN, PH.D.
WILLIAM BERNARD HOUSTON, JR., B.E.E.
REDMOND RICHARD O'BRIEN, S.M.
REESE TREGO PROSSER, PH.D.
LEONARD ROBERTS, PH.D.
ELIAS M. STEIN, PH.D.

Research Associate

MARCEL BERGER, SC.D. — RICHARD V. KADISON, PH.D.

MECHANICAL ENGINEERING

(Including Textile Technology and Engineering Graphics)

JACOB PIETER DEN HARTOG, PH.D.
Professor of Mechanical Engineering; in charge of the Department

JAMES HOLT, S.B.
Professor of Mechanical Engineering; Executive Officer

CHARLES FAYETTE TAYLOR, PH.B., M.E.
Professor of Automotive Engineering

EDWARD ROBINSON SCHWARZ, M.S.
Professor of Textile Technology; in charge of Textile Technology

CARL RICHARD SODERBERG, TEKN.D.
Professor of Mechanical Engineering; Dean of the School of Engineering

JOSEPH HENRY KEENAN, S.B.
Professor of Mechanical Engineering

JOHN ANTHONY HRONES, SC.D.
Professor of Mechanical Engineering

SAMUEL CORNETTE COLLINS, PH.D.
Professor of Mechanical Engineering

EGON OROWAN, D.ENG.
George Westinghouse Professor of Mechanical Engineering

ASCHER HERMAN SHAPIRO, SC.D.
Professor of Mechanical Engineering

MILTON CLAYTON SHAW, SC.D.
Professor of Mechanical Engineering

WILLIAM MACGREGOR MURRAY, SC.D.
Professor of Mechanical Engineering

JOSEPH KAYE, PH.D.
Professor of Mechanical Engineering

WARREN MAX ROHSENOW, D.ENG.
Professor of Mechanical Engineering

ARTHUR LAWRENCE TOWNSEND, S.B.
Associate Professor of Mechanical Engineering; Director of the Lowell Institute School.

CARL LOUIS SVENSON, S.M.
Associate Professor of Heat Engineering

ARCHIBALD WILLIAM ADKINS, A.B., S.B.
Associate Professor of Applied Mechanics

ALVIN SLOANE, B.S.
Associate Professor of Applied Mechanics; Assistant Secretary of the Faculty

AUGUSTUS RUDOLPH ROGOWSKI, S.M.
Associate Professor of Mechanical Engineering

DOUGLAS PAYNE ADAMS, S.B., A.M.
Associate Professor of Engineering Graphics

WILLIAM ALAN WILSON, B.S.
Associate Professor of Mechanical Engineering

JOHN EDWARD ARNOLD, A.B., S.M.
Associate Professor of Mechanical Engineering

STEPHEN HARRY CRANDALL, PH.D.
Associate Professor of Mechanical Engineering

PRESCOTT ARTHUR SMITH, S.B.
Associate Professor of Mechanical Engineering

AUGUST LUDWIG HESSELSCHWERDT, JR., S.M.
Associate Professor of Mechanical Engineering

BRANDON GARNER RIGHTMIRE, SC.D.
Associate Professor of Mechanical Engineering

NORMAN CHRISTIAN DAHL, SC.D.
Associate Professor of Mechanical Engineering

KENNETH ROBERT WADLEIGH, SC.D.
Associate Professor of Mechanical Engineering

STANLEY BACKER, SC.D.
Associate Professor of Mechanical Engineering

JAMES ALAN FAY, PH.D.
Associate Professor of Mechanical Engineering

FRANK AMBROSE MCCLINTOCK, PH.D.
Associate Professor of Mechanical Engineering

MAURICE EDWIN SHANK, SC.D.
Associate Professor of Mechanical Engineering

TAU-YI TOONG, SC.D.
Associate Professor of Mechanical Engineering

JAMES BIGELOW RESWICK, SC.D.
Associate Professor of Mechanical Engineering

WALTER CARL EBERHARD, S.B.
Assistant Professor of Engineering Graphics

DEANE LENT, A.B.
Assistant Professor of Engineering Drawing

GERALD PUTNAM, S.B.
Assistant Professor of Engineering Graphics

HENRY MARTYN PAYNTER, SC.D.
Assistant Professor of Mechanical Engineering

JOHN ALDEN CLARK, SC.D.
Assistant Professor of Mechanical Engineering

STEVEN ANSON COONS
Assistant Professor of Engineering Graphics

JESSE LOWEN SHEARER, SC.D. (*Absent*)
Assistant Professor of Mechanical Engineering

SHIH-YING LEE, SC.D.
Assistant Professor of Mechanical Engineering

JACK BARTLEY CHADDOCK, SC.D.
Assistant Professor of Mechanical Engineering

NATHAN HENRY COOK, SC.D.
Assistant Professor of Mechanical Engineering

ROBERT WELLESLEY MANN, S.M.
Assistant Professor of Mechanical Engineering

THOMAS PAUL RONA, SC.D.
Assistant Professor of Mechanical Engineering

THOMAS PATON GOODMAN, SC.D. (*Absent*)
Assistant Professor of Mechanical Engineering

ALAN HUGH STENNING, SC.D.
Assistant Professor of Mechanical Engineering

ERNEST RABINOWICZ, PH.D.
Assistant Professor of Mechanical Engineering

HENRY MERRIAM MORGAN, S.M.
Assistant Professor of Mechanical Engineering

JOHN FREDERICK TWIGG, B.S., M.A.
Assistant Professor of Engineering Graphics

EARLE HUNT WATTS, B.S.
Assistant Professor of Engineering Graphics

GEORGE ARTHUR BROWN, S.M.
Assistant Professor of Mechanical Engineering

ALVE JOHN ERICKSON, MECH.E. (*Absent*)
Assistant Professor of Mechanical Engineering

FREDDIE DAVID EZEKIEL, SC.D.
Assistant Professor of Mechanical Engineering

MIGUEL ANGEL SANTALO, MECH.E.
Assistant Professor of Mechanical Engineering

GEORGE NICKOLAS HATSOPOULOS, SC.D.
Assistant Professor of Mechanical Engineering

ROBERT RAYMOND ARCHER, PH.D.
Assistant Professor of Mechanical Engineering

J. PERRY BARGER, MECH.E.
Assistant Professor of Mechanical Engineering

PETER GRIFFITH, SC.D.
Assistant Professor of Mechanical Engineering

RICHARD JOSEPH NICKERSON, S.M.
Assistant Professor of Mechanical Engineering

GEORGE SHERIDAN REICHENBACH, SC.D.
Assistant Professor of Mechanical Engineering

JOHN H. HORLOCK, PH.D.
Assistant Professor of Mechanical Engineering (Visiting)

Lecturer

VICTOR EZRA HOWES, B.S.

Instructors

WILLIAM HENRY QUICK, MECH.E.
JOSHUA ELIHU NEIMARK, S.M.
CHARLES KOJABASHIAN, S.M.
JOHN ALLEN MEYER, S.M.
KARL FRITZ MYSLIWETZ, DIPL. ING.
MARSBED HABLANIAN, S.B.
PETER DANIEL HANSEN, M.S.
STEPHEN ROSS MONTGOMERY, B.A., S.M.
WARREN GEORGE NELSON, S.M.
THOMAS BROWN SHERIDAN, M.S.
JOHN ANDREW WELSH, S.B.
JEROME CATZ, S.M.
NILS BERTIL COLDING, TEKN. LIC.
S. WILLIAM GOUSE, S.M.
JOSEPH LECONTE SMITH, JR., M.S.

Technical Instructors

RALPH JOHN BOWLEY
CLARENCE WILLIAM CHRISTIANSEN
FREDERICK HAROLD ANDERSON
JOHN LEACH
EVANS GRAVES ARNOLD

Research Associates

JOHN FRANCIS BLACKBURN, PH.D.
PETER FEDOROVICH GRISHIN, M.SC.
PER GOSTA NORDHAMMAR, M.SC.
YASUTOSHI SENGO, DR. ENG.

MEDICAL DEPARTMENT

JAMES MORISON FAULKNER, M.D.
Professor; Medical Director; in charge of the Department

JOHN WINSLOW CHAMBERLAIN, M.D.
Surgeon; Associate Medical Director

HARRIET LOUISE HARDY, M.D. *Assistant Medical Director; in charge of Occupational Medical Service*

HAROLD ARTHUR CARNES, D.M.D.
Director of Dental Service

MURRAY PHILIP HORWOOD, PH.D.
Professor of Sanitary Science; Director of Sanitation

ROBERT FREDERICK TILLEY, M.D. *Dermatologist*
ROBERT JAMES HERM, M.D. *Ophthalmologist*
THORNTON BROWN, M.D. *Orthopedic Surgeon*
LYMAN GILDER RICHARDS, M.D. *Otolaryngologist*
JAMES HOWARD MEANS, M.D. *Physician*
SAMUEL DRURY CLARK, M.D. *Physician*
LEMOYNE WHITE, M.D. *Psychiatrist*
HERBERT IGNATIUS HARRIS, M.D. *Psychiatrist*
STANLEY COBB, M.D., D.SC. *Psychiatrist*
EDWIN MUNCKS COLE, M.D. *Neurologist and Psychiatrist*
GEORGE WHITE, M.D. *Radiologist*
ALBERT CHARLES ENGLAND, JR., M.D. *Associate Physician*
GILMAN WARD HAVEN, D.D.S.
Assistant Director of Dental Service
OWEN WILLIAM KITE, D.M.D. *Assistant Dentist*
CHARLES VINCENT TREAT, M.D. *Assistant Physician*
CLINTON HARRY BAGENSTOSE, M.D. *Assistant Psychiatrist*
ANNE ROSE O'DONNELL, M.D. *Assistant Radiologist*
GLENN EWING BEHRINGER, M.D. *Assistant Surgeon*
MARTIN JOHN BELLINGER, M.D. *Assistant Surgeon*
GEORGE T. BOTTOMLEY, M.D. *Assistant Surgeon*
EDWARD GERALD CAREY, M.D. *Assistant Surgeon*
JAMES MICHAEL DOONAN, M.D. *Assistant Surgeon*
JOHN LORING ROWBOTHAM, M.D. *Assistant Surgeon*
IRVING ROBERT GELTMAN, S.B. *Clinical Radiologist*
MARTIN LUBIN, M.D. *Consultant in Biophysics*
SAMUEL LEVIN, S.B. *Radiological Safety Officer*
JANET ELIZABETH WALKLEY, B.S. *Industrial Hygiene Chemist*
FREDERICK JAMES VILES, JR., S.M. *Industrial Hygiene Engineer*
CONSTANTINE JOHN MALETSKOS, PH.D.
Radiation Biophysicist; Reactor Protection Officer
THOMAS KELITA WILKINSON, M.S.
Industrial Hygiene and Safety Officer, Lincoln Laboratory

METALLURGY

(Including Mineral Engineering and Ceramics)

JOHN CHIPMAN, PH.D., SC.D.
Professor of Metallurgy; in charge of the Department

ANTOINE MARC GAUDIN, SC.D.
Richards Professor of Mineral Engineering

JOHN TORREY NORTON, SC.D.
Professor of the Physics of Metals; Chairman of the Faculty

FREDERICK HARWOOD NORTON, SC.D.
Professor of Ceramics

MORRIS COHEN, SC.D.
Professor of Physical Metallurgy

JOHN WULFF, D.SC.
Professor of Metallurgy

CARL FREDERICK FLOE, SC.D.
Professor of Metallurgy; Assistant Provost

CARL WILHELM WAGNER, PH.D.
Professor of Metallurgy

HOWARD FLOYD TAYLOR, M.S.
American Brake Shoe Company Professor of Foundry Metallurgy

HERBERT HENRY UHLIG, PH.D.
Professor of Metallurgy

MICHAEL BERLINER BEVER, DR. IUR., SC.D.
Professor of Metallurgy

NICHOLAS JOHN GRANT, SC.D.
Professor of Metallurgy

ALBERT RUDOLPH KAUFMANN, SC.D.
Associate Professor of Metallurgy

BENJAMIN LEWIS AVERBACH, SC.D.
Associate Professor of Metallurgy

JOHN FRANK ELLIOTT, SC.D.
Associate Professor of Metallurgy

PHILIP LOUIS DE BRUYN, SC.D.
Associate Professor of Mineral Engineering

WILLIAM DAVID KINGERY, SC.D.
Associate Professor of Ceramics

WALTER ALAN BACKOFEN, SC.D.
Assistant Professor of Metallurgy

CLYDE MELVIN ADAMS, JR., SC.D.
Assistant Professor of Metallurgy

THOMAS BURNESS KING, PH.D.
Assistant Professor of Metallurgy

GEORGE ECONOMOS, SC.D.
Assistant Professor of Metallurgy

ROBERT EDWARD OGILVIE, SC.D.
Assistant Professor of Metallurgy

CHARLES CORL REYNOLDS, S.M.
Assistant Professor of Metallurgy

MERTON CORSON FLEMINGS, JR., SC.D.
Assistant Professor of Metallurgy

ROBERT AMOS HARD, S.M.
Assistant Professor of Metallurgy

ROBERT L. FLEISCHER, PH.D.
Assistant Professor of Metallurgy

Lecturers

JOHN CROCKER FISHER, 3D, SC.D.

DONALD JAMES REESE, B.S.

Instructors

HENRY STEPHEN SPACIL, S.M.
WILLIAM GORDON MOFFAT, S.B.
GERRIT TERTIUS VAN ROOYEN, S.M.
GORDON ARTHUR BRUGGEMAN, S.B.
VINCENT PAUL SIUTA, B.MET.E.
JAMES HERBERT BROWN, S.M.
GEORGE ALBERT PARKS, M.S.

Technical Instructors

PAUL FREDERICK HUGHES

WALTER ROLAND JOHNSON

Research Associates

ARUP RATAN CHAUDHURI, PH.D.
HAKZE CHON, D.SC.
BRIAN GALE, SC.D.
CHARLES ROBERT KURKJIAN, SC.D.
NOBUHISA UJIIYE, D.ENG.

INSTRUCTING STAFF

METEOROLOGY

HENRY GARRETT HOUGHTON, Sc.D.
Professor of Meteorology; in charge of the Department

HURD CURTIS WILLETT, PH.D.
Professor of Meteorology

JULE GREGORY CHARNEY, PH.D.
Professor of Meteorology

VICTOR PAUL STARR, PH.D.
Professor of Meteorology

JAMES MURDOCH AUSTIN, Sc.D.
Associate Professor of Meteorology

DELBAR POULEUR KEILY, S.B.
Associate Professor of Meteorology

EDWARD NORTON LORENZ, Sc.D.
Associate Professor of Meteorology

MORTON GAITHER WURTELE, PH.D.
Assistant Professor of Meteorology

FREDERICK SANDERS, Sc.D.
Assistant Professor of Meteorology

Lecturer
HEINZ HELMUT LETTAU, PH.D.

Technical Instructor
ETHAN ALLEN MURPHY

Research Associates
PAULINE MORROW AUSTIN, PH.D.
ALAN COGSWELL BEMIS, A.B., S.M.
NOBUHIKO KODAIRA, B.A.
SEIICHI MATSUMOTO, S.M.
NORMAN ALTON PHILLIPS, PH.D.

MILITARY SCIENCE

CHARLES MOSES MCAFEE, JR., M.S., Colonel, Corps of Engineers
Professor of Military Science and Tactics; in charge of the Department

JOSEPH SHIELDS BRINKLEY, JR., B.S.
Lieutenant Colonel, Chemical Corps
Associate Professor of Military Science and Tactics

DONALD STANLEY BOWMAN, B.S.
Lieutenant Colonel, Signal Corps
Associate Professor of Military Science and Tactics

WILLIAM JOSEPH KEATING, A.B., Major, Quartermaster Corps
Associate Professor of Military Science and Tactics

VERNON EVERETT ROBBINS, B.S., Major, Signal Corps
Associate Professor of Military Science and Tactics

WARREN ROGERS, M.S., Major, Corps of Engineers
Associate Professor of Military Science and Tactics

FOREST SHERWOOD GIBSON, B.S., Captain, Ordnance Corps
Assistant Professor of Military Science and Tactics

MAX NICHOLS RUHL, B.I.E., Captain, Corps of Engineers
Assistant Professor of Military Science and Tactics

PETER EUGEN HEXNER, A.B.
First Lieutenant, Chemical Corps
Assistant Professor of Military Science and Tactics

Bandleader
FREDERICK AUGUSTUS HARRIS, JR., B.MUS., ED.M.
Major, Infantry, Retired

Instructors
WARD BEECHER CARROLL, Master Sergeant, U. S. Army
GEORGE DAVID CRAWFORD, Master Sergeant, U. S. Army
LEO FRANCIS MCAULIFFE, JR., Sergeant, U. S. Army
ROY EATON MCGRAW, Master Sergeant, U. S. Army
ROBERT HOWARD MATTSON, Master Sergeant, U. S. Army
RICHARD WHITE KELLEY, Master Sergeant, U. S. Army
CHARLES WILLARD INGALLS, Master Sergeant, U. S. Army
GILBERT EWING TOMLINSON, B.S., Master Sergeant, U. S. Army
BEN H. BERMAN, Sergeant, U. S. Army
HARRY J. COLLIER, Sergeant, U. S. Army

Administrative Assistant
WILBUR LINCOLN DODGE, Master Sergeant, U. S. Army

MODERN LANGUAGES

WILLIAM NASH LOCKE, PH.D.
Professor of Modern Languages; in charge of the Department

WILLIAM FILBERT BOTTIGLIA, PH.D.
Associate Professor of Modern Languages

MORRIS HALLE, PH.D.
Associate Professor of Modern Languages

RICHARD FELIX KOCH, A.M.
Assistant Professor of Modern Languages

GEORGE ALEXANDROVICH ZNAMENSKY, B.D., ED.M.
Assistant Professor of Russian, Emeritus; Lecturer

VICTOR HUSE YNGVE, PH.D.
Assistant Professor of Modern Languages

AVRAM NOAM CHOMSKY, PH.D.
Assistant Professor of Modern Languages

JOSEPH ROY APPLEGATE, PH.D.
Assistant Professor of Modern Languages

MARTIN DYCK, PH.D.
Assistant Professor of Modern Languages

Lecturers
HERMAN KLUGMAN, PH.D.
PIERRE PIGUET, LIC. ES LETTRES

Instructor
STELLA B. GREENFIELD, M.A.

NAVAL ARCHITECTURE AND MARINE ENGINEERING

LAURENS TROOST, IR.
Professor of Naval Architecture; in charge of the Department

FRANK MENDELL LEWIS
Professor of Marine Engineering

GEORGE CHARLES MANNING, Sc.D.
Professor of Naval Architecture

JACK ARTHUR OBERMEYER, S.M., Captain, U.S.N.
Professor of Naval Architecture

EVERS BURTNER, S.B.
Associate Professor of Naval Architecture and Marine Engineering

JOHN HARVEY EVANS, B.ENG.
Associate Professor of Naval Architecture

SHANNON CURTIS POWELL, DOTT.ING.
Associate Professor of Marine Engineering

MARTIN AARON ABKOWITZ, PH.D.
Associate Professor of Naval Architecture

JOE WARREN THORNBURY, S.M., Lieutenant Commander, U.S.N.
Associate Professor of Naval Architecture

AMELIO MILO D'ARCANGELO, S.M.
Assistant Professor of Naval Architecture

ELMER EUGENE ALLMENDINGER, S.M.
Assistant Professor of Naval Architecture

PHYSICS

NATHANIEL HERMAN FRANK, Sc.D.
Professor of Physics; in charge of the Department

GEORGE GRAHAM HARVEY, PH.D.
Associate Professor of Physics; Executive Officer; Associate Director of Research Laboratory of Electronics

GEORGE RUSSELL HARRISON, PH.D., D.Sc., LL.D., D.ENG.
Professor of Physics; Dean of the School of Science

JOHN CLARKE SLATER, PH.D., Sc.D.
Institute Professor: Harry B. Higgins Professor of the Solid State

ARTHUR COBB HARDY, Sc.D.
Professor of Optics and Photography

PHILIP MCCORD MORSE, PH.D., Sc.D.
Professor of Physics; Director of Computation Center

BERTRAM EUGENE WARREN, Sc.D.
Professor of Physics

HANS MUELLER, D.Sc.
Professor of Physics

WAYNE BUCKLES NOTTINGHAM, PH.D.
Professor of Physics

FRANCIS WESTON SEARS, S. M. (*Absent*)
Professor of Physics

ROBLEY DUNGLISON EVANS, PH.D.
Professor of Physics

JERROLD REINACH ZACHARIAS, PH.D.
Professor of Physics; Chairman of Directing Committee, Laboratory for Nuclear Science

BRUNO BENEDETTO ROSSI, PH.D.
Professor of Physics

VICTOR FREDERICK WEISSKOPF, PH.D.
Professor of Physics

ALBERT GORDON HILL, PH.D. (*Absent*)
Professor of Physics

WILLIAM PHELPS ALLIS, Sc.D.
Professor of Physics

FRANCIS BITTER, PH.D.
Professor of Physics

MARTIN DEUTSCH, PH.D.
Professor of Physics

MILTON STANLEY LIVINGSTON, PH.D.
Professor of Physics

HERMAN FESHBACH, PH.D.
Professor of Physics

WILLIAM WEBER BUECHNER, PH.D., Sc.D.
Professor of Physics

CLIFFORD GLENWOOD SHULL, PH.D.
Professor of Physics

ROBERT JEMISON VAN DE GRAAFF, PH.D., D.Sc.
Associate Professor of Physics

CLARK GOODMAN, PH.D. (*Absent*)
Associate Professor of Physics

LASZLO TISZA, PH.D.
Associate Professor of Physics

SANBORN CONNER BROWN, PH.D.
Associate Professor of Physics

GEORGE EDWARD VALLEY, JR., PH.D.
Associate Professor of Physics; Associate Director of Lincoln Laboratory

BERNARD TAUB FELD, PH.D.
Associate Professor of Physics

DAVID HENRY FRISCH, PH.D.
Associate Professor of Physics

MALCOM WOODROW PERSHING STRANDBERG, PH.D.
Associate Professor of Physics

FRANCIS LEE FRIEDMAN, PH.D.
Associate Professor of Physics

ROBERT WALTER WILLIAMS, PH.D.
Associate Professor of Physics

FELIX MARC HERMAN VILLARS, D.Sc. (*Absent*)
Associate Professor of Physics

KARL UNO INGARD, PH.D.
Associate Professor of Physics

FRANCIS EUGENE LOW, PH.D.
Associate Professor of Physics (Visiting)

WILLIAM LESTER KRAUSHAAR, PH.D.
Assistant Professor of Physics

LEE CARRINGTON BRADLEY, III, D.PHIL.
Assistant Professor of Physics

GEORGE WHIPPLE CLARK, PH.D.
Assistant Professor of Physics

JOHN GORDON KING, PH.D.
Assistant Professor of Physics

GEORGE FRED KOSTER, PH.D.
Assistant Professor of Physics

DAVID ORVILLE CALDWELL, PH.D.
Assistant Professor of Physics

HARALD ANTON ENGE, PH.D.
Assistant Professor of Physics

MARVIN HAROLD FRIEDMAN, PH.D.
Assistant Professor of Physics

URI HABER-SCHAIM, PH.D.
Assistant Professor of Physics

ARTHUR KENT KERMAN, PH.D.
Assistant Professor of Physics

JOHN DAVID LINSLEY, PH.D.
Assistant Professor of Physics

WALTER EDWARD THIRRING, PH.D.
Assistant Professor of Physics (Visiting)

ROY WEINSTEIN, PH.D.
Assistant Professor of Physics

INSTRUCTING STAFF

Instructors

Robert Arvel Schluter, Ph.D.
Rolf Paul Scharenberg, Ph.D.
Nathan Sanders Wall, Ph.D.
Irwin Abraham Pless, Ph.D.
David M. Brink, Ph.D.
Norman Carl Rasmussen, Ph.D.
William Merrill Whitney, Ph.D.

Research Associates

Cornelius Payne Browne, Ph.D.
Robert Augur Dudley, Ph.D.
Theodor Friedrich Hueter, Ph.D.
Yahiko Yamada, B.Eng.

ENGINEERING PRACTICE SCHOOL STATION AT OAK RIDGE

Thomas William Mix, S.M.
Assistant Professor of Chemical Engineering; Director

Dennis Wyckoff Vroom, B.M.E. *Assistant Director*

STAFF OF THE INSTITUTE LIBRARY

William Nash Locke, Ph.D.
Director of Libraries

Natalie Neill Nicholson, S.B.
Executive Assistant to Director of Libraries

Cecile Barsky, S.B.

Eleanor Louise Bartlett

Eleanor Canty, B.A.

Marguerite Chamberlain, A.B., S.B.

Barbara Clark Darling, A.B.

Margaret Morris de LeVin, S.B., M.A.
George Eugene Halpern, M.A.
Ann-Marie Hartmere, A.B., M.S.
Jessie Elizabeth Howes, A.B., S.B.
Irma Yarbrough Johnson, S.B., M.A.
Eileen Ruth Kibrick, B.S., A.M.
Barbara Klingenhagen, A.B.
Muriel Josephine Lewis, A.B., S.B.
Pearl Gloria Lewis, B.A., M.S.
Margaret Fraser Little, M.A.

Ralph Reginald McNay, B.E., A.B.
Gladys Ramsey Neary, A.B., S.B.
Gertrude Perry
Burton Aldrich Robie, M.A., S.M.
Caroline Shillaber, A.B., S.B.
Louise Trainor
Hildegarde Ziegler, A.B., S.B.
Ruth McGlashan Lane, B.A., S.B., Ed.M. (*Emeritus*)
Mirian Sprague Smith, S.B. (*Emeritus*)

STAFF OF THE MUSEUMS

Herbert Lynes Beckwith, M.Arch.
Director of Exhibits

Howard Russell Bartlett, B.S., A.M.
Chairman of the Committee on the Technology Museum

INTERDEPARTMENTAL LABORATORIES

ACOUSTICS

Richard Henry Bolt, Ph.D., *Director*

SPECTROSCOPY

Richard Collins Lord, Ph.D., *Director*

ELECTRONICS

Jerome Bert Wiesner, Ph.D., *Director*
George Graham Harvey, Ph.D., *Associate Director*
Henry Joseph Zimmerman n, S.M., *Associate Director*

COMPUTATION CENTER

Philip McCord Morse, Ph.D., Sc.D., *Director*

NUCLEAR SCIENCE

Jerrold Reinach Zacharias, Ph.D., *Chairman of Directing Committee*

Peter Theodore Demos, Ph.D., *Associate Director*

CENTER FOR INTERNATIONAL STUDIES

Max Franklin Millikan, Ph.D.
Professor of Economics; Director

Everett Einar Hagen, Ph.D.
Visiting Professor of Economics

Benjamin Howard Higgins, Ph.D.
Visiting Professor of Economics

Daniel Lerner, Ph.D.
Visiting Professor of Sociology

Wilfred Malenbaum, Ph.D.
Visiting Professor of Economics

Ithiel de Sola Pool, Ph.D.
Associate Professor of Political Science

Paul Rosenstein-Rodan, Ph.D.
Visiting Professor of Economics

Walt Whitman Rostow, Ph.D.
Professor of History

Research Associates

Francis Michel Bator, S.B.
James Eliot Cross, LL.B.
Richard Samuel Eckaus, Ph.D.
David B. Gleicher, Ph.D.
Harold Robert Isaacs, A.B.
Helen Boyden Lamb, Ph.D.
Howard Victor Perlmutter, Ph.D.
Hans Pilhofer, A.B., M.S.
George Rosen, Ph.D.

ATHLETIC STAFF

Richard Loring Balch, M.A.
Director of Athletics

Robert MacMillan Whitelaw, B.S., M.Ed.
Assistant to Director of Athletics; Director of Physical Education

Arne Urbane Arneson, B.S.
Soccer and Assistant Track Coach

Charles Batterman, B.S., M.A.
Freshman Swimming, Diving, and Freshman Lacrosse Coach

John Homer Burke, B.S.
Freshman Basketball and Baseball Coach

Edward Crocker, B.S.
Squash and Tennis Coach

Frank Sands DuBois, A.B.
Freshman Crew Coach

Oscar Frederick Hedlund
Track Coach

James Lester
Physiotherapist and Trainer

James Burge McMillin, B.S.
Crew Coach

Benjamin Robinson Martin, B.S.
Hockey, Lacrosse and Freshman Soccer Coach

Gerald Melville Reed
Assistant Sailing Master

Gordon Harding Smith
Swimming Coach

Walter Cromwell Wood
Sailing Master

RESIDENT STAFF OF THE ALUMNI ASSOCIATION

Harold Edward Lobdell
Executive Vice-President

Donald Porter Severance, S.M.
Secretary and Treasurer

Madeline Ruth McCormick
Assistant Treasurer

Beverly Dudley, M.Sc.
Editor, "The Technology Review"

Ralph Theodore Jope, S.B.
Business Manager, "The Technology Review"

Henry Bugbee Kane, S.B.
Director, Alumni Fund

Joseph Edward Conrad, B.S.
Regional Director of Alumni Fund

FACULTY AND ADMINISTRATIVE OFFICERS EMERITI

AERONAUTICAL ENGINEERING

Jerome Clarke Hunsaker, Sc.D., Eng.D.
Professor of Aeronautical Engineering, Emeritus; Lecturer

ARCHITECTURE

William Emerson, D.A.
Professor of Architecture, Emeritus

William Henry Lawrence, S.B.
Professor of Architectural Engineering, Emeritus

Henry Latimer Seaver, A.M.
Professor of History, Emeritus

Walter Roy MacCornack, Sc.D.
Professor of Architecture, Emeritus

BIOLOGY

Samuel Cate Prescott, Sc.D.
Professor of Industrial Biology, Emeritus

Clair Elsmere Turner, Dr.P.H., Sc.D.
Professor of Public Health, Emeritus

CHEMICAL ENGINEERING

Warren Kendall Lewis, Ph.D., D.Sc., D.Eng.
Professor of Chemical Engineering, Emeritus

CHEMISTRY

Willis Rodney Whitney, Ph.D., Sc.D., Ch.D.
Professor of Chemical Research, Emeritus

Frederick George Keyes, Ph.D., Sc.D.
Professor of Physical Chemistry, Emeritus

Miles Standish Sherrill, Ph.D.
Professor of Physical Chemistry, Emeritus

Earl Bowman Millard, Ph.D.
Professor of Physical Chemistry, Emeritus

Alpheus Grant Woodman, S.B.
Associate Professor of Analytical Chemistry, Emeritus

William Thomas Hall, S.B.
Associate Professor of Analytical Chemistry, Emeritus

Ralph Chillingworth Young, Ph.D.
Associate Professor of Inorganic Chemistry, Emeritus; Lecturer

Gerhard Dietrichson, Ph.D.
Associate Professor of Physical Chemistry, Emeritus

CIVIL AND SANITARY ENGINEERING

Charles Milton Spofford, S.B.
Hayward Professor of Civil Engineering, Emeritus

Charles Blaney Breed, S.B.
Professor of Civil Engineering, Emeritus

John Brazer Babcock, 3d, S.B.
Professor of Railway Engineering, Emeritus; Lecturer

Walter Charles Voss, S.M.
Professor of Building Construction, Emeritus; Lecturer

ECONOMICS AND SOCIAL SCIENCE

Floyd Elmer Armstrong, LL.D.
Professor of Economics and Finance, Emeritus

Donald Skeele Tucker, Ph.D.
Professor of Economics, Emeritus

ELECTRICAL ENGINEERING

RALPH RESTIEAUX LAWRENCE, S.B.
Professor of Electrical Machinery, Emeritus

WILLIAM HENRY TIMBIE, A.B.
Professor of Electrical Engineering and Industrial Practice, Emeritus

HERBERT BRISTOL DWIGHT, D.Sc.
Professor of Electrical Machinery, Emeritus

WALDO VINTON LYON, S.B.
Professor of Electrical Machinery, Emeritus

RALPH GORTON HUDSON, S.B.
Professor of Electrical Engineering, Emeritus

RICHARD DUDLEY FAY, A.B., S.B.
Associate Professor of Electrical Communications, Emeritus; Lecturer

LYMAN MINER DAWES, S.B.
Assistant Professor of Industrial Applications, Emeritus

GEOLOGY AND GEOPHYSICS

HERVEY WOODBURN SHIMER, PH.D., SC.D.
Professor of Paleontology, Emeritus

FREDERICK KUHNE MORRIS, PH.D.
Professor of Geology, Emeritus

WARREN JUDSON MEAD, PH.D.
Professor of Geology, Emeritus

HUMANITIES

ARCHER TYLER ROBINSON, A.M. *Professor of English, Emeritus*

MATTHEW RICHARD COPITHORNE, A.B.
Associate Professor of English, Emeritus

SCHOOL OF INDUSTRIAL MANAGEMENT

ERWIN HASKELL SCHELL, S.B.
Professor of Industrial Management, Emeritus; Lecturer

CHARLES HUNTINGTON PORTER, A.B., S.B.
Professor of Accounting, Emeritus

MATHEMATICS

HENRY BAYARD PHILLIPS, PH.D., LL.D.
Professor of Mathematics, Emeritus

FRANK LAUREN HITCHCOCK, PH.D.
Professor of Mathematics, Emeritus

MECHANICAL ENGINEERING

CHARLES EDWARD FULLER, S.B.
Professor of Theoretical and Applied Mechanics, Emeritus

CHARLES WILLIAM BERRY, S.B.
Professor of Heat Engineering, Emeritus

JOSEPH CAINS RILEY, S.B.
Professor of Heat Engineering, Emeritus

GEORGE WRIGHT SWETT, S.B.
Professor of Machine Design, Emeritus

EARLE BUCKINGHAM
Professor of Mechanical Engineering, Emeritus

GORDON BALL WILKES, S.B.
Professor of Heat Engineering, Emeritus

THEODORE HOWARD TAFT, S.B.
Associate Professor of Heat Engineering, Emeritus

LAWRENCE SOUTHWICK SMITH, S.B
Associate Professor of Applied Mechanics, Emeritus

WALTER HERMAN JAMES, S.B.
Associate Professor of Mechanical Engineering, Emeritus

ARTHUR LINDSAY GOODRICH, S.B.
Associate Professor of Drawing and Descriptive Geometry, Emeritus

IRVING HENRY COWDREY, S.B.
Associate Professor of Testing Materials, Emeritus

JOHN MOYES LESSELLS, B.Sc.
Associate Professor of Mechanical Engineering, Emeritus

ROY GIBSON BURNHAM, S.B.
Assistant Professor of Drawing and Descriptive Geometry, Emeritus

METALLURGY

ROBERT SEATON WILLIAMS, PH.D.
Professor of Physical Metallurgy, Emeritus

MAURICE DEKAY THOMPSON, PH.D.
Professor of Electrochemistry, Emeritus

CARLE REED HAYWARD, S.B.
Professor of Process Metallurgy, Emeritus

VICTOR OLIVER HOMERBERG, SC.D.
Professor of Physical Metallurgy, Emeritus

MODERN LANGUAGES

GEORGE ALEXANDROVICH ZNAMENSKY, B.D., ED.M.
Assistant Professor of Russian, Emeritus; Lecturer

NAVAL ARCHITECTURE AND MARINE ENGINEERING

GEORGE OWEN, S.B.
Professor of Naval Architecture, Emeritus

HENRY EASTIN ROSSELL, S.M.
Professor of Naval Construction, Emeritus

LAWRENCE BOYLSTON CHAPMAN, S.B.
Professor of Marine Transportation and Marine Engineering, Emeritus

ADMINISTRATION

JAMES LIBBY TYSON, B.D., LL.B., PH.D.
Professor Emeritus

GEORGE W. MORSE, M.D.
Medical Director, Emeritus

WILLIAM NATHANAEL SEAVER, A.B.
Librarian, Emeritus

ROBERT GRANVILLE CALDWELL, PH.D., D.LITT.
Dean of Humanities, Emeritus

HORACE SAYFORD FORD, LL.D.
Treasurer Emeritus

JOHN WYMOND MILLER BUNKER, PH.D., SC.D.
Dean of the Graduate School, Emeritus; Special Adviser to the President

JOSEPH CHRISMAN MACKINNON, S.B.
Registrar, Emeritus; Special Adviser to Director of Physical Plant

DELBERT LEON RHIND
Assistant Treasurer, Emeritus

FACULTY COMMITTEES, 1956–57

ACADEMIC REGULATIONS

Assistant Secretary* (*Chairman*)
Secretary*
Dean of Students*
Director of Student Aid*
Registrar*

	Term Expires
K. L. Wildes	1957
J. Kaye	1958
M. B. Bever	1959
L. S. Bryant†	

ADMISSIONS

	Term Expires
H. Ashley (*Chairman*)	1957
Director of Admissions*	
Director of Student Aid*	
Registrar*	
A. S. Michaels	1957
F. B. Hildebrand	1958
A. Kusko	1958
H. P. Aldrich, Jr.	1959
D. P. Shoemaker	1959
K. R. Wadleigh†	

DISCIPLINE

	Term Expires
R. W. Williams (*Chairman*)	1957
Dean of Students*	
R. C. Lord	1957
I. Amdur	1958
T. F. Jones, Jr.	1958
S. H. Crandall	1959
R. E. MacMaster	1959

EXAMINATIONS

	Term Expires
H. Simpson (*Chairman*)	1958
D. P. Adams	1957
M. W. P. Strandberg	1957
R. M. Solow	1958
R. H. Gregory	1959
R. W. Mann	1959

FIRST TWO YEARS

	Term Expires
H. Mueller (*Chairman*)	1958
M. C. Shaw	1957
C. C. Stephenson	1957
C. N. Satterfield	1958
S. A. Coons	1959
D. M. McGregor	1959
W. A. Wilson†	

GENERAL EDUCATION

	Term Expires
M. Cohen (*Chairman*)	1957
W. P. Allis	1957
C. P. Kindleberger	1958
C. F. Taylor	1958
C. Collins	1959
V. F. Weisskopf	1959
A. C. Hardy†	

GRADUATE SCHOOL POLICY

Dean of Graduate School* (*Chairman*)
Secretary of Graduate School* (*Secretary*)
Director of Admissions*
Chairman of Faculty*

W. P. Allis	N. Levinson
J. M. Austin	J. T. R. Nickerson
W. H. Brown	C. H. Norris
J. H. Evans	J. T. Norton
T. S. Gray	S. Ober
T. M. Hill	L. Rodwin
J. W. Irvine, Jr.	R. R. Shrock
J. H. Keenan	I. W. Sizer
C. P. Kindleberger	C. C. Williams

INDUSTRIAL LIAISON

	Term Expires
R. D. Evans (*Chairman*)	1957
A. G. H. Dietz	1957
S. Backer	1958
S. H. Caldwell	1958
E. W. Boehne	1959
H. H. Uhlig	1959

LIBRARY

Executive Board

	Term Expires
A. T. Ippen** (*Chairman*)	1957
Director of Libraries*	
Associate Librarian*	
H. R. Bartlett	1957
S. Ober	1958
B. E. Goetz**	1959
C. G. Swain	1959
R. L. Bishop	1960

Advisory Board

D. P. Adams	W. Hurewicz
M. B. Bever	K. A. Lynch
J. S. Brinkley, Jr.	F. A. McClintock
A. Bush-Brown	H. P. Meissner
J. H. Evans	P. M. Morse
H. W. Fairbairn	R. C. Sanborn
R. H. Frazier	H. Sherman
R. H. Gregory	S. F. Wogan
M. Halle	M. G. Wurtele
M. J. Holley, Jr.	

NOMINATIONS
1956–1957

H. G. Houghton (*Chairman*)
H. R. Bartlett
A. T. Ippen
L. B. Rogers
J. T. Rule
E. H. Schell

STAFF-ADMINISTRATION

Staff

	Term Expires
H. F. Taylor (*Chairman*)	1957
P. D. Hansen	1957
R. C. Lord	1957
H. P. Aldrich, Jr.	1958
S. J. Mason	1958
K. U. Ingard	1959
M. E. Shank	1959

Administration

P. Belluschi	J. R. Killian, Jr.
	J. T. Rule
E. P. Brooks	J. J. Snyder
J. E. Burchard	C. R. Soderberg
E. L. Cochrane	J. A. Stratton
G. R. Harrison	

STUDENT AID

	Term Expires
R. H. Bolt (*Chairman*)	1959
Director of Student Aid*	
D. W. Fuerstenau	1957
E. A. Guillemin	1957
B. L. Averbach	1958
P. Pigors	1958
W. M. Rohsenow	1959
W. V. Clark, Jr.†	1959

STUDENT ENVIRONMENT

	Term Expires
W. H. Stockmayer (*Chairman*)	1958
Dean of Students*	
Associate Dean of Students*	
J. M. Blum	1957
T. W. Lambe	1957
K. Liepmann	1958
R. L. Balch	1959
R. B. Greeley	1959
J. B. Wiesner†	

UNDERGRADUATE COURSES

	‡Term Expires
E. N. Hartley (*Chairman*)	1957
N. J. Grant	1957
N. H. Cook	1958
S. A. Goldblith	1958
W. K. Linvill	1959
F. A. McClintock	1959
B. Kelly†	

UNDERGRADUATE POLICY

	Term Expires
A. M. Gaudin (*Chairman*)	
Chairman of the Faculty*	
L. S. Bryant	1957
A. C. Hardy	1957
C. H. Norris	1958
K. R. Wadleigh	1958
W. V. Clark, Jr.	1959
B. Kelly	1959
J. B. Wiesner	1960
W. A. Wilson	1960

*Ex officio **Appointed by the President †Non-voting member

COMMITTEES ON JOINT PROJECTS, 1956-57

PLASTICS

A. G. H. Dietz (*Chairman*)
A. S. Michaels
W. M. Murray
E. Orowan
E. R. Schwarz
W. H. Stockmayer

STEERING COMMITTEE ON SOLAR ENERGY RESEARCH

G. R. Harrison (*Chairman*)
L. B. Anderson
A. C. Cope
N. H. Frank
T. K. Sherwood
C. R. Soderberg

COMMITTEES ON INTERDEPARTMENTAL LABORATORIES, 1956-57

ACOUSTICS

R. H. Bolt (*Chairman*)
Dean of School of Engineering*
P. Belluschi
G. S. Brown
N. H. Frank

ELECTRONICS

J. B. Wiesner (*Chairman*)
G. S. Brown
N. H Frank
G. G. Harvey
A. G. Hill
H. J. Zimmermann

NUCLEAR ENGINEERING

M. Benedict (*Chairman*)
Dean of School of Engineering*
G. S. Brown
J. Chipman
E. L. Cochrane
J. P. Den Hartog
W. G. Whitman
J. B. Wilbur
J. R. Zacharias

NUCLEAR SCIENCE

J. R. Zacharias (*Chairman*)
Dean of School of Science*
M. Benedict
A. C. Cope
N. H. Frank

Directing Committee

J. R. Zacharias (*Chairman*)
P. T. Demos
M. Deutsch
V. F. Weisskopf

SPECTROSCOPY

R. C. Lord (*Chairman*)
L. C. Bradley
C. W. Garland
G. R. Harrison

OTHER COMMITTEES AND BOARDS, 1956-57

ATHLETIC ADMINISTRATIVE BOARD

J. A. Hrones (Faculty member) (*Chairman*)
Dean of Students*
Medical Director*
Athletic Director*
T. F. Jones, Jr. (Faculty member)
M. G. Kispert
G. P. Grant, Jr. (Alumni member)
L. T. Jester, Jr. (Alumni member)
B. Blanchard (Student member)
R. Heitman (Student member)
T. H. O'Connor, Jr. (Student member)

COMMENCEMENT COMMITTEE

J. W. Sheetz, III (*Chairman*)
H. P. Aldrich, Jr.
R. E. Hewes
E. R. Schwarz
D. P. Severance
G. P. Shultz
W. Speer
C. L. Svenson

FACULTY COMMITTEE ON INVENTIONS AND COPYRIGHTS

C. F. Floe (*Chairman*)
J. A. Beattie
R. L. Bishop
R. L. Bisplinghoff
G. S. Brown
J. W. Daily
G. G. Harvey
H. C. Weber

HOBBY SHOP COMMITTEE

J. Holt (*Chairman*)
B. L. Averbach
C. Collins
J. W. Sheetz, III

PATENT MANAGEMENT COMMITTEE

C. F. Floe (*Chairman*)
P. V. Cusick
F. L. Foster
M. R. Jenney
C. F. J. Overhage
C. R. Soderberg
J. G. Trump

PERSONNEL BOARD

P. V. Cusick (*Chairman*)
R. N. Davis
C. F. Floe
M. G. Kispert
R. C. Maclaurin

SAFETY COUNCIL

E. R. Schwarz (*Chairman*)
D. P. Adams
J. W. M. Bunker
M. J. Dondero
H. W. Fitzpatrick
H. L. Hardy
W. A. Hokanson
W. P. Jensen
C. M. F. Peterson
M. S. Stevens

STUDENT ACTIVITIES BUDGET BOARD

Dean of Students* (*Chairman*)
Chairman Athletic Administrative Board*
P. V. Cusick
T. M. Hill
R. T. Jope
R. M. Briber

STUDENT FINANCIAL AID COMMITTEE

T. P. Pitré (*Chairman*)
J. Jefferson (*Secretary*)
Chairman of Student Aid Committee*
W. A. Hokanson
P. A. Stoddard
K. R. Wadleigh

TECHNOLOGY MUSEUM COMMITTEE

H. R. Bartlett (*Chairman*)
H. L. Beckwith
H. E. Edgerton
H. B. Richmond*
E. R. Schwarz
L. Troost
J. E. Vivian

TECHNOLOGY PRESS BOARD

J. E. Burchard (*Chairman*)
G. S. Brown
M. Deutsch
F. G. Fassett, Jr.
E. H. Huntress
J. H. Keenan
W. W. Rostow
P. A. Samuelson

* Ex officio

GENERAL INFORMATION

GOVERNMENT AND ADMINISTRATION

IN a legal sense the Institute is a body of trustees known as the Corporation which consists of the President, Chancellor, Vice-President and Treasurer, Vice-President for Industrial and Governmental Relations and, "if eligible, the President of the Alumni Association *ex officiis*, of the *ex-officio* members as provided by act of the Legislature, of not less than twenty-five nor more than thirty-five life members, of fifteen alumni term members, and of not more than five special term members. . . . No professor, teacher or lecturer, under engagement for compensation to be paid by the Institute, shall be a member of the Corporation."

Three of the alumni term members are nominated annually for five-year terms by ballot of the Alumni Association. The *ex-officio* members provided by the act of the Legislature are the Governor of the Commonwealth, the Chief Justice of the Supreme Judicial Court, and the Commissioner of Education.

Four stated meetings of the Corporation are held each year, in October, December, March, and June. Between meetings it functions through its officers, its Executive Committee, other committees on Membership, Finance, and Auditing, and its Visiting Committees for the departments of the Institute.

The President presides over the Faculty of the Institute, to which body are entrusted by custom all questions relating to educational policies. The Corporation bylaws provide that the President "shall have the superintendence of the several departments of the Institute, and, subject to the direction of the Executive Committee, shall act as its general executive and administrative officer. . . ."

To aid the President, the Chancellor, and the two Vice-Presidents, there are other duly appointed officers of administration and instruction. Chief among the former are the Deans of the Schools of Engineering, Science, Architecture and Planning, Humanities and Social Studies, Industrial Management, the Graduate School, and Students. These officers are also members of the Administrative Council, together with the Directors of the Division of Sponsored Research and the Industrial Liaison Office; the Secretary of the Institute; the two Assistant Treasurers; the Assistant Provost; the Director of Admissions; the Registrar; the Director of Public Relations; the Medical Director; the Directors of the Summer Session, of Libraries, and of Student Aid; the President and Executive Vice-President of the Alumni Association; the Chairman of the Faculty; and the Executive Assistant to the President.

The Academic Council consists of the President as Chairman, the Chancellor as Vice-Chairman, the Vice-President for Industrial and Governmental Relations, the Vice-President and Treasurer, the Deans of the Schools of Engineering, Science, Architecture and Planning, Humanities and Social Studies, Industrial Management, the Deans of Students and of the Graduate School, the Chairman of the Faculty, and the Executive Assistant to the President.

The Faculty consists of all Professors, Associate Professors, Assistant Professors, and all Professors Emeriti having appointments as lecturers, certain designated Instructors and Research Associates, and the following administrative officers *ex officiis:* the Chairman of the Corporation, President, Chancellor, the Vice-President for Industrial and Governmental Relations, Deans, Registrar, Associate Registrar, Director of Admissions, Associate Director of Admissions, Assistant Director of Admissions, Director of Libraries, Associate Librarian, and the Directors of the Acoustics Laboratory, the Research Laboratory of Electronics, the Laboratory for Nuclear Science and the Spectroscopy Laboratory. For its government the Faculty has adopted a set of "Rules and Regulations" which set forth the duties and powers of its Chairman, Secretary, and Assistant Secretary, and of its standing committees which include those on Graduate School Policy, Undergraduate Policy, First Two Years, General Education, Undergraduate Courses, Academic Regulations, Student Aid, Student Environment, Discipline, Examinations, Admissions, Industrial Liaison, Staff — Administration, Nominations, and Library. These "Rules and Regulations" also provide for a Faculty Council which permits preliminary discussion of questions of major policy by a smaller group prior to submission of these questions for action at the general Faculty meetings.

Though the Institute has but a single Faculty, which meets and deliberates as a unit, its teaching of both undergraduate and graduate studies is through the medium of five academic Schools, each with its own Dean — those of Engineering, Science, Architecture and Planning, Humanities and Social Studies, and Industrial Management.

In the Division of Sponsored Research is centered the business management of the organized research activities of Departments and individual members of the staff which are financed through contracts with government and industry. Certain major research laboratories which have special relevance to national defense and which are thus less intimately associated with the Institute's educational program report directly to the Vice-President for Industrial and Governmental Relations.

The grouping of the curricula of the Institute in the Schools is as follows:

THE SCHOOL OF ENGINEERING

Aeronautical Engineering, Course XVI. Cooperative Course in Aeronautical Engineering, Course XVI-B.

Building Engineering and Construction, Course XVII.
Metallurgy, Course III.
Ceramics.
Chemical Engineering, Course X, and *Chemical Engineering Practice*, Courses X-A and X-B.
Civil Engineering, Course I.
Electrical Engineering, Course VI. Cooperative Course in Electrical Engineering, Course VI-A.
General Engineering, Course IX-B.
Mechanical Engineering, Course II. Cooperative Course in Mechanical Engineering, Course II-B.
Metallurgy, Course III.
Naval Architecture and Marine Engineering, Course XIII, *Naval Construction and Engineering*, Course XIII-A, and *Shipping and Shipbuilding Management*, Course XIII-B.
Nuclear Engineering.
Sanitary Engineering, Course XI.
Textile Technology.

THE SCHOOL OF SCIENCE

Biochemistry.
Biophysics.
Chemistry, Course V.
Food Technology, Courses XX and XX-A, and *Biochemical Engineering*, Course XX-B.
General Science, Course IX-A.
Geology and Geophysics, Courses XII and XII-A.
Mathematics, Course XVIII.
Meteorology, Course XIX.
Physics, Course VIII.
Quantitative Biology, Course VII.
Science Teaching, Course IX-C.

THE SCHOOL OF ARCHITECTURE AND PLANNING

Architecture, Course IV-A.
City Planning, Course IV-B.

THE SCHOOL OF HUMANITIES AND SOCIAL STUDIES

Economics, Politics, and Engineering, Course XIV-A, and *Economics, Politics, and Science*, Course XIV-B.
Humanities and Engineering, Course XXI-A, and *Humanities and Science*, Course XII-B.

THE SCHOOL OF INDUSTRIAL MANAGEMENT

Industrial Management and Business and Engineering Administration. Course XV-A, based on Physical Sciences; Course XV-B, based on Chemical Sciences.

Graduate programs are coordinated and organized under the direction of the Dean of the Graduate School, another major administrative division of the Institute.

DEGREES GRANTED

The Institute offers both undergraduate and graduate Courses of Study. The former lead to the degrees of Bachelor of Science (S.B.) or Bachelor in Architecture (B.Arch.); the latter, to the degrees of Master of Science (S.M.), Master in Architecture (M.Arch.), Master in City Planning (M.C.P.), Aeronautical Engineer (Aer.E.), Building Engineer (Bldg.E.), Chemical Engineer (Chem.E.), Civil Engineer (C.E.), Electrical Engineer (E.E.), Marine Mechanical Engineer (Mar.Mech.E.), Mechanical Engineer (Mech.E.), Metallurgical Engineer (Met.E.), Mineral Engineer (Min.E.), Naval Architect (Nav.Arch.), Naval Engineer (Nav.E.), Sanitary Engineer (San.E.), Doctor of Philosophy (Ph.D.), or Doctor of Science (Sc.D.). It also affords to advanced students and to experienced investigators opportunities for the pursuit of original scientific investigations.

EDUCATIONAL RESOURCES

THE LIBRARIES. The M. I. T. Library system, with resources in excess of 550,000 volumes, is designed to facilitate and extend Institute programs of study and research. A comprehensive current collection of about 6,500 periodicals and serials, and 1,500 government document series, together with extensive back files, provides strong bibliographic and book holdings in all major fields of interest. The M. I. T. Libraries include a General Library and five divisional libraries: the Arthur Rotch Memorial Library of Architecture and Planning, the Dewey Library (Economics, Industrial Management, Industrial Relations), the Engineering Library, the Humanities Library, and the Science Library.

The General Library (Charles Hayden Memorial Library, second floor, south wing) is the administrative center of the Library system. Book purchase, processing, and interlibrary loan are centralized. The union catalogue, reference and bibliographic resources, technical reports, rare books, and other special collections also are found in the General Library. There is representative material on most subjects of interest to Institute personnel and comprehensive coverage of subjects which fall outside the normal scope of the divisional libraries. Special facilities include: the Boston Stein Club Map Room with a unique six-foot revolving relief globe, the Young collection of early American globes, the Theodore Schwarz and other map collections, and related books; a projection room for 16mm motion pictures; the Microreproduction Laboratory with facilities for making and using micro and other documentary reproductions.

The Arthur Rotch Memorial Library of Architecture and Planning (Room 7-238) contains the collections on architecture and pertinent fine arts literature.

Visual aids include mounted photographs, clippings, and slides.

The Dewey Library (Room 52-360) contains the principal collection of books and periodicals in economics, business administration, industrial management, industrial relations, and related fields.

The Engineering Library (Room 10-550) comprises the major collections in the fields of building, civil, electrical, and mechanical engineering, in naval architecture and marine engineering, and (in Room 33-304) in aeronautics.

The Humanities Library is supplemented by the Reserve Book Room (14-N132) and the Music Library (14-E109) with books, scores and records. The collections in philosophy, religion, social sciences, history, literature, and biography occupy extensive space in the general library.

The Science Library (Charles Hayden Memorial Library, first floor, south wing) contains the basic science collections, both books and periodicals, in mathematics, physics and chemistry, biology, food technology, ceramics, geology, metallurgy, meteorology, and the periodical collection for chemical engineering.

Users of the Libraries are required to identify themselves by Bursar's cards or Library cards. Seniors, graduate students, and others engaged in thesis or advanced research are eligible for stack permits. Individual reference service, bibliographic aid, or assistance in using the card catalogue are available at the Reference Desk where books and periodicals not in the Library can frequently be obtained on interlibrary loan or in the form of photostats or microfilm.

Museums. Many departments have their own exhibits, along the corridors adjacent to their laboratories and offices. These exhibits, largely the result of the research or the ingenuity of the staff, broaden and enrich the educational program of the students. In addition, the Francis Russell Hart Nautical Museum, containing a magnificent collection of ship models and the Allan Forbes and Arthur H. Clark print collections, has ample quarters of its own. The collections of ceramics and of minerals, though not fully displayed in public, are also distinguished.

In addition to the permanent exhibitions, the Institute provides monthly exhibitions covering the fields of art, of craft, and of the other works of man. These are displayed in the public lobbies of the Institute and in the New Gallery in the Hayden Library. These presentations, often the only showings in the Boston area, range from handcraft to machine craft, from primitive art through that of the fully developed periods to the art of the experimental present. The New Gallery enables the Institute to have exhibitions of fine arts material of great value. The exhibition program is intended to introduce to the Institute family presentations of new ideas and to enrich the cultural life of the Institute community.

ESTIMATED COST OF A COLLEGE YEAR

Before enrolling in the Institute, each student is urged to make an accurate estimate of his expenses. There are certain basic expenses that every student will have to meet irrespective of his resources or individual tastes. The following minimum estimate of expenses is for an academic year of two terms, including recesses and holidays which fall within and between these terms, making a total of 37 weeks.

Tuition, two terms (1956–57)	$1,100.00
Board, 37 weeks	525.00
Room[1]	330.00
Books and materials	95.00
Insurance	22.00
	$2,072.00

Excluded from this estimate[2] are variable and personal expenditures such as transportation, clothing, laundry, and recreation, for which each individual should make his own estimate. The estimate for board is based on the charges for commons meals (required for freshmen in the Undergraduate Houses), which cover fifteen meals per week in the Institute's dining halls, plus an average allowance for meals for the week ends throughout the academic year. When payment is by the meal, individual variations may be expected.

FINANCIAL AIDS

Scholarships, Loans, Fellowships, Part-Time Employment

Scholarships have been established by bequests and deeds of gift to aid needy and deserving students. All incoming and undergraduate students may apply for scholarship aid. Except for those students who enter under the Combined Plan, students who have attended another college will not be eligible for scholarship aid until they have satisfactorily completed one year's work. Applications for scholarship are thoroughly considered by the Student Financial Aid Committee which makes all awards.

Entering Freshmen: For students of limited means who need help in meeting their expenses, the Institute has available scholarship grants (full and part tuition) for the freshman year. Approximately one quarter of the entering class receive some aid from this source, which includes the Alfred P. Sloan National Scholarships and General Motors Scholarships with maximum grants of $2,000 per annum, the Lockheed National Engineering Scholarships which cover tuition and pay $500 per annum toward other expenses, the William Barton Rogers, Des-

[1]Rentals in the Undergraduate Houses range from a minimum of $240 to a maximum of $380 annually. Upon receiving notice of admission, all new students are given an opportunity to apply for living accommodations on the campus. See Appendix B — Student Housing — for complete information.

[2]Not included in this estimate: $25 deposit for chemical supplies and breakage for all students who take chemistry. Incoming Freshmen should allow $40 more for non-recurring items, such as slide rule and drawing instruments. Books and supplies may be purchased at the Technology Store.

mond, and Cincinnati Milling Machine awards of $1,400 for the first year, Development Fund Scholarships, nineteen Alumni Regional Scholarships of full tuition, and other grants carrying stipends from $300 to full tuition. Application must be filed before February 15. (See Appendix A for complete details.)

UPPERCLASSMEN: After one year of residence any undergraduate may apply for scholarship aid. Applications are made to the Student Financial Aid Committee and grants are made on the annual basis dependent not only on academic excellence but also on demonstrated need. Also available after one year of residence for students with satisfactory academic records is the Technology Loan Fund. Awards are made from this fund, on application to the Student Financial Aid Committee, in addition to any scholarship grants and may reach full tuition for any one year with a maximum of $3,300 for the three later years of the Undergraduate Course. Loans bear interest at one per cent and are repayable at the rate of $50 every six months after graduation. (See Appendix A for complete details.)

GRADUATE STUDENTS: Graduate Scholarships and full- and part-time Assistantships are available for qualified students pursuing work leading to the Master's or Doctor's degrees. Graduate students are eligible for loans from the Technology Loan Fund under conditions similar to those outlined above for undergraduates. (See Appendix A for complete details.)

STUDENT EMPLOYMENT: The Office of Student Personnel is maintained to assist students desiring to help themselves in meeting part of their expenses by placement in on-the-campus jobs. However, the requirements of the Institute curriculum are such that only a limited amount of time may be given to employment, and prospective students are advised to have sufficient funds to cover the expenses of the first year at least. The average that can be earned through part-time employment does not usually exceed $150 per term. This amount may be realized in a number of jobs on the Campus such as those in the dining services, the library, and residence halls. Some outside jobs are available in Boston and Cambridge but these are likely to be limited by the difficulty in scheduling them without conflict with academic appointments. Students from foreign lands, in particular, should clearly understand that the opportunities to secure remunerative employment are seriously restricted by their unfamiliarity with the English language and American business customs.

FEES, DEPOSITS, PAYMENTS, EXPENSES

TUITION FEES. The regular tuition fee is $550 per academic term.

No bills are sent. All payments should be made to W. A. Hokanson, Bursar, Massachusetts Institute of Technology, Cambridge 39, Massachusetts, by the time specified in the registration instructions issued prior to the opening of each term. Students desiring periodic payments within each term should consult with the Bursar before the beginning of each term (not later than the Wednesday before Registration Day). *Students are advised to make their payments by mail.*

The tuition fee for students taking cooperative work in Course VI-A after the second year is $367 for each term including the summer term, provided that the student attends three consecutive terms in a twelve-month period, one of which must be at the works; otherwise, the regular term tuition of $550 is applicable.

Students in Course II-B or XVI-B will pay the tuition fees as listed in the Summer Session Catalogue for the subjects they register for during the Summer Session they attend. They will also register and pay a $65 tuition fee for the six (6) months' period they are at the plant.

For Course X-A or for the Engineering Practice School at Oak Ridge, for the period September through January or February through June the tuition fee is $550. For a single X-A field station, the fee is $215.

Regular students (other than doctoral candidates) and Special Students, including D. S. R. staff appointees, taking only a few subjects who apply to the Bursar for a reduction will be charged at the rate of $17 per unit credit (minimum $65 — maximum $550). Thesis tuition is at the rate of $17 per unit credit (minimum $65 — maximum $550, special students not permitted to do thesis). A regular student is one who is enrolled as an applicant for an academic degree; others are special students (see page 44).

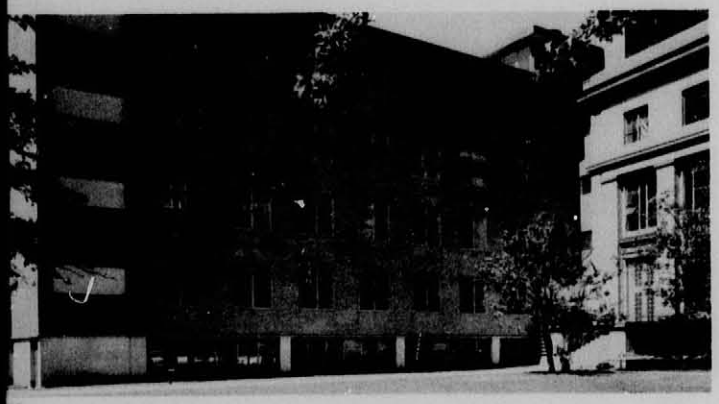
Acceptance by the Graduate School of an applicant for admission as a candidate for an Engineer's or Doctor's degree implies its responsibility for his eventual general examinations at the convenience of his department and no separate fee for such examinations is made.

The tuition fee for thesis research for the Doctor's degree, irrespective of the number of units is $550 per regular term and $275 for the Summer Term. The tuition fee for thesis research for the Master's and Engineer's degrees is $17 per unit credit in either regular term or in the summer, with a minimum of $65 and a maximum of $550 in a regular term and a maximum of $275 in the summer.

The fee for thesis presentation only is $65 for the Bachelor's, Master's, or Engineer's degree and $105 for the Doctor's degree. Thesis presentation refers to those necessary academic events beginning with the actual delivery of the completed document.

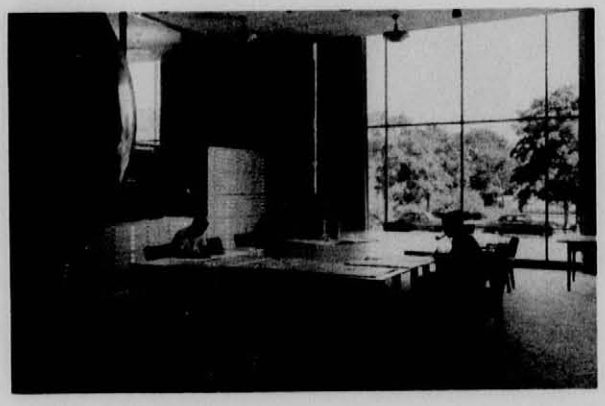
TUITION REFUNDS. Full-time students withdrawing before the end of the term will be charged $45 per week up to last day of attendance; for others the charge will be proportionately adjusted.

DORMITORY RENTALS. All term rentals, both for the Graduate House and all Undergraduate Houses



M. I. T.'s educational plant is an expression of the unity which pervades the Institute — unity among the sciences and humanities, among Faculty, students, and administration, among the intellectual, social, and recreational aspects of living. *From top to bottom, left to right:* The Sloan Metals Processing Laboratory; the new Kresge Auditorium and M. I. T. Chapel; a room in the Graduate House, reserved for graduate students; the Everett Moore Baker House for undergraduates; the Map Room in the Charles Hayden Memorial Library; M. I. T. dinghies on the Charles River Basin; and the Institute viewed at night from across the river in Boston.



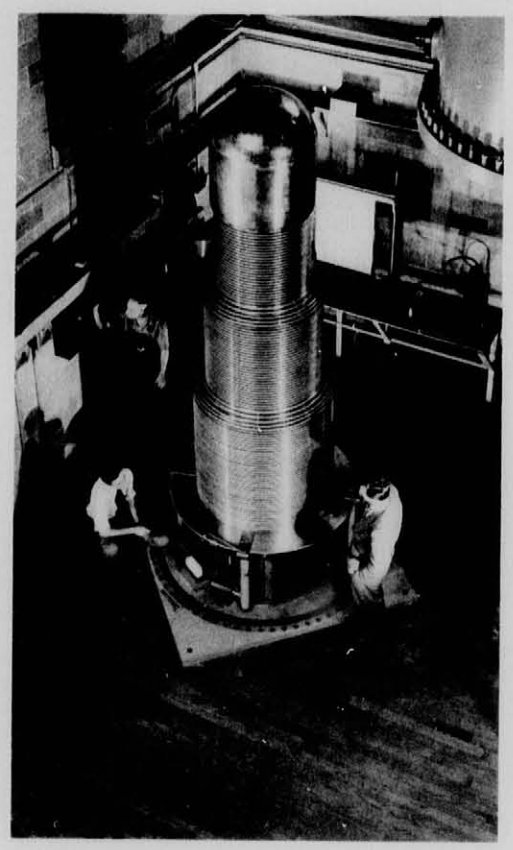


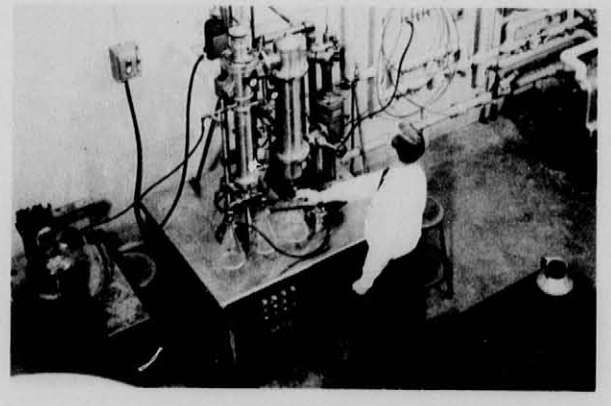


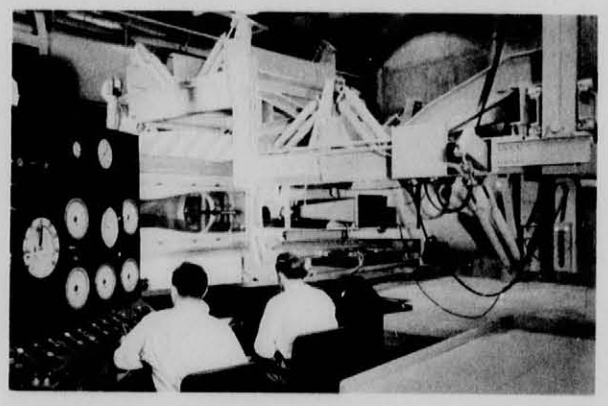
















The laboratories which have brought national fame to M. I. T. are devoted to both teaching and research. *From top to bottom, left to right:* A Van de Graaff generator in the High Voltage Research Laboratory; a pilot plant installation in the Food Technology Laboratories; operating the great Supersonic Wind Tunnel; and examining infrared spectrographs in the Biology Department. *Bottom right:* The Symphony Orchestra is among M. I. T.'s many student musical groups.

are to be paid to the Bursar or arrangements made with him in advance of the beginning of the academic term under the same conditions pertaining to the payment of tuition fees. *No bills are sent.*

COMMONS MEALS. All students taking commons meals must pay the required term fee to the Bursar or arrangement must be made with him in advance of the beginning of the academic term under the same conditions as those pertaining to the payment of tuition fees. *No bills are sent.*

OTHER FEES. A charge of $5 is made for each condition or advanced standing or special examination taken, and $5 for the removal of each deficiency. Health insurance is required of all students except Army, Navy and Air Force students, veterans enrolled under Public Law No. 894, and D. S. R. employees, unless a waiver is signed before September 10, 1956, the date the insurance goes into effect. Any student registering after September 10 will be insured only from the date of filing registration material. The insurance premium is $11 per term. (See under Health of Students, on next page.)

LATE REGISTRATION OR PAYMENT FINE. A fine of $5 is imposed for late registration or late payment of tuition, dormitory rent, or commons meals contract. Students should note that registration is not complete until all fees are paid or arranged for.

DEPOSITS TO COVER CHEMICAL SUPPLIES, MILITARY UNIFORMS, ETC. All first-year students and all students taking Military Science, MS21 and MS22, will be required to make a deposit of $25, from which the costs of laboratory chemicals and supplies, shoes, non-returnable equipment and damage to military uniforms are to be deducted.

All upperclassmen and graduate students taking subjects requiring the use of the Office of Chemical Laboratory Supplies will be required to make a deposit of $25 against which the cost of laboratory chemicals and supplies will be charged.

All deposits must be made at the beginning of the academic year.

If the total cost of chemicals and supplies used exceeds the amount of this deposit, an additional amount sufficient to cover this excess must be paid.

No refund of deposits will be made during the school year except to students leaving the Institute.

TUITION FEES FOR ACADEMIC STAFF APPOINTEES. An academic staff appointee also registered as a student is expected to pay a tuition fee consistent with his opportunity for academic progress, the standard of comparison being the tuition fee for a full-time student. The Committee on Graduate School Policy and the Administration have, therefore, approved the following schedule:

(a) An academic staff appointee registered as a regular graduate student is normally permitted to progress toward a post-baccalaureate degree in accord with the following tabulation:

Staff Appointment	*Normal Academic Registration (see Note 1)*	*Tuition per term (see Note 2)*
Full-time	18 units	$210
Half-time	30 units	330
Third-time	38 units	440

NOTE 1: If, *without interfering with staff duties*, a load somewhat greater than "normal" can be carried, the student's Graduate Registration Officer *may* permit registration by full-time staff up to 24 units, by half-time staff, up to 36 units, and by third-time staff up to 48 units.

NOTE 2: In cases where assigned research is also approved for thesis, a full-time or half-time staff appointee occasionally has the opportunity to progress at a rate faster than that listed above. In such a case, as determined by the staff appointee's department and approved by the Dean of the Graduate School, the staff appointee (whether full-time or half-time) who has the opportunity to progress on thesis research at the rate of a full-time student shall pay the full-tuition fee ($550 per regular term, $275 per summer session) and shall be permitted to register for a full academic load of 48 units. A full-time staff appointee who can progress on thesis research at the rate of a half-time student shall pay a tuition fee of $330 per regular term or $165 per summer session and shall be permitted to register for a maximum of 36 units. In intermediate cases, the tuition principle can normally be satisfied by an appropriate combination of full-time and half-time thesis research registration in successive terms. The increase in academic load above the range normal for the academic appointment is limited to thesis.

(b) The fee for thesis presentation only is $65 for a Master's or Engineer's degree and $105 for a Doctor's degree.

(c) When a member of the academic staff is also a graduate student, his registration as a listener may be approved by his Registration Officer in cases in which the total registration for credit and as listener does not exceed the range normal for the staff member's academic appointment.

(d) Academic staff appointees who are also graduate students may, by departmental and D. S. R. approval, engage in D. S. R. research but without increased compensation. Such research may, by previous approval of a Departmental Committee on Graduate Students, be a part of a thesis for which registration will be permitted and required.

(e) An academic staff appointee for the summer registered as a graduate student in the summer session for not more than *normal academic registration* pays:

Thesis Research only: $105 for full-time, $165 for half-time, and $220 for third-time staff

appointee, if Doctoral candidates; $17 per credit unit, if Bachelor's, Master's, or Engineer's candidates; a minimum of $65 up to maxima same as for Doctoral candidates.

Regular Subjects only: Same as non-staff students.

Maximum Summer Tuition is $170 for full-time, $265 for half-time and $350 for third-time staff appointees.

(f) Upon recommendation of a department the Dean of the Graduate School may set a special tuition rate for an unusual case.

HEALTH OF STUDENTS

The Institute maintains a well-equipped Medical Department with headquarters in the Homberg Memorial Infirmary. Under the supervision of the Medical Director, a staff of thirty-four doctors conducts various clinics daily except Saturday and Sunday. Clinics are maintained in Internal Medicine, Surgery, Orthopedic Surgery, Psychiatry and Neurology, Ophthalmology, Otolaryngology, Dermatology and Occupational Medicine. In addition, the Dental Service supplies emergency, diagnostic, and prophylactic service daily.

The staff physicians are in attendance from 8.30 A.M. to 5 P.M. Monday through Friday, and a graduate nurse is on duty from 8:30 A.M. to 4:30 P.M. At other times emergency treatment is given in the Infirmary on the third floor, where a physician is either on duty or on call. In connection with the clinics adequate X-ray and laboratory facilities are maintained. Any student may receive routine medical care in the clinic without charge. If he is referred to one of the special clinics, a moderate fee is charged. Psychiatric service will be charged for after the fifth interview in any one fiscal year. Insured students are seen in the various special clinics, including psychiatry, without charge other than the insurance premium.

In addition to the clinics, the Homberg Memorial Infirmary building contains a hospital equipped to care for twenty-one bed patients. There are ward accommodations for fifteen patients, six private rooms, and an emergency ward for epidemics with a capacity of thirty extra beds. The hospital is open twenty-four hours daily throughout the year, except for July and August, with a staff of graduate nurses and a visiting physician in attendance. During July and August, hospital care will be provided in a nearby hospital under the supervision of Medical Department physicians. A physician will be on duty on the third floor of the Infirmary for giving emergency treatment after the regular clinic hours during these two months.

The charges for students are low: food, nursing, and medical care in the wards cost ten dollars a day, and the same service in a private room is furnished for twelve dollars a day. For insured students the cost of these services is borne by the insuring agency.

A health insurance plan has been adopted by the Institute for all students for a premium of $11 per term. In return for this sum the insurance agency agrees with certain limitations to pay up to $1,000 toward meeting the cost of each illness or injury. Details of this plan may be secured at any time upon application to the Medical Department. If any student is already adequately protected by insurance or if for any other reason he does not wish to be enrolled in this plan, he may sign a waiver which is a part of the Bursar's Registration Card. To be effective, this must be done before September 10, 1956, the date the insurance goes into effect. No exceptions will be made after that time. Insurance is not required for Army, Navy or Air Force students. Any student registering after September 10 will be insured only from the date of filing registration material. Insurance is not available to full-time D. S. R. staff employees taking one or more subjects.

Every entering student, undergraduate or graduate, is required to be immunized against tetanus and smallpox prior to matriculation. After registering, he is required to report to the Medical Department for a complete physical and dental examination within six weeks after matriculation. All other students are urged to have an X-ray of the chest every other year, an appointment for which should be arranged with the Medical Department. This X-ray will be done without charge before December 15, 1956, but after that date there will be a charge of $5.00. For students entering the second semester, there will be no charge until after March 1, 1957.

No student is permitted to engage in intercollegiate or intramural athletics without having had a physical examination sometime during the academic year in which he participates in the sport.

In case of serious illness involving major operations or complicated medical emergency procedures the student is transferred to one of the Boston or Cambridge hospitals, and then may return to the Infirmary for convalescence. Contagious disease cases are transferred to the Haynes Memorial Hospital in Brighton. Fees at these hospitals are paid by the student or his family or, if insured, by the insuring agency.

GENERAL REGULATIONS

ACADEMIC YEAR. Exercises of the Institute begin on the Monday prior to the last Monday in September and end early in June. In order that freshmen may be properly oriented to the Institute and take various tests administered to all freshmen, the Fall Term for freshmen will begin at 1:00 P.M. on the Wednesday preceding Registration Day. The exercises are omitted on the following Massachusetts legal holidays: January 1, February 22, April 19, May 30, July 4, Labor Day, Columbus Day, November 11, Thanksgiving Day and December 25.

OFFICIAL NOTICES. It is the student's responsibility to keep informed of all official notices on the Official Bulletin Boards.

REGISTRATION. At a date specified in the registration instructions, before the opening of each term, the student is required to fill in and present registration forms to the Registrar.

REGISTRATION OFFICERS AND ADVISERS. Each student is assigned to a Registration Officer who is a member of the Faculty having responsibility for, and control of, his academic program. These Registration Officers serve as academic advisers and insure that each student's particular problem will receive individual consideration.

The Dean of Students is the general consultant and adviser for all students and represents the President in all matters pertaining to student activities, group and individual relations. The Deans of Architecture and Planning, Engineering, Science, Humanities and Social Studies, and Industrial Management and the Heads of the several Departments also serve as consultants to students who seek advice relating to their choice of professional Courses. It is not intended that these advisers shall become, in any sense, guardians of students assigned to them, nor does the Faculty by this action assume any responsibility for the conduct of students outside the halls of the Institute. It is assumed that all students are self-reliant, responsible individuals capable of managing their own affairs and seeking such advice as from time to time they may require. The Office of the Dean of Students is the central clearing house for all matters pertaining to general student welfare.

ATTENDANCE. After approval of his registration, the student is required to attend all exercises, including the final examinations, in the subjects for which he is registered. Irregular attendance or habitual tardiness may lead to probation or suspension. Students are expected to follow the program assignments as published in the official Class Schedules between the hours of 9 A.M. and 5 P.M. There are no classroom exercises on Saturday after 1 P.M. Students who withdraw during the term should obtain approval at the Office of the Dean of Students.

FACULTY-STUDENT RELATIONS. The Faculty assumes that all students come to the Institute for a serious purpose, and that they will conform cheerfully to such regulations as, from time to time, may be made by the Faculty, Administration, the Institute Committee (student government), or the governing body of the Institute houses. It is the general policy to have as few rules and regulations as are consistent with efficient administration and the general welfare. Insofar as is possible, the regulation of the day-to-day affairs of students, residence in the Institute houses or fraternities, extra-curricular activities including athletics, in fact, every phase of life at the Institute except the academic program, is the responsibility of student government.

In case of injury to any building, or to furniture, apparatus, or other property of the Institute, the damage will be charged to the student or students known to be immediately concerned; but if the persons who cause the damage are unknown, the cost of repairing it may be assessed equally upon all the students of the school.

Conduct inconsistent with general good order, or persistent neglect of work, or failure to respond to official notices, or to meet class or examination schedules may lead to probation or dismissal. Students placed on probation by the Committee on Discipline shall be required to report to the Dean of Students as directed.

It is the aim of the Faculty to maintain the highest standards of integrity. The attempt of any student to present as his own the work of another, or any work which he has not honestly performed, or to pass any examination by improper means, is regarded by the Faculty as a most serious offense, and renders the offender liable to immediate expulsion. The aiding or abetting of a student in any dishonesty is also held to be a grave breach of discipline.

The Faculty has approved an experimental program for section quizzes in which as many sections of the Freshman Class as may elect to do so, by unanimous vote, may operate under "the Honor System." There is no disparagement of students who do not participate in this privilege. All students not under the Honor System are proctored in order that no individual student in competition with all others may by dishonest means gain higher grades than he deserves.

A Liaison Committee composed of key administrative officers, chairmen of Faculty Committees, and Student Government representatives meets regularly for discussion of matters pertaining to the curriculum, teaching methods, schedules, and, in fact, all relations of students and Faculty.

EXAMINATIONS. *Final Examinations* are held at the end of each term, the schedule being issued about a month prior to the examination period. Each student is held responsible for obtaining an examination schedule at the Information Office, Room 7-111; for attending the final examinations required in the subjects for which he is registered; and for reporting any conflicts in his examinations *before* the time limit given on the examination schedule.

No member of the instructing staff is empowered to grant excuse from a final examination. Absence from any final examination is equivalent to complete failure except as, on presentation in writing of adequate evidence of sickness or other valid reason for the absence, the Dean of Students may permit a student whose term work has been satisfactory to take an ensuing examination on the subject.

The ability of students to continue their subjects is determined in part by means of examination, but regularity of attendance and faithfulness to daily duties are considered equally essential.

Condition Examinations. A conditional grade received by a student as a term record can only be removed by examination or repetition of the subject. These examinations will be held in March for conditions of the first term; condition examinations for subjects taken in the second term will be given in

September, prior to the opening of the fall term. Each student is held responsible for obtaining an examination schedule and filing an application card for the condition examination *before* the time limit given on the schedule.

A student not taking an examination at the scheduled time forfeits the right to the examination. A student who takes a condition or advanced standing examination in a given term, and fails to pass it, is not allowed to register for that subject in the same term.

Examinations for Advanced Standing. Registered undergraduate students of all classes, with a cumulative rating of 3.50 and above, may take examinations for advanced standing during the condition examination periods in each term provided that they have never been registered for the subjects, or have never attended classes in the particular subjects. Notice of intention must be filed with the Registrar on the usual petition forms, and must be submitted at least three weeks before the day of the first scheduled examination of the examination period. Endorsement by members of the Faculty is not necessary except that examination in a subject which involves laboratory instruction or drawing, must be approved by the Faculty member in charge.

Petitions. The Committee on Academic Regulations is the Faculty body through which the student may appeal for special consideration of his individual case. All requests must be submitted in writing on petition blanks which may be obtained at the Information Office, Room 7-111.

RECREATIONAL FACILITIES

Walker Memorial, built in memory of President Francis Amasa Walker, is the center of the social activities of the Institute. The building was finished in 1917 from funds contributed in part by alumni.

On the third floor are a gymnasium with a regulation basketball court, lockers and dressing rooms, offices for various student activities, and a fencing room. Below are recreation and reading rooms, and a comfortable and interesting recreation center with a small dance floor and soda bar where students can bring their "dates." On the first floor are a large dining hall with cafeteria service, a comfortable lounge and reading room, and the office of the undergraduate government, the Institute Committee. In the basement are bowling alleys, student activity offices, and a lounge room for the Commuters Organization.

Adjacent to this building and the East Campus houses are four tennis courts and the Alumni Swimming Pool completed in 1940, which contains a deep pool for recreational swimming and a shallow one for use by beginners.

On the land west of Massachusetts Avenue are fields for soccer, lacrosse, baseball, softball and football; eight hard surface tennis courts; an artificial-ice skating rink for use during the winter months; a quarter-mile cinder track with a 220-yard straightaway, and a standard one-twelfth mile banked board track with a 60-yard straightaway. The John Rockwell Athletic Cage provides an indoor area 165 x 200 feet for recreational and varsity athletics during the winter months. A portable floor provides excellent facilities for basketball, wrestling, and tumbling; portable stands provide ample space for spectators. Briggs Field House provides excellent additional locker and shower facilities serving the Rockwell Athletic Cage and the playing fields.

A boathouse on the Charles River, supplied with indoor rowing machines, offers to all undergraduates the opportunity to learn under competent coaching how to row in an eight-oared shell. The Sailing Pavilion, located on the Charles River in front of Walker Memorial, is the headquarters of the Nautical Association.

Students who wish to pursue or develop hobbies as a recreation have access to the Hobby Shop — a name describing both a physical facility and the group of students brought together by it. Since the shop was opened in 1938, with space and equipment provided by the Institute, it has been doubled in size. The shop is equipped with all the tools necessary for woodworking, metal working, gem cutting, bookbinding, radio, photography, electroplating, and telescope making.

UNDERGRADUATE ACTIVITIES

To complement and aid its educational work and to enrich its community life, the Institute provides extensive opportunities for students to participate in those extra-curricular pursuits — athletic, literary, musical, dramatic, and social — which further the development of character and personality, and yield health, pleasure and friendship. These enterprises are administered by the students themselves, under a well-organized system of student government, which inculcates responsibility, leadership and initiative.

The Institute Committee. All student activities are supervised by the Institute Committee, the legislative and judicial body of the M. I. T. Undergraduate Association. On this Committee sit elected representatives of the four classes, of the dormitories, the fraternities, and commuters. The full Committee meets regularly to consider all matters pertaining to undergraduate affairs. It has jurisdiction over all undergraduate organizations.

Subcommittees of the Institute Committee supervise the finances of undergraduate activities allocating all funds appropriated by the Institute for the support of student organizations, investigate infractions of the community rules and standards and recommend remedial action, consider jointly with Faculty and Administration matters affecting students, represent the M. I. T. Undergraduate Association in the National Student Association, administer Walker Memorial, supervise all elections, and control the publicity and public relations of student organizations and activities.

The headquarters of the Institute Committee are on the first floor of Walker Memorial.

ATHLETICS. The purpose of athletics at the Institute is not especially to develop highly trained athletes, but rather to encourage all students to participate competently in some form of physical recreation. Control is vested in an Athletic Board composed of Alumni, Faculty and Student Members, and the M. I. T. Athletic Association, an undergraduate organization composed of all captains and managers of varsity teams as working members, and assistant managers and officials of class teams as associate members. Funds are appropriated by the Institute and disbursed by the Undergraduate Association.

No attempt is made to concentrate on coaching the few men composing a single varsity team, but instruction is given to all men reporting for a sport. As a corollary to this, the success of a given athletic activity is gauged by the number of men it attracts. Sports represented by both Varsity and Freshman teams in intercollegiate competition are: track and field, cross-country running, rowing, baseball, skiing, hockey, basketball, fencing, golf, lacrosse, rifle, swimming, tennis, soccer, squash racquets, pistol, sailing, wrestling. Spirited intramural league competitions are held annually in the sports of touch football, basketball, softball, volleyball, swimming, track, tennis, squash racquets, table tennis, and bowling.

NAUTICAL ASSOCIATION. The Nautical Association offers every student an opportunity to learn sailing. A fleet of sixty dinghies of which forty are fibreglass boats, constituting a special Technology class designed by Technology men, and four 24-foot sloops are available for sailing on the Charles River Basin. The Sailing Pavilion, located directly in front of Walker Memorial, provides a large landing float, a rigging and maintenance shop, and storage space.

The Association sponsors a shore school, offering instruction in the theory of sailing and in the handling and maintenance of yachts.

PUBLICATIONS. Undergraduate publishing activities offer opportunities for students to broaden contacts and to acquire practical experience in journalism which may in later years prove to be of material value. All work incident to the editing and financing of the publications is carried on by students, with an Alumni Advisory Council available for consultation.

There are four self-supporting undergraduate publications: *The Tech*, the student newspaper; *The Tech Engineering News*, a monthly technical journal; *Technique*, the yearbook; and *Voo Doo*, a comic magazine. *The Tech*, the official undergraduate news organ, is one of the oldest of college newspapers, having been founded in 1881. *The Tech Engineering News* is the undergraduate scientific magazine, to the editorial columns of which prominent graduates and professional men, as well as undergraduates, contribute. Quite frequently its articles are quoted in professional technical journals, and it has won numerous awards as an outstanding student journal. *Technique* is the yearbook containing pictures and records of seniors and graduate students and, in addition, accounts of all regular undergraduate activities and outstanding social functions of the year.

MUSIC, DRAMA AND DEBATING. The Combined Musical Clubs offer many opportunities to those who would like to sing or to keep up their skill in playing musical instruments. The glee club, the symphony orchestra, and the concert band rehearse weekly and present several concerts at M. I. T. as well as at various colleges in New England. The choral society, a mixed choral group, concentrates on madrigals, cantatas, oratorios, which are presented in public concerts with orchestra and soloists. A dance band consisting of M. I. T. students is in frequent demand for dances in and around Boston. For students interested in dramatics and theatricals, two different activities are available: the *Dramashop*, which produces several serious plays during the college year; and the annual musical comedy, *The Tech Show*, which is written, directed, and produced entirely by students. Opportunity to participate in intercollegiate debating is made available by the Debating Society. During the academic year the debaters make several trips to other colleges for exhibition debates and for tournaments. The annual New England Debate Tournament is held at M. I. T.

TECHNOLOGY CHRISTIAN ASSOCIATION. This organization aims to be of practical service and to foster among members of the Institute community the ideals of Christian living and active Christian service. It organizes students for social service and religious activity in Metropolitan Boston, maintains a theater ticket service and book exchange, manages the Tech House at Round Hill, South Dartmouth, and publishes the freshman handbook.

PROFESSIONAL, SOCIAL, HONORARY, AND SERVICE ACTIVITIES. In addition to these activities, there are some 70 others which have special appeal to smaller groups of the student body.

Each class elects its own officers who are responsible for the management of all class organizations and social functions. Each living group is governed by its own elected representatives: individual House Committees and the Dormitory Council for the Undergraduate Houses, the Inter-Fraternity Conference for the Fraternities, and the Commuters Organization for commuters.

The various Professional Societies hold meetings to which outside lecturers are invited to discuss topics of professional interest. Their most important activity is the presentation of scientific papers by students, culminating in the Stratton Prize Contest.

The Honorary Societies are of two classifications: the honorary professional societies, such as Tau Beta Pi and Sigma Xi for scholarship; and the honorary social and service societies.

Several religious organizations active on the campus offer opportunities for undergraduates of all faiths to meet socially and participate with others of similar concerns in cultural, social, and religious work.

For foreign students, there are organizations where students of like nationalities may meet periodically

to participate in cultural and social activities. Service groups, such as Alpha Phi Omega, the National Scouting fraternity, meet the need of students interested in such activities.

Hobbies, both scientific and recreational, are enjoyed by students participating in the many activities which exist to satisfy their desires for creative work. Some of these include: the Rocket Research Society, the Propeller Club; the Television Club; the Model R. R. Club; WIMX, the Radio Society; the Camera Club; the Flying Club; the Hobby Shop; and WTBS, the student radio station which affords those interested in directing and producing radio programs an opportunity to expand their talents.

Also extremely popular are organizations like the Outing Club, which promotes group activities (skiing, hiking, mountain climbing, square-dancing, etc.) with similar groups in other schools, and the Lecture Series Committee, which serves a very important function by arranging for distinguished lecturers to speak to the undergraduate body on non-technical topics of universal interest.

RESERVE OFFICERS' TRAINING CORPS

A full explanation of the ROTC requirements for the United States Army and Air Force is given on page 87.

PREMEDICAL STUDENTS

Students planning to enter medical school upon completion of their studies at M. I. T. may enroll in almost any of the available courses of instruction. Specific requirements for entrance to medical school can be satisfied by elective subjects. This arrangement (rather than restriction to a special premedical curriculum) is in accordance with the opinion expressed by the Association of American Medical Colleges.

The flexibility and diversity of the programs available to premedical students make it desirable for them to have individual guidance. Shortly after admission each premedical student should consult with Dr. James Faulkner, Adviser to Premedical Students and Medical Director.

PLACEMENT

STUDENT. Without assuming responsibility for finding employment for its graduating class, the Institute offers Seniors and graduate students a program of placement training planned to acquaint them with industrial opportunities and to outline the principles to be observed in seeking employment. Each department has Placement Advisers available for individual consultation, who also cooperate with a well-staffed Placement Office. This office handles most external relationships with prospective employers, and arranges interview schedules between industry and the students.

ALUMNI. A Placement Bureau is also maintained by the Institute to assist alumni in securing positions for which they are particularly fitted, and to aid industry in selecting men for positions requiring engineering or scientific education. There is no charge for these services.

THE TECHNOLOGY DAMES

The Technology Dames is an organization composed of the wives (or mothers, or sisters) of M. I. T. graduate and undergraduate students, research assistants, technical assistants, technical instructors, and teaching fellows. The wife of the president of M. I. T. is a permanent honorary member, and six members appointed from the Technology Matrons serve in an advisory capacity to the executive board.

The organization sponsors a variety of programs oriented toward the role of the young woman as wife, mother, and effective citizen. The monthly *Technology Dames Newsletter* includes news of current programs and social events, as well as Institute facilities and activities open to Dames and their families.

THE SOCIETY OF ARTS

The Society of Arts was provided for in the Charter of the Institute. In the early days, the meetings of the Society were given over to public lectures on new inventions and discoveries, followed by general discussions by the audience. Since 1917, the Society has presented an annual series of Popular Science Lectures. These discourses, always illustrated, are held in Huntington Hall, usually on one week end in the months of December, January, February and March. The Friday and Saturday afternoon lectures are addressed primarily to seniors and science teachers in high and preparatory schools. On Sundays, the M. I. T. family and the general public make up the audience. Because they follow the lines of study and research for which the Institute is known, the lecturers high-light many present-day developments in science and engineering.

THE LOWELL INSTITUTE SCHOOL

The Trustee of the Lowell Institute established in 1903, under the auspices of the Massachusetts Institute of Technology, a Free Evening School.

This School offers three regular courses in the fundamentals of Engineering — Mechanical, Electrical, and Structural or Civil — each extending over two years; and a number of advanced or supplementary single subjects of varied length.

These courses are intended to bring the systematic study of applied science within the reach of young people who are following industrial pursuits and who desire training to fit themselves for higher positions.

Circulars describing the courses of instruction, the nature of the entrance examinations, and other requirements may be obtained by sending a stamped, self-addressed envelope to Professor Arthur L. Townsend, Director, The Lowell Institute School, Massachusetts Institute of Technology, Cambridge 39, Massachusetts.

REQUIREMENTS FOR ADMISSION

ENTRANCE DATES

First Year students may enter only at the beginning of the Fall Term, which is the Monday prior to the last Monday in September.

ADMISSION FROM SECONDARY SCHOOLS

SELECTION OF APPLICANTS. Under the Institute's policy of stabilized enrollment, the size of the First Year class is limited. Since it is expected that the number of applications will exceed the number that can be accommodated, the Faculty Committee on Admissions will exercise discretionary powers of selection.

Preference will be accorded applicants whose evidence of academic fitness and of professional promise indicates that they are particularly qualified to pursue Institute Courses with success. It is the desire of the Faculty to admit only those candidates who possess qualities, both of character and intellect, which indicate their adaptability to an academic environment, and who show promise of their development into useful and forceful citizens.

CHOICE OF COURSE. The candidate is requested to indicate his tentative choice of professional Course at the time of filing his application. After admission, he may reconsider his choice; and he has the option of changing at any time during the first year. Continuation in a Course after the first year, or a change of Course, will depend upon the student's scholastic record, his apparent aptitudes for the particular field of work, and the facilities available at the Institute.

ACADEMIC PREPARATION. The better high and preparatory schools in the United States, and equivalent schools in other countries will, in general, provide suitable preparation to the student who takes full advantage of the opportunities which such schools afford.

The candidate should bear in mind that the wider his intellectual development and the more extensive his attainments, the greater will be the advantages he may expect to gain from study at the Institute. The preparatory course should be a broad one, not confined to technical subjects.

Attention is called particularly to the necessity for thorough preparation in English and mathematics. It is presupposed that a candidate's training in English has been such that he can read with speed, intelligence, and sensitivity, and that he can express his ideas clearly in oral and written form. In mathematics, emphasis should be on thorough mastery of fundamental principles, operations, and definitions rather than on covering a wide range of topics.

Each applicant is required to have completed the following specific preparatory subjects; the figures in parentheses represent the usual "unit" rating, a unit being a full year's study in a secondary school subject taken four or five times a week:

ENGLISH (3)
ALGEBRA (2)
PLANE GEOMETRY (1)
PHYSICS (1)
TRIGONOMETRY (½)

English is normally studied through four years, and this is counted as three units. In some states, algebra is completed in 1½ years; this will satisfy the algebra requirement for candidates from those states.

In addition to the above subjects specifically required, the applicant must also have completed 7½ additional units, or their equivalent, in secondary school studies; no limitations are imposed in the choice of these elective subjects. In the selection of the entering class the Committee will be guided by the quality of the applicant's work and by his apparent promise on grounds of intellect and character, rather than by his choice of electives.

It is nevertheless recommended, though not required, that the elective subjects should include a year of chemistry, as preparation for the first year chemistry course at the Institute, and one or more year's study of history. It is also recommended that the student include solid geometry in his mathematics course.

While there is no requirement of language for admission, the study of modern foreign languages in secondary school is obviously desirable and is recommended. No limitations are imposed with regard to languages, except that if a language is offered at all, it must total at least two units. The choice of languages should be guided by the student's own interest, by the educational opportunities open to him, and by the nature of his probable future work.

A student who has ties with a particular foreign country, or who expects to develop such ties, should naturally study the appropriate language. Thus any who expect to have contacts with Latin America may need Spanish or Portuguese. Those who look forward to advanced work in research or design in a scientific or engineering field are likely to need a knowledge of German, Russian, or French, since there is an extensive and important technical literature in each of these languages.

In unusual cases, students of exceptional promise may be considered for admission without having fulfilled all of the stated requirements.

APPLICATION PROCEDURE. A Preliminary Application form, which may be obtained from the Director of Admissions, should be filed as far as possible in advance of the anticipated date of entrance. This insures that the applicant will receive any announce-

ments which may be issued, as well as Final Application forms, at the proper time.

A Final Application form and two personal endorsement forms will be sent in the Fall preceding the date of entrance, to candidates who have filed Preliminary Application forms.

Candidates should complete the final application form and return it with a non-returnable fee of ten dollars ($10.00). A check or money order is preferred. Also in the Fall, a School Report form will be sent directly to the principal or headmaster of each secondary school which the applicant has attended, and will be returned by the school directly to the Institute.

INTERVIEWS. Applicants for admission to the First Year class, who live within one hundred miles of Cambridge, are expected to have a conference with the Director of Admissions. Office hours are nine to five, Monday through Friday; the office is closed on Saturday. It is not necessary to make an appointment in advance.

Other applicants who live farther than 100 miles from Cambridge will be asked to arrange a conference with a member of the M. I. T. Educational Council. Council members are alumni who have been selected for their ability to represent M. I. T. and for their interest in and liking for young people. These men welcome the opportunity to meet students interested in M. I. T. and are anxious to help them in every possible way.

TOURS. Visitors to M. I. T. may wish to plan their time to include a student-guided tour of the Institute. There are regular, scheduled tours Mondays through Fridays, exclusive of holidays, at 10:00 a.m. and again at 2:00 p.m.

ENTRANCE EXAMINATIONS. All candidates are required to take a series of tests given by the College Entrance Examination Board. This includes the following tests: in the morning, the Scholastic Aptitude Tests; in the afternoon, three one-hour achievement tests: (1) Advanced Mathematics, (2) English Composition, and (3) either Physics or Chemistry.

The Board offers these examinations in the principal cities of the United States and abroad. The test dates, locations, and fees for the current year are outlined in an Information Bulletin which can be obtained by writing to the Board.

Apply to the College Entrance Examination Board, Box 592, Princeton, New Jersey. (Residents of Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming, Alaska, Hawaii, Alberta, British Columbia, Mexico, Australia, Pacific Islands, Japan, and Formosa should apply to the College Entrance Examination Board, P. O. Box 27896, Los Angeles 27, California.)

Candidates may choose any date they wish, or divide the tests among two or more dates in the same or in different years. A candidate should plan to have completed the required series of tests not later than the March test date of the senior year. A student taking Physics or Chemistry in his junior or eleventh grade year may wish to take either the Physics or the Chemistry Achievement Test, along with the Scholastic Aptitude Test, in March or May of that year. The Advanced Mathematics Achievement Test would normally be taken in March of a student's last year in school. The Board should be requested to send the scores directly to the Institute.

The Committee on Admissions will decide whether an applicant's complete set of College Board scores, along with the school marks and other supporting material, are satisfactory. A candidate who completes the tests in March and has submitted all other required material will be notified about admission sometime in early May.

ADMISSION WITH ADVANCED STANDING

A limited number of students whose previous studies entitle them to advanced standing credit will be accepted for the term beginning in September 1957.

SELECTION OF STUDENTS. Students who have completed one or more semesters with high standing at a recognized college, university, engineering school, or junior college and who are entitled to honorable dismissal may apply for admission by transfer. Their eligibility for admission will be determined by the Committee on Admissions after a review of their records. They will be expected in every case to have completed the academic preparation required of students entering the Institute from secondary schools.

Applicants for admission with advanced standing should take the test program described above, given by the College Entrance Examination Board. The afternoon achievement tests may be waived by the Committee on Admissions for applicants who have completed a substantial amount of college grade work in mathematics and science.

ADVANCED CREDIT. Students admitted by transfer may expect to receive advanced credit for subjects of study completed elsewhere which are substantially equivalent to corresponding Institute subjects. A grade above the lowest passing grade is necessary.

All such credits are provisional and become final only after the student has demonstrated his ability to do satisfactory work in the Course of his choice. Students whose records appear not to warrant advanced credit in a subject may be permitted to demonstrate by passing an advanced standing examination that they are entitled to such credit.

A student in another college contemplating later transfer should plan his program of study so as to cover the basic subjects of the Course he expects to enter, paying particular attention to mathematics and physics.

APPLICATION PROCEDURE. A request should be sent to the Director of Admissions for a Preliminary Application form when the student first considers transferring to the Institute. By having the completed form filed with the Director of Admissions,

the student will be assured of receiving any pertinent information as it becomes available. In the winter of 1956–57, final application material will be sent to the applicant. He should then submit to the Director of Admissions, enclosed in one envelope, the following:

1. Application for Admission with Advanced Standing, indicating all subjects which will have been completed at the time of transfer, and a non-returnable fee of ten dollars ($10.00). A check or money order is preferred.
2. Certified transcript of college record to date, including a statement of honorable dismissal or its equivalent. A certified statement covering subjects subsequently taken should be sent as soon as it is available.
3. Catalogue pages describing all subjects which will have been completed; the applicant's name should be written on each page and each subject indicated by a check mark in the margin. Complete catalogues should not be sent.

As soon as the applicant's status is determined he will be informed whether or not he is admitted and how much advanced credit he will be granted. In some cases, it may be necessary to defer action until final grades are available.

All remaining questions about credits must be settled within two weeks after the opening of the academic year. In these cases, the student should consult the Director of Admissions.

Applicants desiring credit in Electrical Engineering Laboratory should present their reports as well as their college records in that subject.

Applicants seeking admission with advanced standing in Architecture will be graded in Design in accordance with their performance in their first problem.

Except for those students who enter under the Combined Plan, students who have attended another college will not be eligible for scholarship aid until they have satisfactorily completed a year's work at M. I. T.

COMBINED PLAN OF STUDY WITH LIBERAL ARTS COLLEGES

While most prospective students of engineering, architecture, or industrial management enter the Institute directly from secondary school, some prefer to attend a liberal arts college before undertaking their professional training. A minimum of two years is generally required to qualify for the S.B. degree in engineering at M. I. T. after graduation from a liberal arts college. For architecture, three or four additional years are required. The total time and expense of this entire educational program may constitute serious obstacles, especially if the student then continues with post-graduate work, as more and more of the better students are finding it advisable to do. In general the Combined Plan is not intended for students who wish to major in a science.

In order to facilitate transfer from a liberal arts college to M. I. T., the Institute has entered into a combined arrangement with a selected group of colleges. Under this arrangement, and by properly planning his studies to include the basic sciences and humanities, a student of high standing may pursue a combined five-year program in which the first three years are spent at the college and the last two (or three, in the case of architecture) at the Institute, leading to the Bachelor's degree from each institution. Thus one year is saved, and the degrees of both institutions and the experience of residence in both are secured.

The academic program at M. I. T. consists of three basic elements: (1) education in the humanities and social sciences; (2) education in basic mathematics, science, and applied science; and (3) education in a professional field. A student may accomplish this program in four years at M. I. T. Or, through the Combined Plan, he may receive his education in the humanities and social sciences, basic mathematics, science, and in some cases applied science, at the liberal arts colleges. He receives further education in applied science and in a professional field at M. I. T. This alternative pattern offered by the Combined Plan extends his undergraduate education to only five years instead of a possible six or seven years.

A student who wishes to follow this program should seek admission to one of the colleges listed below. His later transfer to the Institute under this plan will be contingent on his receiving the recommendation of the college. A faculty adviser has been appointed by each college to assist students in planning their programs and to serve in a liaison capacity with the Institute.

The following colleges have united with the Institute in this program:

Amherst College, Amherst, Massachusetts
Bowdoin College, Brunswick, Maine
Carleton College, Northfield, Minnesota
Hamilton College, Clinton, New York
Miami University, Oxford, Ohio
Middlebury College, Middlebury, Vermont
Oberlin College, Oberlin, Ohio
Ohio Wesleyan University, Delaware, Ohio
Pomona College, Claremont, California
Reed College, Portland, Oregon
Ripon College, Ripon, Wisconsin
St. Lawrence University, Canton, New York
Washington and Jefferson College, Washington, Pennsylvania
Wesleyan University, Middletown, Connecticut
College of William and Mary, Williamsburg, Virginia
Williams College, Williamstown, Massachusetts
College of Wooster, Wooster, Ohio

SPECIAL STUDENTS

Qualified applicants wishing to carry on a special program of study with a clearly defined objective may be admitted as Special Students. Such students are not candidates for a degree.

A prospective Special Student should first obtain an application form from the Director of Admissions. The application and program of study must be approved by the department in which the major part of his work is to be carried on and by the Director of Admissions or Dean of the Graduate School. The applicant must present academic credentials of high quality or evidence of professional experience such as to justify the expectation that he can profitably undertake the program desired. In the absence of adequate academic preparation, Special Students will be required to take examinations in subjects prerequisite to those in which they wish to register.

FOREIGN STUDENTS

Students of foreign citizenship may enter the Institute only in the September term each year. Applications for admission are submitted to the Admissions Committee on May 1 of each year. Since the number of available places will be completely filled at the May 1 review, applications received after that date cannot be considered for the September term of that year but only, if requested, for a subsequent year.

In the Graduate School, applications for admission may be considered as early as March 1, and some notices about admission are mailed shortly after that date. Therefore, if you are making application to the Graduate School, there is some advantage in your completing your application before March 1. Applications completed between March 1 and May 1 will, of course, be given careful consideration.

In the Graduate School only, a few admissions may be possible in the Spring term beginning in February. If application is made for that term, and no vacancy is available, the application will be considered for the following September term.

Action will not be taken on admission until complete application material has been received. Applications accompanied by incomplete credentials cannot be considered.

UNDERGRADUATE COURSES OF STUDY

THE purpose of the undergraduate Courses of Study is to prepare young men and women to accept the responsibilities of citizenship in a democracy and the challenge of opportunities for professional leadership. A wide choice of courses is offered, based on a large number of specified programs, each designed to provide the student with a sense of values and a broad training in one professional field. Flexibility in planning a program is provided by options and by the possibility of substitution of other subjects for certain of those specified in the principal courses of study described.

These Courses are designed to provide intellectual development in both non-technical and professional fields. Each Course has four principal parts: elementary science, including mathematics; basic subjects in the general fields of science, engineering, or architecture, but not specific to a single professional field; an integrated four-year program in the humanities and social studies; and a program of subjects within a single professional field. The scientific and professional subjects are basic in nature, stressing the development of the power to apply fundamental principles to the many different problems which the graduate may expect to meet. They are not designed to give detailed knowledge of industrial or professional practice, as such knowledge is best acquired in the course of subsequent employment or by advanced training in a professional field as provided by the Graduate School.

Elementary science, including mathematics, is represented by subjects taken in the first and second years; basic subjects in science, engineering, or architecture by subjects in the second and third years. An integrated program in general education runs through the four years. Professional subjects within the field of the student's special interest are generally taken in the third, fourth, and, in some cases, a fifth year.

SELECTION OF COURSE OF STUDY

Incoming students generally have a well-defined preference for a specific field of professional interest, while others postpone a selection of a course of study until some time during their first year. The Institute is prepared to assist the latter group in formulating their plans, by outlining the opportunities in many fields with which they may not be familiar. Students are urged to take the initiative and investigate the different fields of architecture, engineering, science, and management and consult with staff members in each department.

In general, students are permitted a free choice of the courses of study offered, except when the demand for admission to certain Courses beyond the first year exceeds the staff and facilities available.

MODIFICATIONS IN COURSES OF STUDY

Although the majority of students elect to follow one of the courses of study as outlined in detail in the next section, these programs may be modified in various ways. Substitutions may be made for some of the subjects listed in the several courses, subject to approval by the head of the Course and the Committee on Academic Regulations, especially when the student desires to follow a logical course of studies differing from those listed. Students may obtain credit for subjects by taking examinations for advanced standing. In this way students of superior ability may progress more rapidly, or may include extra elective subjects in the course of a four-year program.

Attention is called to Courses IX-A and IX-B, in which students may follow a logical program of studies designed to meet individual needs and interests not satisfied by one of the other more rigidly specified courses of study.

REQUIREMENTS FOR THE BACHELOR'S DEGREE

To receive the Degree of Bachelor of Science (S.B.) or Bachelor in Architecture (B.Arch.) the student must have attended the Institute not less than one academic year which must in general be that next preceding his graduation. He must have completed the required curriculum for the Class with which he will graduate unless minor substitutions are permitted. No substitution will be permitted in the first- or second-year programs, excluding professional subjects, or in the Humanities Programs of the third and fourth years. Substitution is not permitted for professional subjects in the second year and for subjects marked with an asterisk (*) in the third and fourth years unless the proposed subject has practically the same subject content, same objectives, and at least the same number of units as the subject in the curriculum.

The ability of the student to perform original research is considered an important feature of his degree requirements, and theses are included in all curricula. All theses and records of work done in preparation of theses are the permanent property of the Institute, and must not be published, either wholly or in part, except by authorization of the heads of the respective departments.

In order to qualify for continued attendance at the Institute, students must meet the minimum requirements of the scholastic rating system.

In addition to the above academic requirements, the student must complete the Athletic Program to qualify for the Bachelor's degree.

PHYSICAL EDUCATION PROGRAM

All male students are required to compile a minimum of eight (8) points through participation in athletics and/or physical education activities. Medical examination, swimming, and physical fitness tests are administered for classification purposes. Those not meeting minimum standards are recommended for participation in developmental classes.

The eight points may be acquired within one academic year by choosing (a) to participate in any of eighteen varsity and freshman intercollegiate sports, (b) to participate in sports instructional classes or developmental classes according to individual needs and interests, or (c) a combination of these. Completion of the above Physical Education Program during the first two years is one of the requirements for the Bachelor's degree.

SYSTEM OF CREDITS

The credit hours associated with a subject indicate the *total* hours per week required in class and laboratory, and estimated outside preparation. The total credits for a subject are listed by two numbers: the first represents hours in class or laboratory, the second estimated preparation time for an average student. Thus the numbers

3–6 after a subject indicate that it involves three hours per week in class and an average of six hours per week of outside preparation. On this basis the normal student schedule is approximately 50 hours per week total time in class, laboratory, and in preparation. This means that a student taking a 50-hour schedule for a term of approximately 15 weeks is registered for 50 units credit, a unit being equivalent to 15 hours of work. The division of class time between lecture or recitation and drawing or laboratory is shown in the Tabulation of Subjects.

THE COURSES

In the following list each Course is indicated by its name and the Roman numeral associated with it.

School of Architecture and Planning

ARCHITECTURE, Course IV-A, leading to the degree of Bachelor in Architecture (B.Arch.) Subjects 4·00 to 4·99.

School of Engineering

Courses leading to the degree of Bachelor of Science (S.B.)

AERONAUTICAL ENGINEERING, Course XVI. Cooperative Course in Aeronautical Engineering, Course XVI-B. Subjects 16·00 to 16·99.

BUILDING ENGINEERING AND CONSTRUCTION, Course XVII. (Discontinued except for Class of 1957.) Subjects 17·00 to 17·99. For undergraduate work see Civil Engineering, Course I.

CHEMICAL ENGINEERING, Course X, and CHEMICAL ENGINEERING PRACTICE, Course X-B. Subjects 10·00 to 10·99.

CIVIL ENGINEERING, Course I. Subjects 1·00 to 1·99.

ELECTRICAL ENGINEERING, Course VI. Cooperative Course in Electrical Engineering, Course VI-A. Subjects 6·00 to 6·99.

GENERAL ENGINEERING, Course IX-B.

MECHANICAL ENGINEERING, Course II. Cooperative Course in Mechanical Engineering, Course II-B. Subjects 2·00 to 2·99 and D1 to D99.

METALLURGY, Course III. Subjects 3·00 to 3·99.

NAVAL ARCHITECTURE AND MARINE ENGINEERING Course XIII, and SHIPPING AND SHIPBUILDING MANAGEMENT, Course XIII-B. Subjects 13·00 to 13·99.

SANITARY ENGINEERING. For undergraduate work see Civil Engineering, Course I.

School of Science

Courses leading to the degree of Bachelor of Science (S.B.)

CHEMISTRY, Course V. Subjects 5·00 to 5·99.

FOOD TECHNOLOGY, Courses XX and XX-A, and BIOCHEMICAL ENGINEERING, Course XX-B. Subjects 20·00 to 20·99.

GENERAL SCIENCE, Course IX-A.

GEOLOGY AND GEOPHYSICS, Courses XII and XII-A. Subjects 12·00 to 12·99.

MATHEMATICS, Course XVIII. Subjects M1 to M99.

METEOROLOGY, Course XIX. (Discontinued except for Classes of 1957, 1958, and 1959.) Subjects 19·00 to 19·99.

PHYSICS, Course VIII. Subjects 8·00 to 8·99.

QUANTITATIVE BIOLOGY, Course VII. Subjects 7·00 to 7·99.

SCIENCE TEACHING, Course IX-C.

School of Humanities and Social Studies

Courses leading to the degree of Bachelor of Science (S.B.)

ECONOMICS, POLITICS, AND ENGINEERING, Course XIV-A, and ECONOMICS, POLITICS, AND SCIENCE, Course XIV-B. Subjects 14·00 to 14·99.

HUMANITIES AND ENGINEERING, Course XXI-A, and HUMANITIES AND SCIENCE, Course XXI-B. Subjects E1 to E99, H1 to H99, Mu1 to Mu99.

School of Industrial Management

Courses leading to the degree of Bachelor of Science (S.B.)

BUSINESS AND ENGINEERING ADMINISTRATION. Course XV-A, based on Physical Sciences; Course XV-B, based on Chemical Sciences. Subjects 15·00 to 15·99.

Roman numerals are used to designate courses of study. Individual subjects are numbered in arabic numerals according to the Department under which the instruction is given. Thus, subject 3·11 is a subject given by the Department of Metallurgy; it is included in several Courses of Study other than that in Metallurgy (Course III). Subjects given by Departments not offering courses of study include Air Science, subjects A1–A99; Languages, subjects L1 to L99; and Military Science, subjects MS1 to MS99.

Architecture (Course IV-A) requires five years for the Bachelor's degree. Courses VI-A, XII-A, XIII-B, and XX-A are of five years' duration, and lead to two degrees: Bachelor of Science and Master of Science, awarded simultaneously. Course VI-A is a cooperative course involving an organized schedule of work in industry. Course IX-C is also of five years' duration and leads to the degree of Bachelor of Science from the Massachusetts Institute of Technology and the degree of Master of Arts in Teaching from Harvard University.

In addition to the prescribed curricula given during the regular academic year from late in September until early in June, certain courses require professional instruction during a summer period, as indicated under the appropriate undergraduate schedules.

THE UNDERGRADUATE PROGRAM IN HUMANITIES AND SOCIAL SCIENCES

The humanities and social sciences are an integral part of education at M. I. T. Their purpose in the curriculum is to impress upon the student how important human relationships are in any society and to develop in him the first-rate human and social values which must accompany technical competence if an individual is to make his maximum contribution as a citizen.

The four-year program is based upon the theory that to achieve a well-balanced professional education a student should pursue these studies simultaneously with his studies in science and engineering. The program is constructed in a manner that will insure the student some breadth in the humanities during his first two years and some depth in a more limited area of either the humanities or social sciences in his third and fourth years.

In the first and second years each student will take a series of four subjects — H11, H12, H21, H22 — designed, through extensive readings in original texts, to provide an introduction to several areas in the humanities and social sciences and a foundation for more advanced study in those areas during the third and fourth years. For students with suitable preparation, special sections of the four basic subjects are offered in French by the Department of Modern Languages.

The objectives of this basic program are:

1. To give the student an introductory knowledge of the most important issues, ideas, periods, and events of the past, selected on the basis of their relevance to the world today.
2. To emphasize the interrelation of the various humanities and social sciences as elements in human experience rather than the distinctive features which characterize them as different areas of academic study.
3. To introduce the student to the process of critical thought as applied in the humanities and social sciences.

Practice in written and oral expression is an integral part of the two-year basic program. Students whose written papers show a lack of knowledge of the fundamentals of composition will be expected to attend remedial sections until the deficiency is remedied. If, at the end of the first year, a student's written work is unsatisfactory, he may receive a deficiency in composition which can be removed by passing E25.

With the exception of students registered in Courses XIV-A, XIV-B, XXI-A, and XXI-B, each student in his third year will elect one of the nine fields listed below as an area for further study. Three subjects taken in the third and fourth years must normally fall within this area while the fourth will usually be a distributional subject in a different area. A student may, if he wishes, elect two additional term subjects in the humanities and social sciences in lieu of two professional electives.

Students enrolled in Courses I, II, II-B, III, IV-A, VI, VI-A, XIII, XIII-B, XV-A, XV-B, XVI, XVI-B, XVII, XX, XX-A, XX-B are required to elect 14.01 sometime during their undergraduate programs unless required in a specific term as stated in the Undergraduate Course Schedules. Successful work in this subject will be credited either as the distributional requirement in humanities or as a part of an appropriate three-term combination.

Students enrolled in Courses XIII-B, XV-A, or XV-B may not select as their field of concentration Field Five, Economics, or Field Eight, Labor Relations.

SUBJECTS

First Year

First Term:
H11 Foundations of Western Civilization

Second Term:
H12 Foundations of Western Civilization

Second Year

First Term:
H21 Humanities
Option A: The United States: Men and Issues
Option B: Modern Western Ideas and Values

Second Term:
H22 Humanities
Option A: The United States: Men and Issues
Option B: Modern Western Ideas and Values

Third and Fourth Years

Any one of the following combinations of subjects may be taken without the approval of a Humanities Adviser. Other combinations are not prohibited but must be specifically approved by a Humanities Adviser.

Subjects indicated by a dagger (†) may be taken as a single subject to satisfy the distributional requirement.

FIELD ONE: HISTORY AND PHILOSOPHY

(Requirements: any three subjects, at least one of which must be in Group B.)

Group A:

†H31 American Social and Intellectual History
†H32 Political Process in Industrial America
†H34 Religious Thought and American Society
†H35 Europe: The Expansion of Europe
†H36 Modern Europe: War, Society, and the State
†H38 Russian Revolution and Soviet Union
†H51 American Economic Development
†H52T Business Leadership in the American Economy
†H55 History of Engineering
†H56 History of Engineering
†H58 Art and Industrial Civilization
†H63 American Foreign Policy in Action
†H71 Basic Ideas of Western Politics and Ethics, 500 B.C.–1500 A.D.
†H73 Science and Philosophy from Greeks to Copernicus
†H75T Philosophic Problems and Systems
†H76T Philosophic Problems and Systems
†H77 Classical Philosophy

Group B:

H65 Problems in Economic Development
H72 Rise of Modern Political and Social Science, 1500–1914
H74 Science and Philosophy from Galileo to Present
H81 Contemporary Ideas on Political and Economic Development
H82 Nationalism and National Development
H83 Philosophy of Science
H84 Topics in History of Science
H85 History and Historians
H91 Special Topics in History
H92 Special Topics in History

FIELD TWO: LITERATURE

†E31 Introduction to Literature, *plus any two of the following:*

E40 Epic Tradition in Literature
E42 Non-Western Literature
E43 English Drama before Ibsen
E44 Nature of Poetry
E45 Shakespeare
E46 Modern Drama since Ibsen
E47 Nineteenth-Century American Literature
E48 Twentieth-Century American Literature
E49 Russia and the West in Modern Russian Literature
E50 The Bible
E51 Modern Novel
E52 Comic Sensibility
E57 Special Readings
E58 Special Readings
L75 Language and Society
L78 Linguistic Structure

FIELD THREE: MODERN LANGUAGES

Group A — German:

L14 Intermediate German *or* †E31 Introduction to Literature, *plus any two of the following:*
†L15 German Literature 1919–1933
†L16 Literature of Postwar Germany
†L20 Great Books and Authors in German Literature

Group B — French:

L54 Intermediate French *or* †E31 Introduction to Literature, *plus any two of the following:*
†L55 Contemporary French Literature
†L56 French Literature of the Third Republic
†L59 Great Books and Authors in French Literature

FIELD FOUR: MUSIC

†Mu31 Introduction to Music *and* Mu32 Western Music from the Middle Ages to the Present, *plus one of the following:*
Mu42 Twentieth Century Music
Mu43 The Opera
Mu44 Classic String Quartet
Mu46 Principles of Music Criticism
Mu51 Seminar in Music

FIELD FIVE: ECONOMICS

†14·01 Economic Principles I *and* 14·02 Economic Principles II *and* *14·09 Economic Problems Seminar

FIELD SIX: POLITICAL SCIENCE

Group A:

†14·91 American Political System
and
†14·92 Comparative Political and Economic Systems
and
14·93 Seminar: Issues in Contemporary American Politics

Group B:

†14·01 Economic Principles I *or* †14·90 Government, Politics, and Technology
and
†14·91 American Political System *or* †14·92 Comparative Political and Economic Systems
and
14·93 Seminar: Issues in Contemporary American Politics

Group C:

†14·01 Economic Principles I *or* †14·81 Personality and Social Structure *or* †14·91 American Political System *or* †14·92 Comparative Political and Economic Systems *or* †H32 Political Process in Industrial America
and
14·95 Politics, Society, and Policy Making
and
14·96 Influences on Policy Decisions

FIELD SEVEN: INTERNATIONAL RELATIONS

†14·51 International Relations
and
14·52 Principles and Problems of American Diplomacy
and
14·53 Seminar in International Politics

FIELD EIGHT: LABOR RELATIONS

†14·01 Economic Principles I *or* †14·73 Organization and Communication in Groups *or* †14·81 Personality and Social Structure
and
†14·63 Labor Relations *and* 14·64 Labor Economics and Public Policy

FIELD NINE: PSYCHOLOGY

Any three of the following:

†14·70 Introductory Psychology
†14·73 Organization and Communication in Groups
14·75 Experimental Psychology
14·77 Psychology of Communication

* Other subjects in the same field may be substituted for this subject when appropriate and on the approval of the Department of Economics and Social Science. Approved subjects include among others: 14·03 Prices and Production, 14·40 Money and Income, 14·43 Public Finance, 14·54 International Trade, and 14·92 Comparative Political and Economic Systems.

UNDERGRADUATE COURSE SCHEDULES

All undergraduate course schedules on the following pages are in effect in 1956–57, unless otherwise indicated.

FIRST YEAR FOR ALL COURSES

THE first-year curricula include fundamental subjects that provide freshmen with a strong foundation for their professional studies. Because these curricula are basic in nature and broad in scope, they can be adapted readily to meet the requirements of any professional course. Thus, although the entering freshman is asked to choose a Course and to plan his first-year program to fulfill the requirements of that Course, he can change his Course at any time before the beginning of the sophomore year with minimum inconvenience. Entering students have an opportunity to discuss their programs with their Freshman Advisers during Freshman Week-End and throughout the year. The curricula listed below state minimum requirements.

An approved list of first year electives has been established to remove the rigidity of the freshman program and to offer the student the opportunity to broaden his knowledge and increase his perception of the social implications of the arts and sciences. During his first year a student in any course, except IV-A, is expected to take subjects from the list totaling at least six units. Failure to complete this requirement satisfactorily will mean the addition of six units to his later program. A student in Course IV-A is required to take 16 units of subjects from the approved list of electives, and failure to complete any part of this requirement will mean the addition of a corresponding number of units to his later program.

With his adviser's consent, a first-year student may take other subjects for which he is qualified in addition to the elective requirement. Most of such subjects will require more than six hours, and many will have final examinations. If such additional subjects are required in the student's later course, satisfactory completion of them in his freshman year will allow him later elective time.

First Year for Courses in the Schools of Engineering, Science, Humanities and Social Studies, and Industrial Management (All courses except IV-A)

First Term	5·01	Chemistry, General	6–5	*Second Term*	5·02	Chemistry, General	6–5
	8·01	Physics	5–6		8·02	Physics	5–6
	H11	Western Civilization, Found	3–5		H12	Western Civilization, Found	3–5
	M11	Calculus	3–6		M12	Calculus	3–6
	MS11	Military Science	3–0		MS12	Military Science	3–0
		or				or	
	AS11	Air Science	3–0		AS12	Air Science	3–0
		Elective Subject*	0 to 6			Elective Subject*	0 to 6
			42 to 48				42 to 48

* Elective subjects totaling at least 6 units for the academic year are to be selected from the list of Approved First-Year Elective Subjects below; the required 6 units may be taken in either term.

The Department of Aeronautical Engineering (Course XVI) and the Department of Naval Architecture and Marine Engineering (Course XIII) *require* Descriptive Geometry D12, 4–2, as the elective subject. The other Courses in the Schools of Engineering and of Industrial Management *recommend* a Graphics subject as the elective subject.

First Year for the School of Architecture and Planning (Course IV-A)

First Term	8·01	Physics	5–6	*Second Term*	8·02	Physics	5–6
	D11	Engineering Drawing	4–2		D12	Descriptive Geometry	4–2
	H11	Western Civilization, Found	3–5		H12	Western Civilization, Found	3–5
	M11	Calculus	3–6		M12	Calculus	3–6
	MS11	Military Science	3–0		MS12	Military Science	3–0
		or				or	
	AS11	Air Science	3–0		AS12	Air Science	3–0
		Elective Subject‡	5 to 11			Elective Subject‡	5 to 11
			42 to 48				42 to 48

‡ Elective subjects totaling at least 16 units for the academic year are to be selected from the list below.

Approved First-Year Elective Subjects†
(See pages 115–169 for Description of Subjects)

First Term	2·70	Creative Thinking	3–3	*Second Term*	1·001	Conservation of Natural Resources	2–4
	5·01	Chemistry, General (IV-A only)	6–5		2·70	Creative Thinking	3–3
	12·001	Astronomy	3–3		4·00	Structure of the City	3–3
	19·003	Elem. Meteorology I	3–3		5·02	Chemistry, General (IV-A only)	6–5
	20·00	Man's Food	3–3		7·00	Perspectives in Life Science	3–3
	D11	Engineering Drawing (All except IV-A)	4–2		12·00	Earth Science (Geol., Geophys., Geochem.)	2–4
	D111	Graphics Laboratory I	3–2		12·001	Astronomy	3–3
	D12	Descriptive Geometry (All except IV-A)	4–2		19·003	Elem. Meteorology I	3–3
	D13	Graphical Processes	2–4		D11	Engineering Drawing (All except IV-A)	4–2
	E11	English Composition	2–4		D12	Descriptive Geometry (All except IV-A)	4–2
	E37	Public Speaking	3–3		D121	Graphics Laboratory II	3–2
	H1	Philosophy & Scientific Method	2–4		D13	Graphical Processes	2–4
	L21	Spoken German§	3–3		D14	Nomography, Elementary	2–4
	L31	English for Foreign Students	3–3		E11	English Composition	2–4
	L61	Introduction to Spoken French§	3–3		E38	Public Speaking	3–3
	M100	Elem. Number Theory	2–4		H1	Philosophy & Scientific Method	2–4
		Language	¶		H2	American Character & Inst.	2–4
					L22	Spoken German§	3–3
					L62	Conversational French§	3–3
						Language	¶

† The number of students admitted to any one of these subjects will depend on the facilities available.
§ Prerequisite: 3 years of high school French or German, as the case may be, or the equivalent.
¶ Any language subject for which the student is prepared.

I. CIVIL ENGINEERING

CIVIL ENGINEERING has been called the foundation of modern civilization. You need only look at one of our great metropolitan areas to realize that the civil engineer is indispensable to urban life. He must design transportation systems — highways, expressways, and parking facilities; railways, rapid-transit facilities and airports; transmission systems and pipe lines. He designs, builds, and operates sanitary facilities — water-supply systems with their dams, aqueducts, and treatment plants that together carry water over long distances and purify it for domestic and industrial use; disposal systems that collect, treat, and dispose of the industrial and domestic wastes of the city. And he must design those large structures such as skyscrapers and industrial buildings without which cities, as we know them today, could not exist. Expenditures for construction represent one-tenth of our national income. To spend this money wisely is a challenge to the civil engineer.

For those who seek an outdoor life and the romance of faraway places, Civil Engineering in the many underdeveloped areas of the world may be appealing. But even greater opportunities lie in our own country — and, in fact, in our own cities — where slum areas, building shortages, water shortages, industrial waste pollution, and traffic strangulation are all demanding attention. There are some who believe that the future trend is toward decentralization of our cities. Should this be so, there are new communities to build and new networks of transportation to link them.

While many civil engineers are employed by private and governmental organizations, the opportunities for eventually establishing a business of one's own — either as a consulting engineer or as a contractor — are more favorable than in the other branches of the engineering profession.

The curriculum in Civil Engineering is arranged so that all students receive training in the basic principles of mathematics and science, in engineering science — such as the mechanics of solids, fluids and soils — and in civil engineering subjects such as surveying, engineering construction, structural engineering and foundation engineering. A system of fourth-year electives permits some degree of specialization in areas such as construction, structural and foundation engineering, sanitary engineering, hydraulic engineering, or transportation engineering; or if one prefers, the fourth-year program may be kept on a more general civil engineering basis.

The Department considers it desirable that students in Civil Engineering spend their summers on actual engineering jobs, and there is a placement program especially directed toward that objective. Second-year subjects in surveying and in civil engineering projects — with the latter aimed at developing an early perspective with respect to the broad scope of the Civil Engineering field — are helpful in connection with summer employment as well as with the entire educational program.

The Course leads to the degree of Bachelor of Science in Civil Engineering.

First Year (See page 49)

Second Year

First Term	1·01	Surveying I	8–0	*Second Term*	1·02	Surveying II	8–0
	1·901	Civil Eng. Projects I	6–4		1·40T	Statics & Dynamics	3–5
	8·03	Physics	5–5		1·902	Civil Eng. Projects II	4–2
	H21	Humanities	3–5		8·04	Physics	5–5
	M21	Calculus	3–6		H22	Humanities	3–5
	MS21	Military Science	3–0		M22	Differential Equations	3–6
		or			MS22	Military Science	3–0
	AS21	Air Science	3–0			or	
					AS22	Air Science	3–0
			28–20				29–23

Third Year

First Term	*1·41T	Materials & Mechanics	6–6	*Second Term*	*1·30	Soil Mech. & Found. Eng.	6–6
	*1·601T	Fluid Mechanics	2–4		*1·42T	Materials & Mechanics	6–6
	*1·911	Engineering Construction	5–4		*1·44T	Structural Eng., Elem.	6–2
	*6·18	Electrical Eng., Fund.	4–6		*1·602T	Fluid Mechanics	3–6
	*12·321	Engineering Geology	4–2		‡	Humanities	3–5
	‡	Humanities	3–5				
			24–27				24–25

Fourth Year

(In effect 1957–58)

First Term	†*1·441	Structural Design	6–0	*Second Term*	†*1·442	Reinforced Concrete Des.	6–0
	*1·451	Structural Analysis	3–6		*2·41	Heat Engineering	4–5
		*Thesis	2			*Thesis	7
		‡Humanities	3–5			‡Humanities	3–5
		‡‡Elective Subjects (see next page)	24			‡‡Elective Subjects (see next page)	18
			49				48

* See Requirements for Bachelor's Degree, page 45.
† 1·443 Structural Design, 7–2, and 1·444 Reinforced Concrete Des., 7–2, may be substituted for 1·441 and 1·442.
‡ 14·01 Economic Principles I, 3–5 is a requirement for graduation and must be one of the Humanities subjects taken. See page 47 for list of Humanities subjects.
‡‡ Students may, if they wish, elect two additional term subjects in the Humanities and Social Sciences (page 47) in lieu of elective subjects.

I. Civil Engineering Continued

First Term Elective Subjects

1·201	Transportation Planning	6–3
1·31	Soil Engineering	3–6
1·43	Materials, Adv.	2–4
†1·443	Structural Design	7–2
1·621	Fluid Mechanics Lab.	6–0
1·701	Hydrology & Hydraul. Eng.	3–6
1.751	Water Supply & Purification	3–6
1·781	Sanitary Science	3–6
1·921	Building Construction	3–3
1·931	Dwelling House Constr.	3–3
15·11	Indust. Management, Int.	3–6
15·41	Finance	3–6
15·50	Accounting	5–4
15·61	Business Law	3–6

Second Term Elective Subjects

1·04	Surveying, Adv.	5–4
1·202	Transportation Eng.	6–3
†1·444	Reinforced Concrete Des.	7–2
1·452	Structural Analysis	3–6
1·702	Hydraulic Engineering	3–6
1·761	Sewerage & Sewage Treatment	3–6
1·782	Sanitary Engineering	3–6
1·922	Construction Management	3–3
15·11	Indust. Management, Int.	3–6
15·41	Finance	3–6
15·61	Business Law	3–6

For students interested in specific fields of Civil Engineering, such as Construction, Hydraulic, Sanitary, Structural and Foundation, or Transportation Engineering, the subjects listed below are suggested. To these may be added other subjects of the student's choice, as time permits.

Construction Engineering

First Term	1·43	Materials, Adv.	2–4	*Second Term*	†1·444	Reinforced Concrete Des.	7–2
	†1·443	Structural Design	7–2		1·452	Structural Analysis	3–6
	1·921	Building Construction	3–3		1·922	Construction Management	3–3
	1·931	Dwelling House Constr.	3–3				

Hydraulic Engineering

First Term	1·621	Fluid Mechanics Lab.	6–0	*Second Term*	1·702	Hydraulic Engineering	3–6
	1·701	Hydrology & Hydraul. Eng.	3–6				

Sanitary Engineering

First Term	1·621	Fluid Mechanics Lab.	6–0	*Second Term*	1·702	Hydraulic Engineering	3–6
	1·701	Hydrology & Hydraul. Eng.	3–6		1·761	Sewerage & Sewage Treatment	3–6
	1·751	Water Supply & Purification	3–6		1·782	Sanitary Engineering	3–6
	1·781	Sanitary Science	3–6				

Structural and Foundation Engineering

First Term	1·31	Soil Engineering	3–6	*Second Term*	†1·444	Reinforced Concrete Des.	7–2
	†1·443	Structural Design	7–2		1·452	Structural Analysis	3–6

Transportation Engineering

First Term	1·201	Transportation Planning	6–3	*Second Term*	1·04	Surveying, Adv.	5–4
	1·31	Soil Engineering	3–6		1·202	Transportation Eng.	6–3

Fourth Year (1956–57 only)

Option 1. Theory and Design

First Term	*1·35	Soil Mech. & Found. Eng.	6–6	*Second Term*	1·42	Structural Analysis	3–6
	*1·41	Structural Analysis	3–6		1·442	Reinforced Concrete Des.	6–0
	¶1·441	Structural Design	6–0		*1·94	Professional Problems	2–4
	1·621	Fluid Mechanics Lab.	6–0			*Thesis	9
		‡Humanities	3–5			¶‡Humanities	3–5
		Elective Subject (see next page)	12			Elective Subject (see next page)	9
			53				47

* See Requirements for Bachelor's Degree, page 4-5

† 1·443 Structural Design, 7–2, and 1·444 Reinforced Concrete Des., 7–2, may be substituted for 1·441 and 1·442.

‡ 14·01 Economic Principles I, 3–5 is a requirement for graduation and must be one of the Humanities subjects taken. See page 47 for list of Humanities subjects.

¶ Students particularly interested in Sanitary Engineering may omit 1·441 and add ‡Humanities, 3–5, in the first term; in the second term omit ‡Humanities, 3–5, and add 1·79 Sanitary Engineering Design, 6–0.

I. Civil Engineering Continued

*First Term Elective Subjects***

1·201	Transportation Planning	6–3
1·70	Hydrology	6–6
1·75	Water Supply & Purification	6–6

*Second Term Elective Subjects***

1·202	Transportation Engineering	6–3
1·71	Hydraulic Engineering	6–3
1·76	Sewerage & Sewage Treatment	6–3

OPTION 3. CONSTRUCTION AND MANAGEMENT

First Term	*1·35	Soil Mech. & Found. Eng.	6–6
	*1·41	Structural Analysis	3–6
		‡Humanities	3–5
		Elective Subjects	21
			50

Second Term	1·42	Structural Analysis	3–6
	1·442	Reinforced Concrete Des.	6–0
	*1·94	Professional Problems	2–4
		*Thesis	9
		‡Humanities	3–5
		Elective Subjects	12
			50

*First Term Elective Subjects***

1·201	Transportation Planning	6–3
1·28	Highways & Airports	3–3
1·441	Structural Design	6–0
1·72	Hydrology & Hydraulic Eng.	3–3
2·41	Heat Engineering	4–5
15·41	Finance	3–6
17·43	Building Construction	5–4

*Second Term Elective Subjects***

1·202	Transportation Engineering	6–3
1·602	Fluid Mechanics	2–4
1·77	Water Supply & Sewerage	3–3
15·11	Indust. Management, Int.	3–6
15·61	Business Law	3–6

II. MECHANICAL ENGINEERING

THE Course in Mechanical Engineering is planned to provide a foundation of basic science applied to engineering methods and techniques to prepare the graduate to enter any industry dealing with heat, power, materials or machinery. The Course does not attempt to give a complete training in current commercial practice, nor does it give complete specialized knowledge of the product of any one industry. The training is focused not only on mastery of principles and facts, but attention is also given to development of personality and the ability to make critical judgments.

The curriculum during the first two years provides a thorough training in the basic subjects of mathematics, chemistry, physics and materials. During the junior and senior years the student becomes familiar with the mechanics of fluids and solids, thermodynamics, properties of materials, materials processing and certain aspects of electrical engineering. Applications of these fundamental subjects are made in the analysis and design of mechanical equipment and processing. Instruction by lectures is paralleled by laboratory work. The student is given opportunity not only to familiarize himself with materials, machinery and instrumentation but also to develop his ability to apply theory and judgment to the solution of engineering problems with due consideration to the economic factors involved.

In the fourth year the students are encouraged to select a field of major interest around which their study program is centered. For this purpose certain subjects have been arranged in a number of groups, each representing a field of endeavor which is of importance in contemporary industry and which has been found to attract student enthusiasm. The developments of laboratories and staff facilities which have taken place in this department during the last few years have made possible the new elective group system.

All students of the Mechanical Engineering Department are urged to obtain six months, or at least one summer, of practical experience in some industrial activity of their own choice before graduation.

The Course leads to the degree of Bachelor of Science in Mechanical Engineering.

HONORS COURSE

The opportunity will be afforded a limited number of students of superior ability to join an Honors Course group. The selection of members of this group will be made by the Department from students who may wish to avail themselves of the opportunity to pursue a coordinated schedule of studies through the senior and graduate years.

A member of the Department will serve as adviser to aid the members of the group in selecting the senior and graduate schedules which may be best suited to their individual interests. The program of subjects selected must (1) have the approval of the Department adviser, (2) fulfill the unit requirements of both the senior year (including the time allotted to Bachelor's thesis) and the graduate year, and (3) include a thesis of not less than 30 units in the graduate year. Before registration for the graduate year, the students selected under this plan must have had at least two months of industrial employment satisfactory to the Department.

The Honors Course leads to the degrees of Bachelor of Science and Master of Science in Mechanical Engineering awarded simultaneously at the end of the graduate year.

*See Requirements for Bachelor's Degree, page 45

‡ 14·01 Economic Principles I, 3–5 is a requirement for graduation and must be one of the Humanities subjects taken. See page 47 for list of Humanities subjects.

** The elective subjects have been selected as those most pertinent to the objectives of each option. Students may, however, under special conditions, substitute electives from the other option provided that they have the necessary prerequisites and the approval of their registration officer. Students may, if they wish, elect two additional term subjects in the Humanities and Social Sciences (page 47) in lieu of elective subjects.

II. Mechanical Engineering Continued

FIRST YEAR (See page 49)

SECOND YEAR

First Term	2·001	Applied Mechanics I	3–5	*Second Term*	2·002	Applied Mechanics II	3–5
	2·701	Machine Drawing	6–0		3·11	Engineering Metals	6–4
	2·85	Machine Tools, Int.	4–1		8·04	Physics	5–5
	8·03	Physics	5–5		H22	Humanities	3–5
	H21	Humanities	3–5		M22	Differential Equations	3–6
	M21	Calculus	3–6		MS22	Military Science	3–0
	MS21	Military Science	3–0			or	
		or			AS22	Air Science	3–0
	AS21	Air Science	3–0				23–25
			27–22				

THIRD YEAR

First Term	*2·003	Applied Mechanics III	4–8	*Second Term*	*2·25	Fluid Mechanics	4–8
	*2·403	Heat Engineering	4–8		*2·37	Mech. Behavior of Materials	4–4
	*2·73	Machine Design	4–2		*2·421	Heat Engineering	3–6
	*6·18	Electrical Eng., Fund.	4–6		*2·731	Machine Design	5–4
		‡Humanities	3–5		*2·86	Machine Tool Fund.	3–2
			19–29			‡Humanities	3–5
							22–29

FOURTH YEAR

Each student is required to take 2·082, 8 units of laboratory in an engineering field, thesis or project, and two terms of Humanities. In addition, each student must take a total of at least 52 units of approved Elective Subjects, irrespective of the time division between the two terms of the fourth year. The following programs in the fields of interest listed below are suggested. The "Additional Subjects" may be any choice approved by the Registration Officer, and may include two Humanities subjects.

GROUP 1. POWER

First Term	2·252	Fluid Mechanics	3–6	*Second Term*	2·082	Mech. Eng. Problems	3–6
	2·43	Heat Engineering	3–6		2·56	Power Plant Eng.	6–6
	2·68	Engineering Laboratory	4–4			*Thesis	9
		‡Humanities	3–5			‡Humanities	3–5
		Additional Subjects	17			Additional Subject	8
			51				46

GROUP 2. AIRCRAFT PROPULSION

First Term	2·252	Fluid Mechanics	3–6	*Second Term*	2·082	Mech. Eng. Problems	3–6
	2·47	Aircraft Propulsion	3–6		2·48	Gas Turbines	4–5
	2·68	Engineering Laboratory	4–4			*Thesis	9
		‡Humanities	3–5			‡Humanities	3–5
		Additional Subjects	17			Additional Subjects	11
			51				46

GROUP 3. AIR CONDITIONING AND REFRIGERATION

First Term	2·252	Fluid Mechanics	3–6	*Second Term*	2·082	Mech. Eng. Problems	3–6
	2·43	Heat Engineering	3–6		2·621	Refrigeration	3–6
	2·663	Air Conditioning	3–6			*Thesis	9
	2·68	Engineering Laboratory	4–4			‡Humanities	3–5
		‡Humanities	3–5			Additional Subjects	12
		Additional Subject	8				47
			51				

* See Requirements for Bachelor's Degree, page 45.
‡ 14·01 Economic Principles I, 3–5 is a requirement for graduation and must be one of the Humanities subjects taken. See page 47 for list of Humanities subjects.

II. Mechanical Engineering Continued

Group 4. Internal Combustion Engines

First Term	2·081	Strength of Materials	3–6	*Second Term*	2·082	Mech. Eng. Problems	3–6
	2·791	Internal Combustion Eng.	3–6		2·792	Internal Combustion Eng.	3–6
	2·7941	Internal Combustion Eng. Lab.	2–2		2·7942	Internal Combustion Eng. Lab.	2–2
		‡Humanities	3–5			*Thesis	9
		Additional Subjects	21			‡Humanities	3–5
			51			Additional Subject	8
							47

Group 5. Materials and Materials Processing

First Term	2·081	Strength of Materials	3–6	*Second Term*	2·082	Mech. Eng. Problems	3–6
	2·31	Mech. Prop. of Materials	4–6		2·32	Mech. Prop. of Materials	4–6
	2·68	Engineering Laboratory	4–4			*Thesis	9
		‡Humanities	3–5			‡Humanities	3–5
		Additional Subjects	14			Additional Subjects	15
			49				51

Group 6. Design

First Term	2·081	Strength of Materials	3–6	*Second Term*	2·082	Mech. Eng. Problems	3–6
	2·732	Machine Design	4–5		2·68	Engineering Laboratory	4–4
	2·78	Hydraulic Mach. & Controls	5–4			*Thesis	9
		‡Humanities	3–5			‡Humanities	3–5
		Additional Subjects	14			Additional Subjects	17
			49				51

Group 7. Production

First Term	2·732	Machine Design	4–5	*Second Term*	2·082	Mech. Eng. Problems	3–6
	M32	Statistics, Elementary	3–6		2·68	Engineering Laboratory	4–4
		‡Humanities	3–5		15·71	Production Management	3–6
		Additional Subjects	23			*Thesis	9
			49			‡Humanities	3–5
						Additional Subject	8
							51

Group 8. Textiles

First Term	2·081	Strength of Materials	3–6	*Second Term*	2·082	Mech. Eng. Problems	3–6
	2·901	Fabric Structure, Prin.	3–6		2·68	Engineering Laboratory	4–4
	2·903	Textile Manufacturing, Elem.	3–6		2·904	Textile Manufacturing, Prin.	3–6
		‡Humanities	3–5			*Thesis	9
		Additional Subjects	14			‡Humanities	3–5
			49			Additional Subject	8
							51

Group 9. Nuclear Engineering§

First Term	2·43	Heat Engineering	3–6	*Second Term*	2·082	Mech. Eng. Problems	3–6
	2·68	Engineering Laboratory	4–4		8·052	Atomic & Nuclear Physics II	4–5
	8·051	Atomic & Nuclear Physics I	4–5			*Thesis	9
		‡Humanities	3–5			‡Humanities	3–5
		Additional Subjects	14			Additional Subjects	15
			48				50

* See Requirements for Bachelor's Degree, page 45.

‡ 14·01 Economic Principles I, 3–5 is a requirement for graduation and must be one of the Humanities subjects taken. See page 47 for list of Humanities subjects.

§ Primarily for students intending to specialize in Nuclear Engineering in their graduate work. It is suggested that M351 and M352 Advanced Calculus for Engineers be among the Additional Subjects elected.

II-B. MECHANICAL ENGINEERING

Cooperative Course (Four Years)

THE objective of the II-B Cooperative Course in Mechanical Engineering is to give students the opportunity to acquire a background of industrial experience prior to the professional work of the fourth year. It provides a period of approximately six months of practical experience, between the end of the sophomore year and the beginning of the senior year, with a selected industrial concern. This is accomplished by rearranging the schedule of subjects taken in the junior year. The academic program is the same as that of the regular Course in Mechanical Engineering. Except for the period when the student is away from the Institute he is able to participate in all extracurricular activities with his own classmates.

The activities of the students away from the Institute vary for each company. The principal objective is to give the students a background for the environment in which they are likely to work after graduation. The cooperating companies have been invited to participate in this program on the basis of their progressive and sympathetic attitude towards this form of training and the benefit which it provides.

The number of students which can be accommodated is limited and consequently registration in the cooperative course is restricted to students of marked aptitude with clear records in the first two years. Admission to the Course is subject to the approval of the Institute and the cooperating companies. College transfer students may be admitted under equivalent conditions.

Students who are interested in this program should apply to Department Headquarters for a set of application forms not later than January 2 of their sophomore year. These forms should be completed and returned by January 15. A statement indicating preference for location and class group desired should be included. A list of cooperating companies is available at the Headquarters of the Department of Mechanical Engineering.

Representatives of the cooperating companies are invited to interview interested students. They will determine, jointly with the Department representative, the distribution of those selected. Students thus chosen become regularly paid employees of a company during the period at the plant and are subject to the usual regulations of that company. They are expected to carry the Course through to completion unless prevented from doing so by exceptional circumstances.

Juniors in the Cooperative Course are also eligible for selection to the Honors Course described under Course II, Mechanical Engineering.

The Course leads to the degree of Bachelor of Science in Mechanical Engineering.

(*Same as Course II through Second Year*)

Group A

Third Year

Summer

Vacation (Approximately 7 weeks)

At Plants (Remainder of Summer)

*2·951 Industrial Practice ..... 40 h.p.w.

Regular Academic Year

		At Plants		*At M. I. T.*	
First Term	*2·952	Industrial Practice ..... 40 h.p.w.	*Second Term* *2·003	Applied Mechanics III	4–8
			*2·403	Heat Engineering	4–8
			*2·73	Machine Design	4–2
			*6·18	Electrical Eng., Fund.	4–6
			‡	Humanities	3–5
					19–29

Fourth Year

Summer

At M. I. T.

*2·25	Fluid Mechanics	4–8
*2·421	Heat Engineering	3–6
*2·731	Machine Design	5–4
*2·86	Machine Tool Fund.	3–2
		15–20

Regular Academic Year

Same as Fourth Year in Course II with the following exception: Students must include in their fourth year program 2·37 Mech. Behavior of Materials, 4–4, and additional ‡Humanities, 3–5.

* See Requirements for Bachelor's Degree, page 45.

‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken. See page 47 for list of Humanities subjects.

II-B. Mechanical Engineering Continued

GROUP B

THIRD YEAR

Summer

At M. I. T.

*2·003	Applied Mechanics III	4–8
*2·403	Heat Engineering	4–8
*2·73	Machine Design	4–2
*2·86	Machine Tool Fund.	3–2
		15–20

Regular Academic Year

	At M. I. T.			*At Plants*	
First Term	*2·25	Fluid Mechanics	4–8	*Second Term*	*2.952 Industrial Practice . . . . . 40 h.p.w.
	*2·421	Heat Engineering	3–6		
	*2·731	Machine Design	5–4		
	*6·18	Electrical Eng., Fund.	4–6		
	‡	Humanities	3–5		
			19–29		

FOURTH YEAR

Summer

At Plants (First 7 weeks)

*2·951 Industrial Practice . . . . . 40 h.p.w.

Vacation (Remainder of Summer)

Regular Academic Year

Same as Fourth Year in Course II with the following exception: Students must include in their fourth year program 2·37 Mech. Behavior of Materials, 4–4, and additional ‡Humanities, 3–5.

III. METALLURGY

METALLURGY is an engineering science that deals with the production, utilization, and behavior of metals and their alloys. The field is quite broad because it is based on physics and chemistry, which are necessary for an understanding of the metallic state; it also relates to chemical engineering in the extraction of metals from their ores and to mechanical engineering in the fabrication of metals into useful forms for ultimate service. There are three main reasons for focussing these disciplines on metals: metals comprise about three-fourths of the elements in the periodic system, and thus are of immense scientific interest as fundamental matter of the universe; metals have remarkable properties as a class of materials that make them particularly useful to mankind; and many metals are available in nature in such quantity and form that they can be produced at reasonable cost in pure or alloyed condition. Accordingly, to a large extent, metals have become the "working substance" of modern industry; it has been estimated that forty per cent of all the jobs in America are connected directly or indirectly with the manufacture and use of steel alone. Moreover, the field is a lively one in research and development because it is now clear that the efficient operation of such complex devices as gas turbines, jet engines, guided missiles, and nuclear reactors will depend not only on the design but also on the materials of construction.

The Course in Metallurgy offers opportunity for study in all phases of the science and engineering of metals. In view of the scope of this area of knowledge, the curriculum contains a core of basic science and engineering subjects and, in the junior and senior years, a wide choice among numerous elective subjects.

The core consists primarily of mathematics, physics, chemistry, and the humanities, along with an introduction to metal science and the engineering principles involved in the extraction and application of metals. The student learns the basic thermodynamics, unit processes, and mechanical operations which underlie the making and shaping of metals; he also studies the inner structure of metals as a foundation for understanding their properties and for selecting the right materials to meet service requirements. He is introduced to the laws governing the alloying of metals and the principles by which new alloys may be developed.

The large block of elective time permits the student to polarize his metallurgical studies in the direction of his interests or to take additional subjects in metallurgical engineering, metal processing, and physical metallurgy. For example, students who are interested in ores and their beneficiation will elect subjects in mineral engineering and geology. A combined program of metallurgical and chemical engineering is feasible for those who wish to concentrate more on the production of metals. Students who are mechanically inclined may elect sequences of subjects leading to machine design, stress analysis, and metal forming. Opportunities are also afforded for combining metallurgy with other disciplines, such as electrical engineering, nuclear engineering, the humanities, or business administration. For students who lean toward science, the curriculum may include a substantial block of subjects in mathematics and physics.

A well integrated system of faculty counseling provides professional guidance to students in the selection of electives during the third and fourth years. However, each

* See Requirements for Bachelor's Degree, page 45.

‡ 14·01 Economic Principles I, 3–5 is a requirement for graduation and must be one of the Humanities subjects taken. See page 47 for list of Humanities subjects.

III. Metallurgy Continued

student must assume the responsibility for planning his program, and the planning is begun under faculty supervision during the latter part of the second year.

The metallurgical engineer of today finds his services in demand by many kinds of metal-producing and metal-consuming industries. Some of these companies are engaged in extracting metals from ores, employing such operations as ore dressing, smelting, refining, and alloying. Other companies are concerned with metal shaping by casting, forging, or welding, and with the heat treatment of metal parts used in manufacture. The metallurgist also plays a prominent role in research on metallurgical phenomena and in the development of new processes and alloys to meet the increasingly severe needs of modern technology.

The Course leads to the degree of Bachelor of Science in Metallurgy.

FIRST YEAR (See page 49)

SECOND YEAR

First Term	2·001	Applied Mechanics I	3–5	*Second Term*	2·002	Applied Mechanics II	3–5
	3·11	Engineering Metals	6–4		3·00T	Extractive Metallurgy	6–4
	8·03	Physics	5–5		8·04	Physics	5–5
	H21	Humanities	3–5		H22	Humanities	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
		or				or	
	AS21	Air Science	3–0		AS22	Air Science	3–0
			23–25				23–25

THIRD YEAR

First Term	3·31	Physical Metallurgy I	7–4	*Second Term*	3·01	Metallurgical Engineering I	4–4
	5·61	Physical Chemistry I	4–4		3·011	Metallurgical Eng. Lab. I	3–1
		‡Humanities	3–5		†5·62	Physical Chemistry II	4–4
		§Elective Subjects	23			‡Humanities	3–5
			50			§Elective Subjects	20
							48

Students registered in the third year, first term, 1956–57: Omit Elective Subjects, 23. Add 2·371 Testing Materials Lab., 2–2, 3·81 Mineral Engineering I, 5–4, and Science Elective Subject, 6 to 9.

REQUIRED DURING SUMMER

3·10	Metallurgical Plant Visits	3–1

FOURTH YEAR

First Term	3·20	Metal. Thermodynamics	4–4	*Second Term*		*Thesis	10
	3·50	X-ray Metallurgy	4–4			‡Humanities	3–5
		‡Humanities	3–5			¶Elective Subjects or additional Thesis	27
		*Thesis	2				45
		¶Elective Subjects	24				
			50				

Metallurgy Elective Subjects for Third and Fourth Years

Each student is expected to plan his own schedule of elective subjects in cooperation with a Faculty Adviser whose approval is required. The elective program is expected to include subjects both within and without the Department of Metallurgy. The following is a list of elective subjects offered within the Department.

3·02	Metallurgical Engineering II	4–4	3·51	Physics of Metals	2–4
3·021	Metallurgical Eng. Lab. II	3–1	3·61T	Elec. & Magnetic Materials	2–4
3·03	Metallurgical Engineering III	3–6	3·70	Ceramics	2–4
3·13	Foundry Engineering	2–4	3·701	Ceramics Lab.	3–0
3·15	Welding Engineering	2–4	3·81	Mineral Engineering I	5–4
3·16	Powder Metallurgy	2–4	3·82	Mineral Engineering II	4–4
3·18	Plastic Working of Metals	2–4	3·83	Mineral Engineering III	6–4
3·32	Physical Metallurgy II	6–6	3·85	Quantitative Mineragraphy	5–2
3·33	Physical Metallurgy III	6–4	3·87	Ore Testing	10–0
3·42	Electrochemistry	2–4			

*See Requirements for Bachelor's Degree, page 45.

†8·07 Thermo. & Statist. Mech., 4–5, may be substituted for 5·62.

‡14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken. See page 47 for list of Humanities subjects.

§Elective Subjects may be selected in Metallurgy or in other fields. It is recommended that 3·02 Metallurgical Eng. II, 4–4, and 3·021 Metallurgical Eng. Lab., 3–1, or 3·32 Physical Metallurgy II, 6–6, be among the Elective Subjects.

¶Up to 6 units of additional thesis may be substituted for Elective Subjects in the fourth year, second term. Students may, if they wish, elect two additional term subjects in the Humanities and Social Sciences (page 47) in lieu of elective subjects.

IV-A. ARCHITECTURE

THE objective of the Course in Architecture is to produce graduates who will be effective and valuable in planning and executing all kinds of building projects. The professional contribution includes understanding building needs of communities and individuals, ability to analyze accurately the requirements in specific cases, skill in the effective and orderly disposition of building elements on sites and in the organization of interior spaces, coordination of the general plan with a simple and economical structural system, research into best methods and materials of construction, control over proportions and details to achieve effective and eloquent expression and integration of planning with equipment and materials necessary to maintain desired conditions of health, enjoyment, and convenience.

Unusual opportunities are available for fundamental training in the basic sciences underlying building technology, for close contact with outstanding laboratory and research facilities in engineering fields related to architecture, and for understanding the broad economic and social approach of the city planner. In recognition of a vital need in the profession for ever greater technical ability and judgment, the curriculum in Architecture integrates technical resources with social and cultural needs.

The Course leads to the degree of Bachelor in Architecture.

First Year (See page 49)

Second Year

First Term	2·001	Applied Mechanics I	3–5	*Second Term*	2·04	Strength of Materials	3–6
	¶4·02	Form & Design	9–11		¶4·11	Architectural Design	9–11
	8·03	Physics	5–5		8·04	Physics	5–5
	H21	Humanities	3–5		H22	Humanities	3–5
	MS21	Military Science	3–0		MS22	Military Science	3–0
		or				or	
	AS21	Air Science	3–0		AS22	Air Science	3–0
			23–26				23–27

Third Year

First Term	*4·131	Architectural Design	9–11	*Second Term*	*4·132	Architectural Design	9–11
	*4·31	Structural Analysis	8–0		*4·32	Structural Analysis	8–0
	*4·53	City Planning Theory	2–4		*4·66	History of Architecture	3–5
	*4·65	History of Architecture	3–5		*17·73	Mat. — Wood, Plastics, Fabrics	3–3
		‡Humanities	3–5			‡Humanities	3–5
			25–25				26–24

Fourth Year

First Term	*2·661	Heating & Ventilation	2–4	*Second Term*	*2·662	Heating & Ventilation	2–4
	*4·141	Architectural Design	12–8		§*4·142	Architectural Design	12–8
		‡Humanities	3–5		*17·74	Materials — Masonry & Metals	5–4
		Elective Subjects (see below)	14			‡Humanities	3–5
			48			Elective Subject (see below)	6 to 8
							49 to 51

Fifth Year

(In effect 1957–58)

First Term	*4·04	Light & Color	9–11	*Second Term*		*Thesis	20
	**4·151	Architectural Design	12–8			Elective Subjects (see below)	28
		Elective Subjects (see below)	8				48
			48				

Elective Subjects

Each student is expected to plan with his registration officer an elective program based primarily on the subjects listed below. He may include additional subjects in the Humanities, and he may propose appropriate graduate subjects or subjects from other curricula if he is properly qualified.

4·051	Graphic Presentation	6–0		4·70	Urban Sociology	2–4
4·052	Graphic Presentation	6–0		4·81	Land Economics	2–4
4·33	Structures Seminar	2–4		6·16	Electricity	3–6
4·34	Structures Seminar	2–4		6·17	Illumination	2–4
4·41T	Architectural Acoustics	3–5		14·20	Building Economics	2–4
4·42	Special Problems	Time arr.				

* See Requirements for Bachelor's Degree, page 45.

‡14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken. The required third- and fourth-year Humanities may be distributed as desired in the last three years of Course IV-A, provided a schedule satisfactory to the Department can be arranged. See page 47 for list of Humanities subjects.

§ On the termination of 4·142 Architectural Design, the student's total progress in architectural design will be appraised by his instructor. If this progress is deemed to be insufficient, the student may be required to register for subjects in architectural design beyond the stated curriculum before being allowed to register for thesis.

¶Registration officer will assign approximately one-half of students to take 4·11 in first term in place of 4·02. These students will take 4·02 in second term.

**4·18 Collaborative Design, 9–11, may be substituted for 4·151.

IV-A. Architecture Continued

FIFTH YEAR (1956–57 only)

First Term	4·051	Graphic Presentation	6–0	*Second Term*	4·052	Graphic Presentation	6–0
	*4·65	History of Architecture	3–5		*4·66	History of Architecture	3–5
	*4·751	Architectural Design	12–9		14·20	Building Economics	2–4
	4·81	Land Economics	2–4			*Thesis	21
		Elective Subject	8			Elective Subject	8
			49				49

IV-B. CITY PLANNING

THE Department of City and Regional Planning is concerned primarily with a program of teaching and research at the graduate level. However, undergraduate electives in city planning, land economics, and similar subjects are offered by the Department and thus are available for selection by students whose major interest is in a related field, such as Architecture or Civil Engineering.

A careful selection of elective subjects by prospective candidates for graduate work in City and Regional Planning may result in a reduction in the normal time needed to complete the requirements for the Master's degree in this field. For example, by making full use of elective time in the upper undergraduate years of Courses IV-A, Architecture, or IX-B, General Engineering, a qualified student might be able to complete the requirements for the degree of Master in City Planning, except for thesis, in two academic terms. Students who expect to apply eventually for admission to the graduate course in City Planning should discuss their undergraduate programs with the Department's registration officer, preferably before the end of their second year.

Course I, Civil Engineering, Course XIV-A, Economics and Engineering, Course XV, Business and Engineering Administration, and Course XXI-A, Humanities and Engineering, are also considered by the Department to be appropriate avenues of approach to graduate work in City Planning, provided full advantage is taken of elective subjects to meet undergraduate prerequisites.

V. CHEMISTRY

THE main objective of the Course in Chemistry is to provide a general and fundamental education based on science for those who seek the Bachelor's degree and a career in some field in which a sound knowledge of chemistry is important, and for those who wish to go on to graduate study and a professional career in chemistry.

Students receive thorough instruction in the principles of inorganic, analytical, organic and physical chemistry, supplemented by instruction in mathematics and physics, in the humanities, including English, History, German, French, and other nonprofessional subjects.

In the third and fourth years, elective time is available to enable the student to extend his knowledge in fields of special interest. Students intending to take graduate work, for example, may elect a series of subjects tending to increase their ability to utilize the opportunities in graduate study. Students intending to enter industry may take subjects which offer the fundamentals in a selected field of science or engineering. Elective time may be used for additional subjects in the humanities.

Elective series are available in advanced analytical, inorganic, nuclear, organic, and physical chemistry; in chemical engineering, ceramics, textiles, economics, physics, mathematics, geology, biology and biochemistry, food technology, and metallurgy.

The Course aims to stimulate and develop the research attitude, and the schedule includes a thesis in the fourth year to provide an opportunity for the student to demonstrate his aptitude for creative effort.

The Course leads to the degree of Bachelor of Science in Chemistry.

FIRST YEAR (See page 49)

SECOND YEAR

First Term	5·10	Qualitative Analysis	11–3	*Second Term*	5·13	Quantitative Analysis	12–4
	8·03	Physics	5–5		8·04	Physics	5–5
	H21	Humanities	3–5		H22	Humanities	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
		or				or	
	AS21	Air Science	3–0		AS22	Air Science	3–0
		§Language	3–5				
			28–24				26–20

* See Requirements for Bachelor's Degree, page 45.
§ Students should acquire a reading knowledge of German and French. Additional subjects in German and French will be credited as Elective time.

V. Chemistry Continued

THIRD YEAR

First Term	5·41	Organic Chemistry I	4–4	*Second Term*	5·42	Organic Chemistry II	4–4
	5·414	Organic Preparations I	9–0		5·424	Organic Prep. II. & Anal.	9–0
	5·61	Physical Chemistry I	4–4		5·62	Physical Chemistry II	4–4
	5·613	Physical Chem. Lab. I	6–2		5·623	Physical Chem. Lab. II	6–2
		†Humanities	3–5			†Humanities	3–5
		Elective Subject	8			Elective Subject	8
			49				49

FOURTH YEAR

First Term	5·061	Inorganic Chemistry, Adv.	2–4	*Second Term*	5·062	Inorganic Chemistry, Adv.	2–4
	5·43	Organic Chemistry III	2–4		5·44	Organic Chemistry IV	2–4
		*Thesis	15			*Thesis	15
		†Humanities	3–5			†Humanities	3–5
		Elective Subjects	15			Elective Subjects	15
			50				50

Students are expected to take as electives two of the following subjects: 5·66 Surface & Colloid Chem., 2–4; 5·67 Atomic & Molec. Struct., Int., 2–4; 5·68 Kinetics of Chem. React., 2–4. (5·75 may be substituted for 5·67.)

VI. ELECTRICAL ENGINEERING

THE field of electrical engineering has become one of great variety and scope. Its products and services influence the daily living of most of the world's population. Much of its growth has been compressed into a relatively short period of time; so short, that the changes involved appear to be almost revolutionary. Moreover, there is every reason to believe that continued growth and change will prevail for many years to come.

These considerations present a unique challenge to the prospective student and to the teacher of electrical engineering. In a field where new concepts and new developments are steadily appearing, professional study and professional training must do more than achieve competence to handle the problems and the requirements of the present. The student must search for deep understanding of his work, and not merely for the development of specific skills and methods.

The objective of the Course in Electrical Engineering is to enable the student to meet this challenge, and thus to provide an enduring basis upon which he can establish a career in any of the professional, industrial, or business areas which depend upon electrical engineering. Emphasis is placed throughout the Course on the needs and aptitudes of the individual, and various features of the program contribute strongly to the development of initiative, judgment, resourcefulness, and responsibility. Individual study, under staff guidance, is encouraged. Close association among staff and students is a vital element in the educational atmosphere. Laboratory work includes a large proportion of project activity in which the stress is placed on individual experimental investigations, performed under supervision, rather than on standardized experiments. Small class sections serve to encourage vigorous and healthy discussion among students of similar interests.

In preparation for his career, the electrical engineering student must develop a working mastery of the basic sciences of mathematics and physics, with emphasis on mechanics, electricity and magnetism, and thermodynamics. On these are built his professional study of the principles of electrical engineering and their applications. It is equally vital, however, that the student learn to deal effectively with non-technical situations and problems. His ultimate level of responsibility is likely to be influenced quite as much by his understanding of people, judgment, sense of values, and breadth of outlook as by his technical competence. The humanities and social studies, therefore, form an important and integral part of his program. Special emphasis is given to the development of ability to write and speak English effectively.

A major feature of the professional program of the second, third, and fourth years is the group of eight classroom-laboratory subjects which are required for all students in the Department. In the classroom emphasis is placed first on basic principles and methods of analysis, and then on their applications to a broad range of specific electrical processes and equipment. The student becomes aware that these principles and applications form a closely integrated body of electrical science. By the study of elective subjects and through his thesis research in the fourth year, he achieves a still deeper understanding of the significance of that basic science, through its application to problems in a field of his own choice.

While the laboratory program is coordinated with the work of the classroom, its objectives go beyond the mastery of related experimental facts, methods, and techniques. Here the student encounters the need for engineering judgment, team work, and careful planning. He sharpens his ability to observe and gains confidence in making decisions. The major objective is the development of independent, creative thought and initiative, through a program which requires the student to assume a progressively increased responsibility for the planning and execution of his laboratory work.

The profession of electrical engineering is one which brings rich intellectual and spiritual rewards. These satisfactions are enhanced for the engineer who remains a student of his subject. The Course in Electrical Engineering is designed to impart attitudes and habits which lead the student to continue to study, whether in graduate school, by industrial training programs, or by self-study.

The Course leads to the degree of Bachelor of Science in Electrical Engineering.

* See Requirements for Bachelor's Degree, page 45. † See page 47 for list of subjects.

VI. Electrical Engineering Continued

FIRST YEAR (See page 49)

SECOND YEAR

First Term	2·001	Applied Mechanics I	3–5	*Second Term*	2·002	Applied Mechanics II	3–5
	6·00	Circuit Theory, Int.	7–5		6·01	Circuit Theory, Int.	7–5
	8·031	Physics	5–5		8·041	Physics	5–5
	H21	Humanities	3–5		H22	Humanities	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
		or				or	
	AS21	Air Science	3–0		AS22	Air Science	3–0
			24–26				24–26

THIRD YEAR

First Term	*6·02	Electronic Circuits	7–5	*Second Term*	*6·04	Elec. Energy Conversion	7–5
	*6·03	Fields, Energy & Forces	7–5		*6·05	Applied Electronics	7–5
	M351	Adv. Calculus for Eng.	3–6			‡Humanities	3–5
		‡Humanities	3–5			§§Elective Subjects	18
		**Elective Subject	9				50
			50				

**Elective Subject must be selected from the following:

2·40	Heat Engineering	4–5
8·051	Atomic & Nuclear Physics I	4–5

§§Elective Subjects should be selected from the following, or equivalent out-of-department subjects:

2·07	Dynamics	3–6
2·42	Heat Engineering	3–6
8·052	Atomic & Nuclear Physics II	4–5
M352	Adv. Calculus for Eng.	3–6

FOURTH YEAR

First Term	*6·06	Electromech. Power Modulators	7–5	*Second Term*		*Thesis	7
	*6·07	Energy Trans. & Rad.	6–5			‡Humanities	3–5
		*Thesis	2			¶Elec. Subjects or Additional Thesis	30
		‡Humanities	3–5				45
		¶Elective Subjects	12				
			45				

VI-A. ELECTRICAL ENGINEERING

COOPERATIVE COURSE

THE engineering graduate, before he can take responsibility for important industrial projects, must have an educational background of sound fundamental scientific and economic principles, and in addition, must be acquainted with industrial practices in his specialized field of employment. This interlinking of theory and practice is provided in the Cooperative Course in Electrical Engineering, in which a selected group of students pursues a course of study and practice which correlates the scientific and engineering principles of the classroom and laboratory with approximately seventy weeks of practical experience in the plants of a particular industry. This educational plan makes it possible for the student to do his "undergraduate" work in industry in parallel with his undergraduate academic studies at the Institute and, at the time of graduation, to be in a position to utilize immediately the more advanced principles studied in the senior and graduate years. The first four years are identical in academic content with that of Course VI. The fifth or final year includes a complete academic year of graduate work subject to the provisions of the Graduate School.

Candidates for admission to the third year are selected from the second-year class at the Institute, and from transfer students who have completed substantially the equivalent of the first two years of Course VI. Since the Course leads to the Master's degree, acceptance into the cooperative year is made by the Institute on the basis of a promising scholastic record, and by the companies upon personal qualifications which indicate adaptability to the work of the company involved.

Each class is divided into two groups (A and B) which alternate after the second year, one group studying at the Institute in Cambridge while the other group is working at the plants of the cooperating companies.

The men when in training at the plants are subject to the usual company regulations. They receive regular compensation for their work. During the practice periods classes are held two evenings a week in academic subjects.

Students who are admitted to a course with the approval of both parties are expected to carry it through to completion unless prevented by exceptional circumstances. Also, the companies are expected to continue the course of practical training to completion for the students who have already enrolled. At the conclusion of the course graduates are not obligated to accept employment with the cooperating company, nor is the company obligated to offer such employment.

The Course leads to the degrees of Bachelor of Science and Master of Science in Electrical Engineering awarded simultaneously at the end of the graduate year.

The following nine organizations offer the plant experience.

The GENERAL ELECTRIC COMPANY affords practical experience in many areas, emphasis being placed on training for the technical and executive responsibilities incident to the electrical manufacturing industries. The

* See Requirements for Bachelor's Degree, page 45.
‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken. See page 47 for list of Humanities subjects.
¶Registration Officers should be consulted for suitable elective subjects. A total of 16 units of additional Humanities may be elected.

VI-A. Electrical Engineering Continued

manufacturing practice is taken in plants located in Lynn, Schenectady, Pittsfield, Syracuse, Erie, Bridgeport and Philadelphia. The earlier assignments deal with the manufacturing processes and planning, and the testing of manufactured products. The later assignments may include research or development projects in the various laboratories and engineering offices.

The Boston Edison Company affords practical experience as related to maintenance, operation and administration of a company which furnishes electric light and power as a public service. Students trained in the plants of the Company work on projects involving general repair and maintenance, the handling of customer relations, the operation of generating stations, and the solution of transmission and distribution engineering problems.

The Bell Telephone Laboratories offer experience in communications research and development. Students receive assignments, which are generally in the apparatus development, switching systems development, and transmission systems development departments. Special assignments in other development departments or in the research departments may be arranged if such appear to be to the best interest of the students and the Laboratories. Work locations will be in New York City or at the suburban laboratory in Murray Hill, New Jersey.

The General Radio Company provides practical experience in the manufacture of communications and electronic apparatus. The first period is spent in the factory where the student becomes acquainted with shop practices, materials and products of manufacture. The second term is spent in the instrument calibration laboratory, where the students learn to test the behavior of manufactured instruments or of experimental models which may be in the developmental stage. The third term is spent as Junior Engineering Assistant in the development laboratories, and the final term is specially arranged to meet the needs of the individual student.

The Philco Corporation offers laboratory experience in many fields, including radio and television. Regular student assignments are in the radio engineering, factory engineering, and research departments. Special assignments are made to students having special interests. While regular assignments are directed toward training men for developmental and research work upon completion of the course, these special assignments may lead a man to many other departments of the company, including, for example, the patent department.

The American Gas and Electric Service Corporation offers practical experience in the operation and planning of a large power network. Assignments will be in New York City, headquarters of the Corporation. Field trips to Virginia, Indiana, and Ohio in connection with operation, construction, and maintenance are contemplated. A joint program with the General Electric Company is also available in which the student alternates his assignments between the two companies. Opportunities in the field of power research are offered.

The Naval Ordnance Laboratory carries out investigations in both pure and applied science. The Laboratory affords experience in research, development, design, and evaluation of mines, depth charges, fuses, torpedo mechanisms, pyrotechnics, ammunition components, demolition outfits, and many other items of Naval Ordnance. Students may expect assignments in the Research, Engineering and Technical Evaluation Departments in the fields of acoustics, physical optics, terrestrial magnetism, piezoelectricity, explosive phenomena, interior ballistics, electrochemistry, X-ray techniques, mechanical computation, applied statistics, numerical mathematics methods, exterior ballistics, gas dynamics, supersonic aerodynamics, hydrodynamics, plastics research and technology. Assignments in other parts of the Laboratory will be made whenever there is a special interest indicated by the student.

The Air Force Cambridge Research Laboratories offer opportunity to participate in varied problems of organized research directed primarily toward National Defense. The work performed includes research in the field of microwave optics, solid state physics, geophysics, communication and radar electronics, as well as construction, maintenance, testing, analysis and circuit design.

The Raytheon Manufacturing Company offers experience in the development and manufacture of electronic equipment including radar systems, underwater sound equipment, digital and analog computers, television, microwave systems, and communications equipment; of tubes including magnetrons, klystrons, television tubes, receiving tubes, miniature and subminiature tubes, and germanium and silicon type diodes and transistors; and of components such as special purpose transformers, toroids, delay lines, and computer components. Engineering assignments are made in development, design and process engineering. Assignments may be made in research in the last year and would include the fields of solid state devices, micro-waves, ultrasonics, magnetics and servomechanisms. Laboratory and production facilities involved in this program are located near Boston, in Newton, Waltham, Quincy, Lowell, Wayland and Bedford.

International Business Machines Corporation offers industrial experience in research, development, design, and associated manufacturing activities in the field of electronic digital computers, data processing machines, business machines, and time equipment. Assignments may be on solid-state devices and other components, circuits and circuit networks, programming, systems test, and production test equipment. On any assignment, the degree of student responsibility will depend upon his abilities and experience at that time. Work locations will be in the Poughkeepsie-Kingston and Endicott-Owego areas of New York State.

(*Same as Course VI through Second Year*)

GROUP A

THIRD YEAR

At M. I. T.

Summer	*6·02	Electronic Circuits	7–5
Term	*6·03	Fields, Energy, & Forces	7–5
		¶Elective Subject	9
			33

¶Elective Subject must be selected from the following:

2·40	Heat Engineering	4–5
8·051	Atomic & Nuclear Physics I	4–5

* See Requirements for Bachelor's Degree, page 45.

VI-A. Electrical Engineering Continued

At Plants

First Term	M351	Adv. Calculus for Eng.	3–6
	6·901		
	6·905		
	6·911	Industrial Practice .....40 h.p.w.	
	6·931	(Students to register for one of these sub-	
	5·941	jects.)	
	6·951		
	6·961		
	6·971		
	6·981		
	6·991		

At M. I. T.

Second Term	*6·04	Elec. Energy Conversion	7–5
	*6·05	Applied Electronics	7–5
	M352	Adv. Calculus for Eng.	3–6
		‡Humanities	3–5
		§§Elective Subject	9
			50

§§Elective Subject should be selected from the following, or equivalent out-of-department subjects;

2·07	Dynamics	3–6
2·42	Heat Engineering	3–6
8·052	Atomic & Nuclear Physics II	4–5

Fourth Year

At Plants

Summer Term	*6·071	Energy Trans. & Rad.	3–5
	6·902		
	6·906		
	6·912	Industrial Practice .....40 h.p.w.	
	6·932	(Students to register for one of these sub-	
	6·942	jects.)	
	6·952		
	6·962		
	6·972		
	6·982		
	6·992		

At M. I. T.

First Term	*6·06	Electromech. Power Modulators	7–5
	*6·072	Energy Trans. & Rad. Lab.	3–0
		‡Humanities	3–5
		‡Humanities	3–5
		Prof. Elective Subjects	18
			49

At Plants

Second Term	‡14·01	Economic Prin. I — Humanities	3–5
	6·903		
	6·907		
	6·913	Industrial Practice .....40 h.p.w.	
	6·933	(Students to register for one of these sub-	
	6·943	jects.)	
	6·953		
	6·963		
	6·973		
	6·983		
	6·993		

Students registered in the fourth year, second term, 1956–57: Omit 14·01. Add Prof. Elective Subject, 9.

Graduate Year

At Plants

Summer Term		Elective Subject	9
	6·904		
	6·908		
	6·914	Industrial Practice .....40 h.p.w.	
	6·934	(Students to register for one of these sub-	
	6·944	jects.)	
	6·954		
	6·964		
	6·974		
	6·984		
	6·994		

At M. I. T.

First Term		Graduate Study & Thesis	48
			48

At M. I. T.

Second Term		Graduate Study & Thesis	48
			48

* See Requirements for Bachelor's Degree, page 45.

‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken, as specified. See page 47 for list of Humanities subjects.

VI-A. Electrical Engineering Continued

Group B

Third Year

At Plants

Summer Term	*6·021	Electronic Circuits	3–5
	6·901	Industrial Practice — 40 h.p.w. (Students to register for one of these subjects.)	
	6·905		
	6·911		
	6·931		
	6·941		
	6·951		
	6·961		
	6·971		
	6·981		
	6·991		

At M. I. T.

First Term	*6·022	Electronic Circuits Lab.	4–0
	*6·03	Fields, Energy & Forces	7–5
	‡14·01	Economic Prin. I — Humanities	3–5
	M351	Adv. Calculus for Eng.	3–6
		‡Humanities	3–5
		¶Elective Subject	9
			50

¶Elective Subject must be selected from the following:

2·40	Heat Engineering	4–5
8·051	Atomic & Nuclear Physics I	4–5

At Plants

Second Term	M352	Adv. Calculus for Eng.	3–6
	6·902	Industrial Practice — 40 h.p.w. (Students to register for one of these subjects.)	
	6·906		
	6·912		
	6·932		
	6·942		
	6·952		
	6·962		
	6·972		
	6·982		
	6·992		

Fourth Year

At M. I. T.

Summer Term	*6·04	Elec. Energy Conversion	7–5
	*6·05	Applied Electronics	7–5
		Prof. Elective Subject	9
			33

At Plants

First Term	*6·071	Energy Trans. & Rad.	3–5
	6·903	Industrial Practice — 40 h.p.w. (Students to register for one of these subjects.)	
	6·907		
	6·913		
	6·933		
	6·943		
	6·953		
	6·963		
	6·973		
	6·983		
	6·993		

At M. I. T.

Second Term	*6·06	Electromech. Power Modulators	7–5
	*6·072	Energy Trans. & Rad. Lab.	3–0
		‡Humanities	3–5
		‡Humanities	3–5
		Prof. Elective Subject	9
		§Elective Subject	9
			49

§Elective subject should be selected from the following, or equivalent out-of-department subjects:

2·07	Dynamics	3–6
2·42	Heat Engineering	3–6
8·052	Atomic & Nuclear Physics II	4–5

Graduate Year

At Plants

Summer Term		Elective Subject	9
	6·904	Industrial Practice — 40 h.p.w. (Students to register for one of these subjects.)	
	6·908		
	6·914		
	6·934		
	6·944		
	6·954		
	6·964		
	6·974		
	6·984		
	6·994		

At M. I. T.

First Term		Graduate Study and Thesis	48
			48

At M. I. T.

Second Term		Graduate Study and Thesis	48
			48

* See Requirements for Bachelor's Degree, page 45.

‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken, as specified. See page 47 for list of Humanities subjects.

VII. QUANTITATIVE BIOLOGY

THE curriculum in the biological sciences is devised to furnish fundamental training in pure and applied biology which may prepare students for professional careers in biology (teaching and research), for medical training, and for work involving technical applications in industries concerned with biological materials and fermentation processes. Stress is laid on the application of quantitative, analytical methods in the subjects of pure biology, hence particular emphasis is given to those fields which, in the present stage of development, are susceptible of such treatment.

The first two years are devoted to fundamental subjects in mathematics, physics, and chemistry plus introductory biology and studies in the humanities; specialization begins in the third year. While the student is assured of a sound background in the basic sciences of mathematics, physics and chemistry, and the fundamentals of modern biology, provision is made in the third and fourth years for a wide choice of electives both in the biological sciences and in the humanities.

Modern medicine is rapidly becoming less empirical and more scientific so that it is especially important, for those who wish to prepare for medical research, to become acquainted with the quantitative approach to biological phenomena.

The Course leads to the degree of Bachelor of Science in Quantitative Biology.

FIRST YEAR (See page 49)

SECOND YEAR

First Term	7·01	General Biology I	3–4	*Second Term*	5·12	Quantitative Analysis	7–3
	7·011	General Biology Lab. I	3–0		7·02	General Biology II	3–4
	8·03	Physics	5–5		7·021	General Biology Lab. II	3–1
	H21	Humanities	3–5		8·04	Physics	5–5
	M21	Calculus	3–6		H22	Humanities	3–5
	MS21	Military Science	3–0		M22	Differential Equations	3–6
		or			MS22	Military Science	3–0
	AS21	Air Science	3–0			or	
		Elective Subject	8		AS22	Air Science	3–0
			48				27–24

THIRD YEAR

First Term	*5·41	Organic Chemistry I	4–4	*Second Term*	*5·62	Physical Chemistry II	4–4
	*5·416	Organic Preparations I	6–0		*5·621	Physical Chem. Lab. II	4–2
	*5·61	Physical Chemistry I	4–4		*7·04	Embryology	8–4
	*5·611	Physical Chem. Lab. I	4–2			†Humanities	3–5
	*7·03	Genetics & Cytology	6–4			Elective Subjects	12
		†Humanities	3–5				46
			27–19				

FOURTH YEAR

First Term	*7·05	Gen. Biochem. & Physiol. I	3–6	*Second Term*	*7·06	Gen. Biochem. & Physiol. II	3–6
	*7·051	Gen. Biochem. & Physiol. Lab. I	8–0		*7·061	Gen. Biochem. & Physiol. Lab. II	6–0
		*Thesis	10			*Thesis	10
		†Humanities	3–5			†Humanities	3–5
		Elective Subjects	12			Elective Subjects	16
			47				49

VIII. PHYSICS

THE Course in Physics is intended to give its graduates a broad and fundamental training in both experimental and theoretical physics. This preparation is of sufficient depth and breadth so that the graduate is well equipped to build his professional career either in industry in a field of applied physics, or in undertaking graduate education in physics, to fit him for an industrial or academic professional life involving fundamental research, or the more advanced aspects of physics. In addition to a central core of requirements for the bachelor's degree, it is the intent of the curriculum to enable each student to select a considerable variety of subjects and to proceed at a pace best suited to his individual desires and capabilities.

The Course leads to the degree of Bachelor of Science in Physics.

FIRST YEAR (See page 49)

SECOND YEAR

First Term	8·031	Physics	5–5	*Second Term*	6·10	Elec. Circuit Theory, Elem.	4–8
	H21	Humanities	3–5		8·041	Physics	5–5
	M21	Calculus	3–6		H22	Humanities	3–5
	MS21	Military Science	3–0		M22	Differential Equations	3–6
		or			MS22	Military Science	3–0
	AS21	Air Science	3–0			or	
		¶Elective Subjects	18		AS22	Air Science	3–0
			48			¶Elective Subject	6
							48

* See Requirements for Bachelor's Degree, page 45. † See page 47 for list of subjects.
¶ Students are required to take one term of chemistry in addition to 5·01 and 5·02.

VIII. Physics Continued

THIRD YEAR

First Term	*8·05	Phys.: Atoms, Molec. & Nucl. I	4–6	*Second Term*	6·02	Electronic Circuits	7–5
	*8·08	Electronics	4–5		*8·06	Phys.: Atoms, Molec. & Nucl. II	4–6
	*8·09	Exp. Atomic Phys. I	6–3		*8·10	Exp. Atomic Phys. II	4–2
	M351	Adv. Calculus for Eng.	3–6		M352	Adv. Calculus for Eng	3–6
		†Humanities	3–5			†Humanities	3–5
			20–25				21–24

Students registered in the third year, first term, 1956–57, who took the sequence M21, M351 in the second year: Omit M351. Add M352 Adv. Calculus for Eng., 3–6.

Students registered in the third year, second term, 1956–57, who omitted M22 and took the sequence M21, M351, M352: Omit M352. Add Elective Subject, 9. Students who have already passed M352 may take 8·07 or 8·71 as an elective.

FOURTH YEAR

First Term	*8·11	Experimental Physics	8–4	*Second Term*	*8·07	Thermodyn. & Statist. Mech.	4–5
	*8·72	Int. Theoretical Physics II	4–8		*8·71	Int. Theoretical Physics I	4–8
		*Thesis	1			*Thesis	12
		†Humanities	3–5			†Humanities	3–5
		¶Elective Subjects	12			¶Elective Subject	8
			45				49

Students registered in the fourth year, second term, in 1956–57 and 1957–58, who took the sequence M21, M351, M352 (omitting M22), and who elected and passed 8·07 or 8·71 as the Elective Subject required in the third year, second term, must take an additional Elective Subject, 9, in place of the 8·07 or 8·71 already passed.

IX-A. GENERAL SCIENCE

IX-B. GENERAL ENGINEERING

In the general areas of science and of engineering there are many fascinating and important professional fields which are, nevertheless, not of such major size as to warrant the establishment of a separate curriculum for each. Thorough training adapted to many of these fields is available in Courses IX-A and IX-B, both of which permit great flexibility in the choice of subjects.

These curricula may take many forms; for example, the student may prepare for a specific field of science or engineering, for entrance into a specific industry, or for a specific enterprise. Recognizing the key importance of trained liaison personnel equipped to deal with more than one specialty, he may develop a program combining two or more fields.

Whatever the student's ultimate objective, it is desirable that he have a strong basic training in either science or engineering. To assure this thorough groundwork, certain essential subjects are included in Course IX-A, General Science, and in Course IX-B, General Engineering. In addition, the electives in the third and fourth years must include at least 48 units in an appropriate field of science or engineering.

Additional electives enable the student to round out his major program and add such other subjects as may interest him. His choice of electives is subject to the approval of the Head of Courses IX-A and IX-B. The outlines below give the required subjects and a list of electives.

Course IX-A leads to the degree of Bachelor of Science in General Science.

Course IX-B leads to the degree of Bachelor of Science in General Engineering.

IX-A. GENERAL SCIENCE

FIRST YEAR (See page 49)

SECOND YEAR

First Term	5·11	Qualitative Analysis	7–3	*Second Term*	5·12	Quantitative Analysis	7–3
	8·03	Physics	5–5		8·04	Physics	5–5
	H21	Humanities	3–5		H22	Humanities	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
		or				or	
	AS21	Air Science	3–0		AS22	Air Science	3–0
		Elective Subject	8			Elective Subject	8
			48				48

* See Requirements for Bachelor's Degree, page 45. † See page 47 for list of subjects.
¶ Students are required to take one term of chemistry in addition to 5·01 and 5·02.

IX–A. General Science Continued

Third Year

First Term	**5·61	Physical Chemistry I	4–4	*Second Term*	**5·62	Physical Chemistry II	4–4
	**8·08	Electronics	4–5		**8·07	Thermodyn. & Statist. Mech.	4–5
	**M351	Adv. Calculus for Eng.	3–6		**M352	Adv. Calculus for Eng.	3–6
		†Humanities	3–5			†Humanities	3–5
		§Elective Subjects	16			§Elective Subjects	16
			50				50

Fourth Year

First Term	*Thesis	4	*Second Term*	*Thesis	5
	†Humanities	3–5		†Humanities	3–5
	§Elective Subjects	36		§Elective Subjects	35
		48			48

First Term Suggested Elective Subjects

5·41	Organic Chemistry I	4–4
5·414	Organic Preparations I	9–0
5·611	Physical Chem. Lab. I	4–2
7·01	General Biology I	3–4
7·011	General Biology Lab. I	3–0
8·05	Phys.: Atoms, Molec. & Nucl. I	4–6
8·09	Exp. Atomic Physics I	6–3
8·72	Int. Theoretical Physics II	4–8
12·321	Engineering Geology	4–2
20·41	Bacteriology	7–3

Second Term Suggested Elective Subjects

5·42	Organic Chemistry II	4–4
5·424	Org. Prep. II & Anal.	9–0
5·621	Physical Chem. Lab. II	4–2
7·02	General Biology II	3–4
7·021	General Biology Lab. II	3–1
7·04	Embryology	8–4
8·15	Photography	2–1
8·16	Optics	3–6
8·17	Color Measurements	3–2
8·71	Int. Theoretical Physics I	4–8
12·322	Engineering Geology	2–4
M32	Statistics, Elem.	3–6

IX-B. GENERAL ENGINEERING

First Year (See page 49)

Second Year

First Term	2·001	Applied Mechanics I	3–5	*Second Term*	2·002	Applied Mechanics II	3–5
	8·03	Physics	5–5		8·04	Physics	5–5
	H21	Humanities	3–5		H22	Humanities	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
		or				or	
	AS21	Air Science	3–0		AS22	Air Science	3–0
		Elective Subject	9			Elective Subject	9
			47				47

Third Year

First Term	**2·40	Heat Engineering	4–5	*Second Term*	**2·42	Heat Engineering	3–6
	**3·11	Engineering Metals	6–4			†Humanities	3–5
	**6·18	Electrical Eng., Fund.	4–6			¶Elective Subjects (see next page)	33
		†Humanities	3–5				50
		¶Elective Subjects (see next page)	13				
			50				

Fourth Year

First Term	*Thesis	4	*Second Term*	*Thesis	5
	†Humanities	3–5		†Humanities	3–5
	¶Elective Subjects (see next page)	36		¶Elective Subjects (see next page)	35
		48			48

* See Requirements for Bachelor's Degree, page 45. † See page 47 for list of subjects.

** Substitutions may be made only with subjects in the same field.

§ Total elective subjects for the third and fourth years must include a total of at least 48 units in one field of science. Elective subjects other than those suggested will be approved if they conform to the student's general objective.

¶ Total elective subjects for the third and fourth years must include a total of at least 48 units in one field of engineering. Elective subjects other than those suggested will be approved if they conform to the student's general objective.

IX-B. General Engineering Continued

First Term Suggested Elective Subjects

2·003	Applied Mechanics III	4–8
2·081	Strength of Materials	3–6
2·663	Air Conditioning	3–6
2·681	Engineering Laboratory	3–3
2·701	Machine Drawing	6–0
2·73	Machine Design	4–2
2·791	Internal Combustion Eng.	3–6
5·11	Qualitative Analysis	7–3
15·50	Accounting	5–4
M351	Adv. Calculus for Eng.	3–6

Second Term Suggested Elective Subjects

1·40	Structural Analysis	3–6
1·613	Fluid Resist. & Turb. Diff.	3–6
2·50	Heat Transfer	4–4
2·621	Refrigeration	3–6
2·792	Internal Combustion Eng.	3–6
6·19	Electronic Instrument	4–6
15·61	Business Law	3–6
M352	Adv. Calculus for Eng.	3–6

IX-C. SCIENCE TEACHING

(In cooperation with the Harvard Graduate School of Education)

WELL-trained and broadly educated teachers of science and mathematics in secondary schools and junior colleges are playing an increasingly important part in our society, and are in active demand in both public and independent schools. Such a teaching career requires, in addition to adequate general education, a background in mathematics and the natural sciences, with some concentration in one of these, as well as training in education as a professional field. The fact that M. I. T. and Harvard University are neighboring institutions in Cambridge makes it possible for the education subjects to be taken at the Harvard Graduate School of Education, under a cooperative agreement.

The first three years are spent mainly at the Institute, though some education subjects at Harvard University are introduced as early as the third year. Continuance beyond the third year requires formal application for admission to the Harvard Graduate School of Education. In general, an average of less than C in all M. I. T. subjects will make acceptance doubtful. The graduate year includes practice teaching in nearby secondary schools, as well as further studies in education at Harvard University, and more advanced work in mathematics and science at the Institute.

Course IX-C leads to the degree of Bachelor of Science in General Science from the Institute, and to the degree of Master of Arts in Teaching from Harvard University.

FIRST YEAR (See page 49)

SECOND YEAR

First Term	5·11	Qualitative Analysis	7–3	*Second Term*	7·02	General Biology II	3–4
	7·01	General Biology I	3–4		7·021	General Biology Lab. II	3–1
	7·011	General Biology Lab. I	3–0		8·04	Physics	5–5
	8·03	Physics	5–5		‡14·70	Introductory Psychology	3–5
	H21	Humanities	3–5		H22	Humanities	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
		or				or	
	AS21	Air Science	3–0		AS22	Air Science	3–0
			27–23				23–26

THIRD YEAR†

First Term	‡‡6·18	Electrical Eng., Fund.	4–6	*Second Term*	‡‡5·12	(a) Quantitative Analysis	7–3
	‡‡7·03	Genetics & Cytology	6–4		‡‡7·04	(b) Embryology	8–4
		or			‡‡M32	Statistics, Elementary	3–6
		¶Elective Subject	10			‡Humanities	3–5
	‡‡8·051	Atomic & Nuclear Physics I	4–5			¶(a) Elective Subject	10
		‡Humanities	3–5			¶(b) Elective Subject	8
	§C-8	Curriculum & Meth. in Math.	4–7		§B-1	Educational Psych. & Meas.	4–7
			48				48

FOURTH YEAR††

First Term	‡H73	Science & Phil., Greeks-Copernicus	3–5	*Second Term*	‡H74	Science & Phil., Galileo-Present	3–5
		*Thesis	4			*Thesis	5
		‡Humanities	3–5			‡Humanities	3–5
		¶Elective Subjects	18			¶Elective Subjects	18
	§A-3	Philosophy: Educational Policy	4–7		§C-12	College Algebra & Geometry	4–7
			49				50

* See Requirements for Bachelor's Degree, page 45.
† Students take either the subjects indicated as (a) or those indicated as (b).
‡ 14·70, H73, and H74 will not be accepted as Humanities subjects. See page 47 for list of Humanities subjects.
§ Subjects taken at Harvard Graduate School of Education, substitutions subject to their approval.
¶ The Elective Subjects taken to fulfill the graduation requirement must include at least 40 units forming a related pattern centered in physics, chemistry, biology, or mathematics. The remaining Elective unit requirement may be completed with subjects of the student's own choice upon the approval of the Head of Course IX-C.
†† Entrance into the fourth year is subject to the approval of the Head of Course IX-C and the Harvard Graduate School of Education.
‡‡ Certain specified substitutions in the same field may be made.

IX-C. Science Teaching Continued

GRADUATE YEAR

First Term		¶Elective Subjects	20	*Second Term*		¶Elective Subjects	18
	§B-6	The American School	4–7		§C-16	Supervised Teaching	24
	§C-10	Teaching of Science	4–7			**§Curriculum & Methods Sem.	2–4
		**§Curriculum & Methods Sem.	2–4				48
			48				

X. CHEMICAL ENGINEERING

PROCESS industries such as chemicals and petroleum need men who can develop, design and operate new processes, men who can visualize the needs and outlets for new products and the possibilities of producing them, and men who have the potentialities for managerial responsibility in highly technical enterprises. Preparation for careers in these fields calls for a comprehension of both chemical and engineering principles. The course in Chemical Engineering is planned to afford broad preparation in fundamentals and to cultivate the ability to handle the unconventional problems which characterize these expanding industries.

The work in chemistry, covering inorganic, analytical, physical and organic chemistry, is nearly the same as that given to students in chemistry during the first three years, except for some reduction in laboratory requirements. The subjects in mechanical and electrical engineering are intended to supply the fundamentals which are needed by the chemical engineer. The work in chemical engineering and in industrial chemistry is of a professional nature, designed to develop a capacity for original thought and action. Competent students may make substitutions in the curriculum with the approval of the Head of the Department.

A graduate year of the Course in Chemical Engineering Practice provides unique opportunity for the development and application of the basic professional principles.

The Course leads to the degree of Bachelor of Science in Chemical Engineering.

FIRST YEAR (See page 49)

SECOND YEAR

First Term	5·11	Qualitative Analysis	7–3	*Second Term*	5·12	Quantitative Analysis	7–3
	8·03	Physics	5–5		8·04	Physics	5–5
	10·11	Chemical Engineering	1–1		10·28	Chemical Engineering	4–6
	10·17	Industrial Chemistry	3–4		H22	Humanities	3–5
	H21	Humanities	3–5		M22	Differential Equations	3–6
	M21	Calculus	3–6		MS22	Military Science	3–0
	MS21	Military Science	3–0			or	
		or			AS22	Air Science	3–0
	AS21	Air Science	3–0				25–25
			25–24				

THIRD YEAR

First Term	2·001	Applied Mechanics I	3–5	*Second Term*	2·002	Applied Mechanics II	3–5
	5·41	Organic Chemistry I	4–4		5·42	Organic Chemistry II	4–4
	5·416	Organic Preparations I	6–0		5·426	Qual. Organic Analysis	6–0
	5·61	Physical Chemistry I	4–4		5·62	Physical Chemistry II	4–4
	5·612	Physical Chem. Lab. I	2–0		5·622	Physical Chem. Lab. II	2–0
	10·29	Chemical Engineering	4–6		10·18	Industrial Chemistry	3–6
		†Humanities	3–5			†Humanities	3–5
			26–24				25–24

FOURTH YEAR

First Term	10·15	Thesis Reports	3–0	*Second Term*	6·18	Electrical Eng., Fund	4–6
	10·21	Industrial Chemistry	3–6		10·32	Chemical Engineering	4–6
	10·26	Industrial Chem. Lab.	10–0			*Thesis	12
		or				†Humanities	3–5
	10·27	Chemical Eng. Lab.	10–0			Elective Subject	8
	10·31	Chemical Engineering	4–6				48
		†Humanities	3–5				
		Elective Subject	8				
			48				

*See Requirements for Bachelor's Degree, page 45. † See page 47 for list of subjects.

§ Subjects taken at Harvard Graduate School of Education, substitutions subject to their approval.

¶ The Elective Subjects taken to fulfill the graduation requirement must include at least 40 units forming a related pattern centered in physics, chemistry, biology, or mathematics. The remaining Elective unit requirement may be completed with subjects of the student's own choice upon the approval of the Head of Course IX-C.

** Discussion and preparation seminar in field chosen for C-16.

X-B. CHEMICAL ENGINEERING PRACTICE

THE facilities of the School of Chemical Engineering Practice are available for a selected group of undergraduates during the second half of the senior year. Students desiring to take this Course should register in the first term of the fourth year and those accepted will spend the second term at the Field Stations of the School of Chemical Engineering Practice. The nature of the work in the School of Chemical Engineering Practice is described under the section on Chemical Engineering in The Graduate School.

The Course leads to the degree of Bachelor of Science in Chemical Engineering Practice.

(*Same as Course X through Third Year*)

FOURTH YEAR

First Term	6·18	Electrical Eng., Fund.	4–6	*Second Term*	10·30	Engineering Equipment	9–0
		or				School Chem. Eng. Practice	
	10·21	Industrial Chemistry	3–6			§10·84 Bangor Station	12–0
	10·31	Chemical Engineering	4–6			§10·85 Parlin Station	12–0
	10·32	Chemical Engineering	4–6			§10·86 Buffalo Station	12–0
		†Humanities	3–5			*Thesis	15
		†Humanities	3–5				48
			18–28 or 17–28				

XI. SANITARY ENGINEERING

Sanitary engineering involves the application of the physical, chemical, and biological sciences to the processing of water supplies and municipal and industrial wastes. Atmospheric pollution and the control of water quality are of prime importance to public health and to the growth of industries and municipalities. New industries such as nuclear power create new problems and ever-expanding opportunities for research and development work in the Sedgwick Laboratories of Sanitary Science. These laboratories have excellent facilities for teaching and research in sanitary chemistry, radioactivity, microbiology, and process engineering to prepare men for service with public health and public works agencies, colleges and research organizations, consulting engineers, and industry.

Much of the Institute's work in Sanitary Engineering is given at graduate level, but undergraduate training in Sanitary Engineering is obtained by enrolling in Course I, Civil Engineering. Second year students in Course I should refer to the program in Civil Engineering, with particular attention to the Sanitary Engineering elective subjects in the fourth year.

XII. GEOLOGY AND GEOPHYSICS

THE origin, age, and composition of the earth, the physical state of the earth's interior, and the origin of the oceans and atmosphere are among the most challenging and perplexing problems of science. They all lie within the domain of the earth scientists — geologists, geochemists, geophysicists, meteorologists, and oceanographers — but they can be successfully attacked only by using the latest contributions from the physical and engineering sciences.

Our expanding industrial economy is making heavy demands on the petroleum and mineral industries, and on the companies that find and develop the raw materials for these industries. Reserves of petroleum and natural gas, of metallic ores, and of many non-metallic substances such as domestic water supply are increasingly difficult to maintain; likewise, reserves of nuclear fuels are now being sought everywhere. The easy discoveries have been made, the low-cost deposits have been exhausted, and the industries must rely in the future on improvements and new developments in geological, geochemical, and geophysical methods in their exploration programs. The industrial needs for men trained in these fields of earth science are shared by research, government, military, and atomic energy organizations engaged in a wide variety of problems related to raw materials, defense, global strategy, and pure scientific discovery.

Thus, careers in geology, geochemistry, and geophysics offer a wide variety of work in teaching and research positions, in governmental bureaus and private and industrial laboratories, in field work in many different parts of the world, and in independent consulting.

Accordingly, the curriculum emphasizes the importance of diversification of subject matter and flexibility of choice of subjects by requiring a well-rounded program of mathematics, physics, chemistry, and certain engineering subjects, as well as a broad choice in professional subjects in geology, geochemistry, and geophysics. There is also a generous allotment of time for unrestricted electives which the student may choose from any course in the Institute.

Emphasis is placed on laboratory and field work at every level of the program in the belief that students learn best by doing. The summer following the sophomore year is spent at the Nova Scotia Centre for Geological Sciences, where the student learns surveying, mapping, and geological field methods during a ten-week period, five weeks of which are spent in tent camps.

An optional cooperative program of geophysical field training has been arranged with Geophysical Service, Inc., of Dallas, Texas, for the summer following the third year. During this summer, the student who participates in the program is employed by the company as a regular employee and after a week of orientation lectures in Dallas joins a field party engaged in seismic exploration in a part of the continent where active petroleum search is going on. Other juniors are employed by petroleum and mining companies and are likely to be sent to areas as distant as Mexico, California, British Columbia, New Brunswick, and Newfoundland. This professional field experience is considered to be an essential part of a student's undergraduate program; it gives him an opportunity to test and apply what he has learned and also shows him why he will need subjects that will be taken later.

* See Requirements for Bachelor's Degree, page 45. † See page 47 for list of subjects. § Students will take two of these stations.

XII. Geology and Geophysics Continued

Many excellent opportunities for advanced undergraduates exist in research, where theoretical work on the methods and instruments of geochemistry and geophysics is going on constantly. Some positions offer a combination of theoretical and instrumental work in a laboratory and applied work in the field. For such positions graduates of Course XII have always been much in demand.

Each student entering Course XII is assigned to a staff member of the Department of Geology and Geophysics, who will act as his adviser. The student has the responsibility of working out his own program of subjects each term, but he will always have the guidance of his adviser in doing so. By choosing the proper electives he may concentrate his work in one or a combination of the following fields: Basic Geology; Crystallography; Engineering Geology; Geochemistry; Geophysics; Mineralogy; Mineral Industry; Mineral Deposits; Mineral Fuels (Petroleum and Natural Gas); Petrology; Sedimentation, Stratigraphy and Paleontology; Structural Geology; and Theoretical Geology.

The following course of study leads to the degree of Bachelor of Science in Geology and Geophysics. It is strongly recommended, however, that all qualified seniors continue into the five-year program, described under Course XII-A, as the fifth year offers an excellent opportunity for the student to extend and deepen his training and to prepare himself better for professional or further academic work.

FIRST YEAR (See page 49)

SECOND YEAR

First Term	8·031	Physics	5–5	*Second Term*	8·041	Physics	5–5
	12·011T	Mineralogy I	7–3		12·302	Historical Geology	7–4
	12·301T	Physical Geology	7–4		H22	Humanities	3–5
	H21	Humanities	3–5		M22	Differential Equations	3–6
	M21	Calculus	3–6		MS22	Military Science	3–0
	MS21	Military Science	3–0			or	
		or			AS22	Air Science	3–0
	AS21	Air Science	3–0			§Elective Subject	8
			28–23				49

REQUIRED DURING SUMMER AT NOVA SCOTIA CENTRE FOR GEOLOGICAL SCIENCES

12·303T Geological Surveying	7–0
12·304T Field Investigations & Reports	17–0
	24–0

THIRD YEAR

First Term	§Elective Subjects	48	*Second Term*	§Elective Subjects	48
		48			48

FOURTH YEAR

First Term	§Elective Subjects	48	*Second Term*	*Thesis	15
		48		§Elective Subjects	33
					48

XII-A. GEOLOGY AND GEOPHYSICS

(FIVE-YEAR PLAN)

THE problems that geologists, geochemists, geophysicists, and other earth scientists now have to consider require more basic science and more geological training than ever before, and this situation will certainly be intensified in the future. For this reason, it is no longer possible for students to get adequate training for certain kinds of professional careers in the earth sciences in the normal four-year program. The primary educational objective of Course XII is to train geologists, geochemists, and geophysicists for the future; the five-year plan tabulated below has been organized with this purpose in view. This plan gives the qualified student maximum opportunity for a broad and thorough training in the basic sciences and a diversified training in the different fields of earth science — geology, geochemistry, geophysics, etc. Upon completion of the program he should be able to work in widely diversified fields and on many different kinds of problems in the areas mentioned in the description of the four-year curriculum.

Inasmuch as all requirements, except number of hours of thesis and of unrestricted electives, are the same for both Course XII and Course XII-A, candidates for the five-year plan will generally apply for it by the end of the first term of the senior year; at that time their qualifications will be examined and their preparation for graduate work determined. Since Course XII-A leads to the Master's degree, acceptance of a student for the graduate year will depend partly on his scholastic record and partly on the professional promise he has demonstrated in the field or laboratory, or in professional summer work with some organization.

Course XII-A leads to the degrees of Bachelor of Science and Master of Science in Geology and Geophysics, awarded simultaneously at the end of the graduate year.

* Thesis may be started in the first term of the fourth year, but not more than a total of 15 units will be accepted for graduation. See Requirements for Bachelor's Degree, page 45.

§ Each student is expected to plan his own schedule of elective subjects in cooperation with a Faculty Adviser whose approval is required. These subjects must be so chosen that they fulfill the following requirements:

a. At least 4 subjects (32 units) in Humanities, which may be taken at any time after the first term of the second year, provided existing subject sequences in Humanities are followed. See page 47 for list of Humanities subjects.
b. At least 54 units in some combination of subjects in mathematics, physics, chemistry (in addition to subjects in these fields scheduled in the first two years), and electrical engineering.
c. At least 64 units of professional subjects in Course XII (in addition to the subjects scheduled in the second year and summer following the second year, and excluding thesis).
d. 35 units of unrestricted electives, excluding all freshman electives. These unrestricted electives may be taken in any department in the Institute, if approved by the student's adviser.

XII-A. Geology and Geophysics Continued

Same as Course XII through Third Year¶

FOURTH YEAR

First Term	¶Elective Subjects	48	*Second Term*	¶Elective Subjects		48
		48				48

GRADUATE YEAR‡
(In effect 1957–58)

First Term	¶Elective Subjects	48	*Second Term*	†Thesis		30
		48		¶Elective Subjects		18
						48

XIII. NAVAL ARCHITECTURE AND MARINE ENGINEERING

STUDENTS desirous of preparing for a professional career in the design and building of ships and their propulsion machinery, or in allied industries, will find in this course a curriculum to meet their objectives.

For the first two years the program comprises mainly fundamental and basic subjects in science and the humanities, which provide an essential foundation for the professional subjects of the upper years. In the second year, however, there are included introductory subjects in ship construction which deal with the broad aspects of shipbuilding and the power plant equipment of vessels, and with the operation of shipyards.

In the third and fourth years instruction in naval architecture and ship design are carried on concurrently with instruction in marine engineering. The study of allied subjects such as applied and fluid mechanics, heat engineering and electrical engineering, is also taken up. Naval architecture and ship design include considerations such as: stability, subdivision of the hull, freeboard and tonnage, ship motions among waves, powering, steering, launching, and structural design, while marine engineering embraces steam machinery and Diesel engines, arrangement of machinery in the ship, and auxiliary equipment used in marine power plants.

The Course leads to the degree of Bachelor of Science in Naval Architecture and Marine Engineering.

FIRST YEAR (See page 49)

SECOND YEAR

First Term	2·001	Applied Mechanics I	3–5	*Second Term*	2·002	Applied Mechanics II		3–5
	2·851	Machine Tool Lab	4–0		3·11	Engineering Metals		6–4
	8·03	Physics	5–5		8·04	Physics		5–5
	13·40	Elem. Ship Des. & Constr. I	4–1		13·41	Elem. Ship Des. & Constr. II		4–1
	H21	Humanities	3–5		H22	Humanities		3–5
	M21	Calculus	3–6		M22	Differential Equations		3–6
	MS21	Military Science	3–0		MS22	Military Science		3–0
		or				or		
	AS21	Air Science	3–0		AS22	Air Science		3–0
			25–22					27–26

THIRD YEAR

First Term	*1·611T	Fluid Mechanics	3–6	*Second Term*	*2·42	Heat Engineering		3–6
	*2·081	Strength of Materials	3–6		*6·18	Electrical Eng., Fund		4–6
	*2·40	Heat Engineering	4–5		*13·02	Naval Architecture II		4–5
	*13·01	Naval Architecture I	4–5		*13·45	Ship Structures		3–6
	*13·42	Hull Form Design	5–0		13·52	Marine Engineering I		3–3
		§Humanities	3–5			§Humanities		3–5
			22–27					20–31

* See Requirements for Bachelor's Degree, page 45.

† Thesis may be started in the first term of the graduate year, and up to 10 units of additional thesis may be substituted for elective subjects in the graduate year

‡ Students must comply with all regulations of the Graduate School for the Master of Science degree with specification.

§14·01 Economic Principles I, 3–5, is a requirement for graduation and may be used in partial fulfillment of Humanities requirements. Students planning to register in Course XIII-B in the fourth year are not permitted concentration in Field Five, Economics, or Field Eight, Labor Relations, in satisfaction of Humanities requirements. See page 47 for list of Humanities subjects.

¶ Each student is expected to plan his own schedule of elective subjects for each term in cooperation with a Faculty Adviser whose approval is required. These subjects must be so chosen that they fulfill the following requirements:

a. At least 4 subjects (32 units) in Humanities, which may be taken at any time after the first term of the second year (See Course XII schedule), provided existing subject sequences in Humanities are followed. See page 47 for list of Humanities Subjects.

b. At least 5½ units in some combination of subjects in mathematics, physics, chemistry (in addition to subjects in these fields scheduled in the first two years), and electrical engineering.

c. At least 98 units of professional subjects in Course XII (in addition to the subjects of the second year and summer following the second year, and excluding 30 units of thesis), of which at least 34 units must be in graduate "A" subjects.

d. 82 units of unrestricted electives, excluding all freshman electives. These unrestricted electives may be taken in any Department in the Institute, if approved by the student's adviser.

XIII. Naval Architecture and Marine Engineering Continued

FOURTH YEAR

First	*2·371	Testing Materials Lab.	2–2	*Second*	*13·46	Ship Design	9–2
Term	*2·681	Engineering Lab.	3–3	*Term*	*13·54	Marine Eng. Dynamics	2–4
	*13·43	Ship Structural Drawing	3–0		*13·62	Marine Eng. Des. IV	5–0
	*13·53	Marine Engineering II	3–5			*Thesis	9
	*13·61	Marine Eng. Des. III	5–0			§Humanities	3–5
		§Humanities	3–5			Elective Subject	8
		Prof. Elective Subject	6				47
		Elective Subject	8				
			48				

XIII-B. SHIPPING AND SHIPBUILDING MANAGEMENT

THE Department offers a Course in Shipping and Shipbuilding Management open to students who wish to plan a coordinated five-year program at the graduate and undergraduate level. It is intended for those who desire to obtain significant competence in the areas of management, administration, and economics in addition to the technical competence implied by the Bachelor of Science degree in Course XIII. Registration in this Course is accepted only from students who have substantially completed the first three years of the Department's regular curriculum and whose academic standing is such that they may be expected to meet the requirements of the Graduate School.

The fourth year of study will ordinarily consist of all the specifically required subjects of the Course XIII curriculum (except thesis) together with subjects in the Department of Economics and Social Science and the School of Industrial Management which will provide the prerequisites necessary for later registration in Graduate subjects in Courses XIV and XV. In the fifth year, such Graduate subjects, together with the thesis and Departmental subjects, will form the bulk of the academic work, emphasis being placed in particular areas to suit the interests and qualifications of the student.

The student will be registered in Course XIII-B during his last two years, the last year as a Regular Graduate Student. His individual program must be approved by this Department, after consultation with and concurrence of the School of Industrial Management and/or the Department of Economics and Social Science, as appropriate. It must comprise at least 96 units in addition to the total units called for by the undergraduate curriculum of the Department, of which at least 72 units must be "A" subjects (including thesis). It must satisfy all specific subject requirements of the regular Course XIII curriculum and the undergraduate Humanities requirement of Course XIII-B, and will include 16 units of Electives in the fourth year available for additional Humanities subjects. A single thesis of at least 29 units, but not more than 40 units, is required; it will ordinarily involve subject matter integrating the shipping or shipbuilding field with the economics or management field.

The Course leads to the degrees of Bachelor of Science in Naval Architecture and Marine Engineering and Master of Science in Shipping and Shipbuilding Management awarded simultaneously at the end of the fifth year.

(*Same as Course XIII through Third Year*)

FOURTH YEAR

First	*2·371	Testing Materials Lab.	2–2	*Second*	*13·46	Ship Design	9–2
Term	*2·681	Engineering Lab.	3–3	*Term*	*13·54	Marine Eng. Dynamics	2–4
	*13·43	Ship Structural Drawing	3–0		*13·62	Marine Eng. Des. IV	5–0
	*13·53	Marine Engineering II	3–5			§Humanities	3–5
	*13·61	Marine Eng. Des. III	5–0			¶Prof. Elective Subject	9
		§Humanities	3–5			Elective Subject	8
		¶Prof. Elective Subject	6				47
		Elective Subject	8				
			48				

GRADUATE YEAR

First		Thesis	5	*Second*		Thesis	24
Term		¶‡Graduate Study	43	*Term*		¶‡Graduate Study	24
			48				48

*See Requirements for Bachelor's Degree, page 45.

‡May include up to a total of 11 units of additional Thesis in the graduate year.

§ 14·01 Economic Principles I, 3–5, is a requirement for graduation and may be used in partial fulfillment of Humanities requirements. Students registered in Course XIII-B are not permitted concentration in Field Five, Economics, or Field Eight, Labor Relations, in satisfaction of Humanities requirements. See page 47 for list of Humanities subjects.

¶The coordinated program of Professional Electives and Graduate Study will be approved by the Registration Officer after consultation with and concurrence of the Department of Economics and Social Science and the School of Industrial Management, as appropriate. Compliance with all regulations of the Graduate School is required.

XIV-A. ECONOMICS, POLITICS, AND ENGINEERING
XIV-B. ECONOMICS, POLITICS, AND SCIENCE

THE Courses in Economics, Politics, and Engineering, and Economics, Politics, and Science combine basic training in either engineering or science with the social sciences. Through emphasis on the relationships among scientific, engineering, economic, political, and human relations problems, this combination provides the student with an understanding of both technical and non-technical aspects of an industrial society. Such training is aimed at preparation for a wide range of careers, particularly in the research, engineering, economics, personnel, sales, production, and international departments of business, and in governmental and labor organizations. Students concentrating in political science will be equipped with knowledge and skills for dealing with the increasing range of problems arising between business and government and involving the activities of governmental agencies and political groups in matters of direct concern to scientists and engineers. In addition, the Courses can provide a broad undergraduate training preparatory to graduate work in such fields as law, medicine, science, engineering, business administration, and economics.

Students in Course XIV-A will elect an area of engineering concentration. This will correspond to one of the established engineering fields at M. I. T. The program of studies worked out for each individual student will include the core subjects required of those majoring in that engineering field, as recommended by the particular engineering department. There will then be a substitution of social science subjects for the more specialized subjects and the electives offered after the sophomore year in the engineering courses.

Similarly, students in Course XIV-B will choose an area of science concentration. The same general principle will apply here, with the appropriate science subjects again being recommended by the science department concerned.

On the economic side of the programs for both Courses, the emphasis is upon the economic and social structure within which business is conducted and technologic change takes place. The objectives here are threefold: (1) to convey an understanding of human behavior, particularly in industrial settings; (2) to analyze the organization and operation of our economic system; and (3) to develop an understanding of broad questions of social policy. In this way, the range of the student's insight will be broadened so that he will be able to recognize a maximum number of administrative choices in any given situation and be able to judge intelligently the probable consequences of each choice. Thus, he will develop his analytical powers in the social sciences to supplement his scientific and engineering skills. For those concentrating in economics some differences in emphasis are possible, particularly in the directions of industrial relations or industrial economics. In the typical case, however, the choice of appropriate professional electives will enable the student to complete a substantial amount of work in both these fields.

The political science side of the program will emphasize the growing interrelationship between government on the one hand and science and engineering on the other in an era of changing technology. The objectives are: (1) to provide an understanding of the basic nature of political behavior and the political process at all levels; (2) to examine the role of government in relation to science and technology both in the American and foreign political systems and in international relations; (3) to develop familiarity with the techniques of policy formulation and decision-making on issues of public policy. There will be opportunity in the third and fourth years to concentrate either upon developments in the American and comparative political systems, political theory, international politics, or political behavior.

Course XIV-A leads to the degree of Bachelor of Science in Economics, Politics, and Engineering, and Course XIV-B leads to the degree of Bachelor of Science in Economics, Politics, and Science.

A general program and two sample curricula are given below to show how the Courses work in practice. A student interested in Course XIV-A or Course XIV-B should consult with the Department of Economics and Social Science to learn of the other possible programs.

FIRST YEAR (See page 49)

SECOND YEAR**

First Term	8·03	Physics	5–5
		or	
	8·031	Physics	5–5
	14·01	Economic Principles I	3–5
	H21	Humanities	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
		or	
	AS21	Air Science	3–0
		¶Lang. or Basic Eng. or Sci. Subj.	8 to 12
			46 to 50
Second Term	8·04	Physics	5–5
		or	
	8·041	Physics	5–5
	14·02	(a) Economic Principles II	3–5
	14·90	(b) Govt., Politics & Tech.	3–5
	H22	Humanities	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
		or	
	AS22	Air Science	3–0
		¶Lang. or Basic Eng. or Sci. Subj.	8 to 12
			46 to 50

¶ To be selected after consultation with Registration Officer. Students in Course XIV-A take Engineering Subjects and students in Course XIV-B take Science Subjects, except where Language is accepted in the second year.

** Students planning to specialize in Economics take the program of subjects indicated as "(a)"; those planning to specialize in Political Science take the program of subjects indicated as "(b)".

XIV-A. Economics, Politics, and Engineering Continued
XIV-B. Economics, Politics, and Science Continued

Third Year**

First Term	14·33	(a) Statistics, Elem.	3–5	*Second Term*	15·52	(a) Bus. & Nat. Income Account.	3–5
		(b) Polit. Sci. Elec. Subj.	3–5			(b) Polit. Sci. Elec. Subj.	3–5
		§Humanities Elec. Subj.	3–5			§Humanities Elec. Subj.	3–5
		Course XIV Elec. Subj.	3–5			Course XIV Elec. Subj.	3–5
		¶Basic Eng. or Sci. Subj.	24 to 26			¶Basic Eng. or Sci. Subj.	24 to 26
			48 to 50				48 to 50

Fourth Year**

First Term		*Thesis	3	*Second Term*		*Thesis	7
		Elective Subject	8			Elective Subject	8
		Course XIV Elec. Subj.	16			Course XIV Elec. Subj.	24
		¶Eng. or Sci. Elec. Subj.	18 to 22			¶Eng. or Sci. Elec. Subj.	9 to 12
			45 to 49				48 to 51

Course XIV Elective Subjects§

Economics†				*Political Science*‡			
	14·03	Prices & Production	3–5		14·91	Amer. Polit. System	3–5
	14·40	Money & Income	3–5		14·92	Comp. Polit. & Econ. Systems	3–5
	14·43	Public Finance	3–5		14·93	Sem.: Issues in Contemp. Amer. Pol.	3–5
	14·54	International Trade	3–5				
	14·63	Labor Relations	3–5		H71	Basic Ideas of West. Pol. & Ethics, 500 B.C.–1500 A.D.	3–5
	14·64	Labor Ec. & Pub. Policy	3–5		H72	Rise of Mod. Pol. & Soc. Sci. 1500–1914	3–5
	14·72	Union-Manage. Rel.	3–6		H81	Contemp. Ideas on Pol. & Econ. Develop.	3–5
	14·73	Org. & Commun. in Groups	3–5				
	14·79	Psych. of Learn. & Motiv.	3–5				
	14·81	Personality & Soc. Struct.	3–5				
	14·04	Indust. Org. & Pub. Pol.	3–5		14·51	International Relations	3–5
	14·21	Econ. of Invention	3–5		14·52	Amer. Dipl., Prin. & Prob.	3–5
	15·42	Finance	3–6		14·53	Sem. in Internat. Polit.	3–5
	15·73	Management Lab.	6–3				
	H52T	Bus. Lead. in Amer. Econ.	3–5				
	H65	Prob. in Econ. Develop.	3–5				
	14·32	Statis. Qual. Cont.	3–6		14·95	Polit. Soc. & Policy Making	3–5
	14·371	Statistical Theory	3–6		14·96	Influences on Pol. Decis.	3–5
	14·372	Statistical Theory	3–6		H82	Nationalism and Nat. Develop.	3–5
	15·51	Indust. Accounting	5–4				

XIV-A. Sample Program. Based on Mechanical Engineering

First Year (See page 49)

Second Year**

First Term	2·001	Applied Mechanics I	3–5	*Second Term*	2·002	Applied Mechanics II	3–5
	2·85	Machine Tools, Int.	4–1		8·04	Physics	5–5
	8·03	Physics	5–5		14·02	(a) Economic Principles II	3–5
	14·01	Economic Principles I	3–5		14·90	(b) Govt., Politics & Tech.	3–5
	H21	Humanities	3–5		H22	Humanities	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
		or				or	
	AS21	Air Science	3–0		AS22	Air Science	3–0
			24–27				20–26

Third Year*

First Term	2·003	Applied Mechanics III	4–8	*Second Term*	2·25	Fluid Mechanics	4–8
	2·403	Heat Engineering	4–8		3·11	Engineering Metals	6–4
	14·33	(a) Statistics, Elem.	3–5		15·52	(a) Bus. & Nat. Income Account.	3–5
		(b) Polit. Sci. Elec. Subj.	3–5			(b) Polit. Sci. Elec. Subj.	3–5
		Course XIV Elec. Subj.	3–5			Course XIV Elec. Subj.	3–5
		††Lang. or Humanities Elec. Subj.	3–5			††Lang. or Humanities Elec. Subj.	3–5
			17–31				19–27

* See Requirements for Bachelor's Degree, page 45.

† The elective program in economics will normally be made up of 14·03, one additional subject in the first group, one subject in the second group, and four other subjects chosen from any two of the groups listed above.

‡ The political science elective program will normally include one subject in each of the four groups listed above, together with two additional subjects in one of these fields. Political Science Seminar 14·97 will be required of all students in Political Science.

§ Students may not use as their Humanities Elective 14·01 or any of the subjects indicated as electives in their own field of concentration. In addition, students concentrating in economics may not use 14·02; those electing political science may not use 14·90.

¶ To be selected after consultation with Registration Officer. Students in Course XIV-A take Engineering Subjects and students in Course XIV-B take Science Subjects, except where Language is accepted in the second year.

** Students planning to specialize in Economics take the program of subjects indicated as "(a)"; those planning to specialize in Political Science take the program of Subjects indicated as "(b)".

†† A language above the elementary level, or any subject offered by the School of Humanities and Social Studies, except as indicated by § in the Course XIV-A curriculum.

XIV-A. Economics, Politics, and Engineering Continued
XIV-B. Economics, Politics, and Science Continued

FOURTH YEAR

First Term	2·252	Fluid Mechanics	3–6	*Second Term*	*Thesis		7
		or			Engineering Elec. Subj.		9
	2·421	Heat Engineering	3–6		Course XIV Elec. Subj.		24
	6·18	Electrical Eng., Fund.	4–6		Eng. or Humanities Elec. Subj.		8 to 9
		*Thesis	3				48 to 49
		Course XIV Elec. Subj.	16				
		Eng. or Humanities Elec. Subj.	3–5				
			46				

XIV-B. SAMPLE PROGRAM. BASED ON MATHEMATICS

FIRST YEAR (See page 49)

SECOND YEAR**

First Term	8·031	Physics	5–5	*Second Term*	8·041	Physics	5–5
	14·01	Economic Principles I	3–5		14·02	(a) Economic Principles II	3–5
	H21	Humanities	3–5		14·90	(b) Govt., Politics & Tech.	3–5
	M21	Calculus	3–6		H22	Humanities	3–5
	MS21	Military Science	3–0		M22	Differential Equations	3–6
		or			MS22	Military Science	3–0
	AS21	Air Science	3–0			or	
		Language	3–5		AS22	Air Science	3–0
			20–26			Language	3–5
							20–26

THIRD YEAR**

First Term	14·33	(a) Statistics, Elem.	3–5	*Second Term*	15·52	(a) Bus. & Nat. Income Account	3–5
		(b) Polit. Sci. Elec. Subj.	3–5		M62	Modern Algebra	3–6
		‡‡Math. Elective Subj.	18			(b) Polit. Sci. Elec. Subj.	3–5
		Science Elec. Subj.	6			‡‡Math. Elective Subj.	9
		Course XIV Elec. Subj.	3–5			Science Elec. Subj.	9
		§§Lang. or Humanities Elec. Subj.	3–5			Course XIV Elec. Subj.	3–5
			48			§§Lang. or Humanities Elec. Subj.	3–5
							51

FOURTH YEAR

First Term	*Thesis	3	*Second Term*	*Thesis		7
	‡‡Math. Elective Subj.	18		‡‡Math. Elective Subj.		12
	Course XIV Elec. Subj.	16		Course XIV Elec. Subj.		24
	Sci. or Humanities Elec. Subj.	8		Sci. or Humanities Elec. Subj.		8
		45				51

XV-A AND XV-B. BUSINESS AND ENGINEERING ADMINISTRATION

(UNDERGRADUATE COURSES IN THE SCHOOL OF INDUSTRIAL MANAGEMENT)

THE Courses in Business and Engineering Administration are designed especially for students who combine an aptitude for science and engineering with a potential capacity for ultimate managerial responsibilities. Successful management of industrial enterprises in the future will demand ability to master technological problems of ever-increasing complexity, comprehension of basic management and business principles, and awareness of the characteristics of human behavior. Fundamental training in science and engineering has proved to be an excellent basis for this subsequent study and practice of business administration. The Massachusetts Institute of Technology is uniquely qualified to provide a curriculum which blends science and engineering with business administration and the humanities.

The recent enlargement of the graduate and research programs of the School of Industrial Management brings direct benefit to the undergraduate courses, as the same staff and facilities are used for both graduate and undergraduate programs.

Business Administration Program

The program in industrial management begins in the sophomore year with an introduction to basic economics. This is followed by a consideration of the economic aspects of managerial problems. The junior year requires the study of six one-term subjects, each dealing with a major functional area of industrial management. Emphasis is placed on ability to analyze business problems including the use of many of the rapidly developing mathematical and statistical methods, as well as upon understanding of managerial procedures.

In the senior year opportunity is afforded for selection, with the aid and advice of the faculty, of three or four one-term subjects compatible with the particular interests and aptitudes of the individual student. The range of

* See Requirements for Bachelor's Degree, page 45.

** Students planning to specialize in Economics take the program of subjects indicated as "(a)"; those planning to specialize in Political Science take the program of subjects indicated as "(b)".

‡‡ Each student must include in his total four-year program at least two subjects from the following group: M39, M411, M442, M50, M831, M832. The other Mathematics Electives may be M32 or any third, fourth, or graduate year mathematics subjects.

§§ A language above the elementary level, or any subject offered by the School of Humanities and Social Studies, except as indicated by § in the Course XIV-B curriculum.

XV-A and XV-B. Business and Engineering Administration Continued

elective subjects available is such that the student may in this year both broaden his knowledge by the study of new areas and increase his depth of understanding by doing more advanced work in one or more subjects with which he already has some familiarity. An important part of the fourth-year program is the thesis, which affords the dual opportunity of exploring in depth a problem of the student's own choice and of carrying out a limited research program on his own initiative.

The program of business and economic subjects covers the external as well as the internal aspects of management. The aim is to encourage an enlightened attitude toward business problems as they relate to industrial, economic, sociological, and political trends. Although current techniques are discussed and evaluated, there is no attempt to develop specialized vocational skills.

Science and Engineering Programs

Courses XV-A and XV-B are designed to place emphasis on subject matter of a fundamental nature and to discourage concentration in any one professional engineering field. It has been concluded that within the limits of a four-year program, development of a secondary engineering specialty is incompatible with the primary objective of sound professional education for administration; that the proper objective for the science and engineering components of the curricula is the laying of a solid foundation both for effective industrial management and for further progress in professional engineering should such later become desirable. To this end every effort has been made to incorporate in Course XV-A that subject matter basic to engineering rooted in the physical sciences and in Course XV-B similar subject matter appropriate to specialties evolving from the chemical sciences. Within these options, considerable freedom is available for the substitution of basic subjects in such areas as electrical engineering for mechanical engineering. The substitutions are made in the areas of fundamentals rather than applied specialties.

Both Courses lead to the degree of Bachelor of Science in Business and Engineering Administration.

XV-A. Business and Engineering Administration (Based on Physical Sciences)

First Year (See page 49)

Second Year

First Term	2·001	Applied Mechanics I	3–5	*Second Term*	2·002	Applied Mechanics II	3–5
	2·85	Machine Tools, Int.	4–1		8·04	Physics	5–5
	8·03	Physics	5–5		15·01	Indust. Manage. I	3–6
	§14·01	Economic Prin. I — Humanities	3–5		H22	Humanities	3–5
	H21	Humanities	3–5		M221	Prob. & Operations Analysis	3–6
	M21	Calculus	3–6		MS22	Military Science	3–0
	MS21	Military Science	3–0			or	
		or			AS22	Air Science	3–0
	AS21	Air Science	3–0				20–27
			24–27				

Recommended During Summer

Industrial or Business Practice

Third Year

First Term	2·40	Heat Engineering	4–5	*Second Term*	1·611T	Fluid Mechanics	3–6
	3·11	Engineering Metals	6–4		2·42	Heat Engineering	3–6
	*15·02	Indust. Manage. II	3–6		*15·30	Personnel Administration	3–6
	*15·50	Accounting	5–4		*15·41	Finance	3–6
	*15·81	Marketing	3–6		*15·71	Production Management	3–6
			21–25			§Humanities	3–5
							18–35

Fourth Year

First Term	6·18	Electrical Eng., Fund.	4–6	*Second Term*	6·19	Electronic Instrument	4–6
		*Thesis	2			*Thesis	10
		§Humanities	3–5			§Humanities	3–5
		Eng. Elective Subject	9			Hum. or Prof. Elective Subj.	8
		Prof. Elective Subject	9			Prof. Elective Subject	9
		Hum. or Prof. or Eng. Elec. Subj.	8				45
			46				

* See Requirements for Bachelor's Degree, page 45.

§ Concentration in Field Five, Economics, or Field Eight, Labor Relations, is not permitted in satisfaction of Humanities requirements. 14·01 Economics Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken, as specified. See page 47 for list of Humanities subjects.

XV-A and XV-B. Business and Engineering Administration Continued

XV-B. Business and Engineering Administration (Based on Chemical Sciences)

First Year (See page 49)

Second Year

First Term	5·11	Qualitative Analysis	7–3	*Second Term*	5·12	Quantitative Analysis	7–3
	8·03	Physics	5–5		8·04	Physics	5–5
	§14·01	Economic Prin. I — Humanities	3–5		15·01	Indust. Manage. I	3–6
	H21	Humanities	3–5		H22	Humanities	3–5
	M21	Calculus	3–6		M221	Prob. & Operations Anal.	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
		or				or	
	AS21	Air Science	3–0		AS22	Air Science	3–0
			24–24				24–25

Recommended During Summer
Industrial or Business Practice

Third Year

First Term	5·41	Organic Chemistry I	4–4	*Second Term*	5·42	Organic Chemistry II	4–4
	5·416	Organic Preparations I	6–0		5·62	Physical Chemistry II	4–4
	5·61	Physical Chemistry I	4–4		*15·30	Personnel Administration	3–6
	*15·02	Indust. Manage. II	3–6		*15·41	Finance	3–6
	*15·50	Accounting	5–4		*15·71	Production Management	3–6
	*15·81	Marketing	3–6			§Humanities	3–5
			25–24				20–31

Fourth Year

First Term	6·18	Electrical Eng., Fund	4–6	*Second Term*	10·28	Chemical Engineering	4–6
	10·11	Chemical Engineering	1–1			*Thesis	10
	10·17	Industrial Chemistry	3–4			§Humanities	3–5
		*Thesis	2			Hum. or Prof. Elective Subj.	8
		§Humanities	3–5			Prof. Elective Subject	9
		Hum. or Prof. or Eng. Elec. Subj.	8				
		Prof. Elective Subject	9				45
			46				

XVI. AERONAUTICAL ENGINEERING

THE primary objective of the Undergraduate Course in Aeronautical Engineering is to prepare the student to apply the methods of the aeronautical engineer to the design and construction of aircraft and their component systems. To do this he must determine the nature of an engineering problem, select between alternate solutions, and judge the effects of compromises.

As a foundation for professional practice, the course provides general training in science, mathematics, and the humanities followed by study of the professional subjects of aeromechanics, aerodynamics, stability, automatic control, structures, and power plants. Work in the classroom is supplemented by laboratory experiments illustrative of the theory and methods of prediction used in design and culminates in an integrated engineering project.

The Course leads to the degree of Bachelor of Science in Aeronautical Engineering.

Honors Course

The opportunity will be afforded a limited number of students of superior ability to join an Honors Course group. The selection of members of this group will be made by the Department from students who may wish to avail themselves of the opportunity to pursue a coordinated schedule of studies through the senior and graduate years. A member of the Department will serve as adviser to aid members of the group in selecting the senior and graduate schedules which may be best suited to their individual interests.††

The Honors Course leads to the degree of Bachelor of Science in Aeronautical Engineering and either the degree of Master of Science in Aeronautical Engineering or the degree of Aeronautical Engineer awarded simultaneously at the end of the graduate program.

* See Requirements for Bachelor's Degree, page 45.

§ Concentration in Field Five, Economics, or Field Eight, Labor Relations, is not permitted in satisfaction of Humanities requirements. 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken, as specified. See page 47 for list of Humanities subjects.

†† The program must include completion of all unit and Humanities requirements for the Bachelor's degree and for either the Master's degree or the degree of Aeronautical Engineer, but only a single thesis of not less than 30 units in the graduate program.

XVI. Aeronautical Engineering Continued

FIRST YEAR (See page 49)

SECOND YEAR

First Term	2·001	Applied Mechanics I	3–5	*Second Term*	2·04	Strength of Materials	3–6
	8·03	Physics	5–5		8·04	Physics	5–5
	16·70	Aircraft Detail Design	9–0		16·00	Aeromechanics	4–5
	16·82	Aeronautical Eng., Int.	3–1		H22	Humanities	3–5
	H21	Humanities	3–5		M22	Differential Equations	3–6
	M21	Calculus	3–6		MS22	Military Science	3–0
	MS21	Military Science	3–0			or	
		or			AS22	Air Science	3–0
	AS21	Air Science	3–0				21–27
			29–22				

THIRD YEAR§§

First Term	*2·40	¶Heat Engineering	4–5	*Second Term*	*6·18	(a) Electrical Eng., Fund.	4–6
	*6·18	(b) Electrical Eng., Fund.	4–6		6·19	(b) Electronic Instrument	4–6
	*16·01	Aeromechanics	5–5		*16·02	Aerodynamics	6–6
	*16·10	Applied Aerodynamics	4–8		*16·13	Airplane Stability & Cont.	3–6
	*16·20	(a) Aircraft Structures	4–6		*16·20	(b) Aircraft Structures	4–6
		‡Humanities	3–5		16·21	(a) Aircraft Structures	4–6
			20–29			‡Humanities	3–5
							20–29

FOURTH YEAR

First Term	*16·30	Automatic Control, Prin.	3–9	*Second Term*	*16·72	Aeronautical Eng.	9–3
	*16·53	Aircraft Propulsion	3–6			*Thesis or Project	9
	16·65	Aeronautical Eng. Lab.	6–6			‡Humanities	3–5
	*16·71	Aeronautical Eng.	10–0			‡Humanities	3–5
		Prof. Elec. Subj. or Hum.	8			Prof. Elec. Subj. or Hum.	8
			51				45

Suggested Professional Elective Subjects§

	2·48	Gas Turbines	4–5		16·302	Aeronautical Systems	3–6
	2·79	Int. Comb. Eng., Elem.	3–6		16·50	Rotat. Wing Aircraft	3–6
	16·03T	Aerodynamics, Prin.	4–5		16·76	Orbital Vehicles	3–6
	16·105	Applied Aerodyn.	3–6		16·91	Aeroelasticity	3–6
	16·22	Aircraft Structural Theory	3–6		M351	Adv. Calculus for Eng.	3–6
	16·23	Aircraft Struct. Des.	3–5		M352	Adv. Calculus for Eng.	3–6

XVI-B. AERONAUTICAL ENGINEERING

COOPERATIVE COURSE (FOUR YEARS)

THE aim of the cooperative program for Aeronautical Engineering undergraduates is to provide an opportunity for about six months experience in an industrial organization before the professional work of the senior year. Continuous contact with industrial problems should enable a student to discover and develop his aptitudes and interests to better advantage than would be possible with shorter periods of employment. The program does not interfere with the student's academic progress nor with his extra-curricular activities in association with his classmates.

The cooperating companies of the aircraft industry will pay the students at prevailing rates during their period of employment. The students will pay their own transportation and living expenses while away from the Institute.

Students who are interested in the program should apply to Department Headquarters for a set of Personnel Record Forms prior to March 1 of their sophomore year: These forms should be filled out completely and returned by March 15. A statement as to the location where the student would prefer to work should be appended to the forms.

Representatives of the cooperating companies will be invited to interview interested students and to determine, jointly with the Department representative, the distribution of those selected for employment. Students thus selected become regular employees during their period of employment in an aircraft plant, and are subject to the

* See Requirements for Bachelor's Degree, page 45.
‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken. See page 47 for list of Humanities subjects.
§ Other electives may be chosen with approval of Registration Officer.
§§ Students must select either the program of subjects indicated as "(a)" or that indicated as "(b)."

XVI-B. Aeronautical Engineering Continued

usual regulations of the company. They are expected to carry the course through to completion unless they are prevented by exceptional circumstances.

A list of the companies cooperating in this program will be available at the Headquarters of the Department of Aeronautical Engineering.

Juniors in the Cooperative Course are also eligible for selection to the Honors Course described under Course XVI, Aeronautical Engineering.

The Course leads to the degree of Bachelor of Science in Aeronautical Engineering.

(*Same as Course XVI through Second Year*)

THIRD YEAR

Summer

At M. I. T. (First 6 weeks)

*2·40	Heat Engineering	4–5
*16·01	Aeromechanics	5–5
		9–10

Vacation (Approximately 2 weeks)

At Plants (Remainder of Summer)

*16·851	Industrial Practice	40 h.p.w.

Regular Academic Year

At Plants

First Term	*16·852	Industrial Practice	40 h.p.w.

At M. I. T.

Second Term	*6·18	Electrical Eng., Fund.	4–6
	*16·02	Aerodynamics	6–6
	*16·10	Applied Aerodynamics	4–8
	*16·20	Aircraft Structures	4–6
	‡Humanities		3–5
			21–31

FOURTH YEAR

Summer

At M. I. T.

*16·13	Airplane Stability & Cont.	3–6
	‡Humanities	3–5
	‡Humanities	3–5
		9–16

Regular Academic Year

Same as Course XVI with the following exceptions in the second term: Omit one Humanities, 3–5. Add 6·19 Electronic Instrument., 4–6, or 16·21 Aircraft Structures, 4–6.

XVII. BUILDING ENGINEERING AND CONSTRUCTION

SINCE Building Engineering and Construction and Civil Engineering are so closely related, the undergraduate courses in these two fields have been combined into a single curriculum which constitutes a revision of the Civil Engineering curriculum (Course I).

Students who are particularly interested in Building Engineering and Construction should, therefore, register in Civil Engineering. A system of fourth-year electives has been adopted that will give flexibility to the revised program. The aims of undergraduate education at the Institute call for breadth through fundamentals, and the new electives will permit specialization in Building Engineering and Construction to an extent that is consistent with these aims.

The fourth-year program for Course XVII will be given during 1956–57, so that those who entered Course XVII as second-year students in the Fall Term of 1954 can complete their course of studies in accordance with the program on which they embarked.

FOURTH YEAR (1956–57 only)

First Term	*1·41	Structural Analysis	3–6
	*6·18	Electrical Eng., Fund.	4–6
	*17·53T	Wood Des. & Graph. Anal.	5–6
	*Thesis		2
	‡Humanities		3–5
	Elective Subject		8
			48

Second Term	*1·42	Structural Analysis	3–6
	*17·40	Job Management	2–4
	*17·54T	Concrete Design	4–5
	*Thesis		7
	‡Humanities		3–5
	Elective Subjects		13
			52

* See Requirements for Bachelor's Degree, page 45.

‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken. See page 47 for list of Humanities subjects.

XVIII. MATHEMATICS

THE Institute offers exceptional opportunities for the study of mathematics, in both its theoretical aspects and its applications to scientific and engineering work.

The Course outlined is for students who desire to study more mathematics than is contained in the other professional courses. It is well adapted to serve as a preparation for specializing in pure mathematics, in applied mathematics, in mathematical physics, or in engineering fields requiring proficiency in mathematics. The Course also offers excellent opportunities for students who wish to major in mathematical statistics or applied statistics. For most of the students in Course XVIII the curriculum serves as a preparation for further professional training at the graduate level.

Any student who has completed, with a sufficiently high record, the work of the first two years in any of the professional courses in the Institute or their equivalent, may be admitted to the third year in this Course.

The Course leads to the degree of Bachelor of Science in Mathematics.

FIRST YEAR (See page 49)

SECOND YEAR

First Term	8.031	Physics	5–5	*Second Term*	8.041	Physics	5–5
	H21	Humanities	3–5		H22	Humanities	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
		or				or	
	AS21	Air Science	3–0		AS22	Air Science	3–0
		Language	3–5			Language	3–5
		Eng. or Sci. Elec. Subj. (not Math.)	8			Eng. or Sci. Elec. Subj.	9
			46				47

THIRD YEAR

First Term	*M62	Modern Algebra	3–6	*Second Term*	*M832	Analysis	3–9
	*M831	Analysis	3–9			†Humanities	3–5
		†Humanities	3–5			¶Prof. Elective Subject	9
		¶Prof. Elective Subject	9			Elective Subjects	18
		Elective Subject	0				47
			47				

FOURTH YEAR
(In effect 1957–58)

First Term		*Thesis	5	*Second Term*	*M442	Diff. Geometry, Elem.	3–6
		†Humanities	3–5			*Thesis	7
		¶Prof. Elective Subjects	24			†Humanities	3–5
		Elective Subject	8			¶Prof. Elective Subject	12
			45			Elective Subject	12
							48

FOURTH YEAR (1956–57 only)

First Term	*M831	Analysis	3–9	*Second Term*	*M832	Analysis	3–9
		*Thesis	4			*Thesis	7
		†Humanities	3–5			†Humanities	3–5
		§Elective Subjects	21			§Elective Subjects	21
			45				48

XIX. METEOROLOGY

THE undergraduate course in Meteorology will be discontinued as of September, 1956. All undergraduate students in the classes of 1959 and earlier will be permitted to complete the Course. Entering students in 1956 and later who are interested in meteorology are advised to register in Courses VI, VIII, IX, XII or XVIII. Programs may be arranged in these Courses that include adequate preparation in mathematics and the physical sciences as well as certain basic subjects in meteorology. Such a program, followed by at least one year of graduate study in meteorology, is considered to be an excellent preparation for a professional career in meteorology.

† See page 47 for list of subjects.

* See Requirements for Bachelor's Degree, page 45.

§ Each student must include in his program M442 Diff. Geometry, Elem., 3–6, and at least 36 units of other Professional Elective Subjects; viz., 8.71, 8.72, M341, M342, M50, or any 12-unit Mathematics subject.

¶ At least 30 of the 54 units of Professional Elective Subjects must be chosen from mathematics subjects; the remaining 24 units are to be chosen from mathematics and/or engineering or science subjects which, together with the 30 units of mathematics subjects, make up an integrated program. All of these 54 units must be in subjects at the third year, fourth year, or graduate level.

XIX. Meteorology Continued

SECOND YEAR (1956–57 only)

First Term	2·001	Applied Mechanics I	3–5	*Second Term*	2·002	Applied Mechanics II	3–5
	8·03	Physics	5–5		8·04	Physics	5–5
	19·00	General Meteorology	6–3		19·50	Meteorological Lab., Int.	3–0
	H21	Humanities	3–5		H22	Humanities	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		M32	Statistics, Elementary	3–6
		or			MS22	Military Science	3–0
	AS21	Air Science	3–0			or	
			23–24		AS22	Air Science	3–0
							23–27

THIRD YEAR (1956–57, and 1957–58 only)

First Term	*19·01	Descriptive Meteorol. I	3–6	*Second Term*	*2·40	Heat Engineering	4–5
	*19·21	Meteorol. Observations	4–2			or	
	19·70	Physics of Atmos. Elem.	2–4		*8·07	Thermodyn. & Statist. Mech.	4–5
		†Humanities	3–5		19·02	Descriptive Meteorol. II	3–6
		Elective Subjects	17		19·30	General Climatology	2–4
			46			†Humanities	3–5
						Elective Subjects	15
							47

FOURTH YEAR (1956–57, 1957–58, and 1958–59 only)

First Term	*19·51	Synoptic Lab. I	15–0	*Second Term*	*19·44	Synoptic Meteorol. I	3–6
	*19·601	Theoretical Meteorol., Int.	3–6		*19·62	Dynamic Meteorology I	3–6
	19·83	Oceanography	2–4			*Thesis	9
		*Thesis	3			†Humanities	3–5
		†Humanities	3–5			Elective Subjects	12
		Elective Subject	8				47
			49				

XX. FOOD TECHNOLOGY

THE marked technological progress taking place in modern food industries has created a demand for men having thorough knowledge of the basic sciences pertaining to foods, combined with the ability to apply that knowledge in the technical processes of food production, manufacture, storage, and distribution. Increasing emphasis on quality control as it concerns food and food products in manufacture has necessitated the development of new chemical, physical, biological, and microscopic techniques, and increased the demand for personnel to interpret the significance of such developments in commercial practice.

The undergraduate work in food technology is planned to provide students with a broad perspective in all the contributory sciences supplemented by the more specific technological aspects which especially concern the food industries, and to fit the men for either the laboratory or production branches of such organizations.

This training is equally valuable for those desiring to enter the fermentation industries producing beverages, glycerine, industrial alcohols, solvents, organic acids, or other commercial products of organic origin, or others which are concerned with the control of biological agents such as enzymes, and micro-organisms.

Substitutions may be made for certain of the outlined subjects at the discretion of the registration officer when students are intending to continue their studies for an advanced degree or have special interests in contiguous fields.

The Course leads to the degree of Bachelor of Science in Food Technology.

FIRST YEAR (See page 49)

SECOND YEAR

First Term	7·01	General Biology I	3–4	*Second Term*	5·12	Quantitative Analysis	7–3
	7·011	General Biology Lab. I	3–0		8·04	Physics	5–5
	8·03	Physics	5–5		20·41	Bacteriology	7–3
	20·001	Food Production	6–4		H22	Humanities	3–5
	H21	Humanities	3–5		M221	Prob. & Operations Anal.	3–6
	M21	Calculus	3–6		MS22	Military Science	3–0
	MS21	Military Science	3–0			or	
		or			AS22	Air Science	3–0
	AS21	Air Science	3–0				28–22
			26–24				

* See Requirements for Bachelor's Degree, page 45.

† See page 47 for list of subjects.

XX. Food Technology Continued

THIRD YEAR

First Term	*5·41	Organic Chemistry I	4–4	*Second Term*	5·15	Instrument. Analysis	2–2
	*5·61	Physical Chemistry I	4–4		5·151	Instrument. Anal. Lab.	4–2
	*20·01	Chem. & Tech. Food Sup. I	7–3		5·62	Physical Chemistry II	4–4
	*20·42	Industrial Microbiology	6–4		*20·02	Chem. & Tech. Food Sup. II	7–3
		‡Humanities	3–5			‡Humanities	3–5
		Elective Subject	8			Elective Subject	9
			52				45

FOURTH YEAR

First Term	2·601	Food Engineering	4–2	*Second Term*	2·602	Food Engineering	4–2
	*7·05	Gen. Biochem. & Physiol. I	3–6		*20·12	Tech. of Food Products	6–4
	*20·11	Tech. of Food Products	6–4		20·14T	Chem. Eng. Food App.	6–4
	20·13	Chem. Eng. Food App.	4–6			*Thesis	9
	20·32	Chemistry of Nutrition	4–2			‡Humanities	3–5
		*Thesis	3			Elective Subject	5
		‡Humanities	3–5				48
			52				

XX-A. FOOD TECHNOLOGY

A LIMITED number of outstanding students in the regular four-year curriculum, Course XX, will, upon application, be selected during the third year to enter a slightly modified fourth year course to be followed by a fifth, or graduate, year. A period of six months between the fourth and fifth year in this course will be spent in technical positions in selected food industries to enable each man to have some industrial experience before completing his academic work.

The Course leads to the degrees of Bachelor of Science and Master of Science in Food Technology awarded simultaneously at the end of the graduate year.

(Same as Course XX through Third Year.)

FOURTH YEAR

First Term	2·601	Food Engineering	4–2	*Second Term*	2·602	Food Engineering	4–2
	*7·05	Gen. Biochem. & Physiol. I	3–6		*20·12	Tech. of Food Products	6–4
	*20·11	Tech. of Food Products	6–4		20·14T	Chem. Eng. Food App.	6–4
	20·13	Chem. Eng. Food App.	4–6		20·322	Chem. of Nutrition Lab.	5–0
	20·32	Chemistry of Nutrition	4–2			‡Humanities	3–5
		‡Humanities	3–5			Elective Subject	8
			24–25				47

GRADUATE YEAR

First Term	7·81	Enzymology	2–4	*Second Term*	20·52	Food Technology, Adv.	6–4
	20·51	Food Technology, Adv.	8–4		20·62	Food Technology Seminar	2–2
	20·61	Food Technology Seminar	2–2			Thesis	20
		Thesis	16			Elective Subjects	14
		Elective Subject	10				48
			48				

XX-B. BIOCHEMICAL ENGINEERING

RECENT developments in the production of pharmaceuticals and antibiotics and in the food and fermentation industries indicate a strong need for technical personnel with training in the basic biological sciences and in engineering as represented by chemical engineering. In order to make such training available to students who wish to enter this field, the Department of Food Technology offers a coordinated program in Biochemical Engineering. The Course is basically the undergraduate curriculum in chemical engineering, with modifications to allow the study of biology, bacteriology, microbiology, and biochemistry. As warranted by future enrollment, new subjects will be offered to give the students a more thorough background in microbiology and biochemistry and placing the emphasis in chemical engineering on the biological rather than the chemical industry.

The Course leads to the degree of Bachelor of Science in Biochemical Engineering.

* See Requirements for Bachelor's Degree, page 45.
‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken. See page 47 for list of Humanities subjects.

XX-B. Biochemical Engineering Continued

(Same as Course XX through Second Year)

THIRD YEAR

First Term	*5·41	Organic Chemistry I	4–4	*Second Term*	5·15	Instrument. Analysis	2–2
	*5·416	Organic Preparations I	6–0		5·151	Instrument. Anal. Lab.	4–2
	*5·61	Physical Chemistry I	4–4		*5·42	Organic Chemistry II	4–4
	*5·612	Physical Chem. Lab. I	2–0		*5·426	Qual. Organic Analysis	6–0
	*10·17	Industrial Chemistry	3–4		*5·62	Physical Chemistry II	4–4
	*20·42	Industrial Microbiology	6–4		*5·622	Physical Chem. Lab. II	2–0
		‡Humanities	3–5			‡Humanities	3–5
			28–21			Elective Subject	8
							50

FOURTH YEAR

First Term	*7·05	Gen. Biochem. & Physiol. I	3–6	*Second Term*	*20·14T	Chem. Eng. Food App.	6–4
	*20·13	Chem. Eng. Food App.	4–6		*20·48	Biochemical Eng.	8–2
	20·32	Chemistry of Nutrition	4–2			*Thesis	8
	*20·47	Biochemical Eng.	8–2			‡Humanities	3–5
		*Thesis	7			Elective Subjects	12
		‡Humanities	3–5				48
			50				

XXI-A. HUMANITIES AND ENGINEERING

XXI-B. HUMANITIES AND SCIENCE

THE Courses in Humanities and Engineering and in Humanities and Science consist of about 60 per cent basic science and engineering and about 40 per cent humanities and social science. Their broad objective is to provide a kind of general education in science and engineering, but they are also designed to provide the training necessary for graduate work in science, engineering, medicine, law, business or public administration, and some fields of the humanities.

Members of the class of 1958 and succeeding classes may combine one of the fields of science and engineering with a program either in American Industrial Society or in Philosophy and Literature. Course XXI leads in four academic years to the degree of Bachelor of Science; it is arranged to permit a student, if he wishes, in a fifth year to earn a second bachelor's degree with specific designation in the particular field of science or engineering he has been exploring; in some cases this fifth year can lead to a master's degree. To this end, the program of studies for each student will include the core subjects required by and other subjects recommended by one of the engineering or science departments. It will substitute for certain specialized engineering or science subjects the combinations of subjects that together constitute the programs in American Industrial Society or in Philosophy and Literature.

The American Industrial Society program emphasizes the development of and the social interrelationships within contemporary American culture. It examines the nature of change in the United States, the persistence of certain processes and attitudes of mind, and the transmutation of others. It also analyzes the contributions and problems of the scientist and engineer as instruments of change and therefore, in the largest sense of the words, as agents of stability. These emphases are intended to develop an understanding of how conflicting interests are peacefully reconciled in a democratic society, thereby to enhance the student's perceptions about the possibilities of his own future role as a scientist or engineer or in some other calling.

The Philosophy and Literature program focusses on rather different relationships, especially those between scientific and other kinds of thought. It emphasizes the structure as well as the meaning of creative efforts in literature, the arts, and philosophy, intending in this way to increase the student's awareness of the beauty that attends the rigor of science and engineering, of the symmetry of effort experienced by creative men in dissimilar disciplines. These approaches are designed to stimulate the imagination as well as to broaden the understanding.

Course XXI-A leads to a degree of Bachelor of Science in Humanities and Engineering, and Course XXI-B leads to the degree of Bachelor of Science in Humanities and Science.

All the possible programs cannot be listed here, but a general program and two sample curricula are given below. A student interested in Course XXI-A or XXI-B should consult with the Department of Humanities to learn of other possible programs.

* See Requirements for Bachelor's Degree, page 45.
‡14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken. See page 47 for list of Humanities subjects.

XXI-A. Humanities and Engineering Continued
XXI-B. Humanities and Science Continued

FIRST YEAR (See page 49)

SECOND YEAR**

First Term	8·03	Physics	5–5	*Second Term*	8·04	Physics	5–5
		or				or	
	8·031	Physics	5–5		8·041	Physics	5–5
	14·01	(a) Economic Principles I	3–5		14·02	(a) Economic Principles II	3–5
	E31	(b) Literature, Int.	3–5			or	
	H21	Humanities	3–5		14·90	(a) Govt., Politics & Tech.	3–5
	M21	Calculus	3–6		E32	(b) Literary Theory	3–5
	MS21	Military Science	3–0		H22	Humanities	3–5
		or			M22	Differential Equations	3–6
	AS21	Air Science	3–0		MS22	Military Science	3–0
		¶Lang. or Basic Eng. or Sci. Subj.	8 to 12			or	
			46 to 50		AS22	Air Science	3–0
						¶Lang. or Basic Eng. or Sci. Subj.	8 to 12
							46 to 50

THIRD YEAR**

First Term	14·95	(a) Pol., Soc. & Pol. Making	3–5	*Second Term*	H32	(a) Pol. Proc. in Ind. Amer.	3–5
	H51	(a) Amer. Econ. Develop.	3–5		H52T	(a) Bus. Lead. in Am. Econ.	3–5
	H73	(b) Sci. & Phil., Gr. — Copern.	3–5		H74	(b) Sci. & Phil., Gal. — Pres.	3–5
	H75T	(b) Phil. Prob. & Systems	3–5		H76T	(b) Phil. Prob. & Systems	3–5
		§Humanities Elec. Subj.	3–5			§Humanities Elec. Subj.	3–5
		¶Basic Eng. or Sci. Subj.	24 to 26			¶Basic Eng. or Sci. Subj.	24 to 26
			48 to 50				48 to 50

FOURTH YEAR**
(In effect 1957–58)

First Term	H93	(b) Phil. & Lit. Seminar	3–6	*Second Term*	H94	(b) Phil. & Lit. Seminar	1–4
	H95	(a) Am. Indust. Soc. Sem.	3–6		H96	(a) Am. Indust. Soc. Sem.	1–4
		Elective Subject	8 to 9			*Thesis	12
		†Course XXI Elec. Subj.	16			Elective Subject	8 to 9
		¶Eng. or Sci. Elec. Subj.	12 to 16			†Course XXI Elec. Subj.	3–5
			45 to 50			¶Eng. or Sci. Elec. Subj.	12 to 16
							45 to 50

Course XXI Elective Subjects

American Industrial Society

H31	Amer. Soc. & Intellect. Hist.	3–5
H32	Pol. Process in Indust. Am.	3–5
H34	Relig. Thought & Am. Soc.	3–5
H63	Amer. For. Pol. in Action	3–5
H65	Prob. in Econ. Develop.	3–5
H85	History & Historians	3–5
14·09	Econ. Prob. Seminar	3–5
14·30	Statistics, Elem.	2–4
14·61	Industrial Relations	3–6
14·81	Personality & Soc. Struct.	3–5
14·96	Influences on Pol. Decis.	3–5

Philosophy and Literature

H34	Relig. Thought & Am. Soc.	3–5
H58	Art & Indust. Civil.	3–5
H71	Basic Ideas of W. Pol. & Eth., 500 B.C.–1500 A.D.	3–5
H72	Rise of Mod. Pol. & Soc. Sci., 1500–1914.	3–5
H77	Classical Philosophy	3–5
H83	Phil. of Science	3–5
H84	Topics in Hist. of Sci.	3–5
E47	19th Cent. Amer. Lit.	3–5
E48	20th Cent. Amer. Lit.	3–5
E49	Russia & W. in Mod. Russ. Lit.	3–5
E50	The Bible	3–5
E51	Modern Novel	3–5
E52	Comic Sensibility	3–5

* See Requirements for Bachelor's Degree, page 45.
† To be selected after consultation with Registration Officer.
§ A language above the elementary level or any subject offered by the School of Humanities and Social Studies, except those designated as Electives in the student's field of Humanities concentration.
¶ To be selected after consultation with Registration Officer. Students in Course XXI-A take Engineering Subjects and students in Course XXI-B take Science Subjects, except where Language is accepted in the second year.
** Students planning to specialize in American Industrial Society take the program of subjects indicated as "(a)"; those planning to specialize in Philosophy and Literature take the program of subjects indicated as "(b)".

XXI-A. Humanities and Science Continued
XXI-B. Humanities and Engineering Continued

XXI-A. Sample Program. Based on American Industrial Society and Electrical Engineering

First Year (See page 49)

Second Year

First Term	6·00	Circuit Theory, Int.	7–5	*Second Term*	6·01	Circuit Theory, Int.	7–5
	8·031	Physics	5–5		8·041	Physics	5–5
	14·01	Economic Principles I	3–5		14·02	Economic Principles II	3–5
	H21	Humanities	3–5			or	
	M21	Calculus	3–6		14·90	Govt., Politics & Tech.	3–5
	MS21	Military Science	3–0		H22	Humanities	3–5
		or			M22	Differential Equations	3–6
	AS21	Air Science	3–0		MS22	Military Science	3–0
			24–26			or	
					AS22	Air Science	3–0
							24–26

Third Year

First Term	6·02	Electronic Circuits	7–5	*Second Term*	6·04	Elec. Energy Conversion	7–5
	6·03	Fields, Energy & Forces	7–5		6·05	Applied Electronics	7–5
	14·95	Pol., Soc. & Policy Making	3–5		H32	Pol. Proc. in Ind. Amer.	3–5
	H51	Amer. Econ. Develop.	3–5		H52T	Bus. Lead. in Amer. Econ.	3–5
	M351	Adv. Calculus for Eng.	3–6			§Humanities Elec. Subj.	3–5
			23–26				23–25

Fourth Year

First Term	2·001	Applied Mechanics I	3–5	*Second Term*	2·002	Applied Mechanics II	3–5
	H95	Am. Indust. Soc. Sem.	3–6		H96	Am. Indust. Soc. Sem.	1–4
		‡Eng. or Humanities Elec. Subj.	8			‡Eng. or Humanities Elec. Subj.	8 or 9
		‡Eng. Elec. Subj.	9			Course XXI Elec. Subj.	3–5
		Course XXI Elec. Subj.	16			§Humanities Elec. Subj.	3–5
			50			*Thesis	12
							49 to 50

XXI-B. Sample Program. Based on Philosophy and Literature and Biology

First Year (See page 49)

Second Year

First Term	7·01	General Biology I	3–4	*Second Term*	5·12	Quantitative Analysis	7–3
	7·011	General Biology Lab. I	3–0		7·02	General Biology II	3–4
	8·03	Physics	5–5		7·021	General Biology Lab. II	3–1
	E31	Literature, Int.	3–5		8·04	Physics	5–5
	H21	Humanities	3–5		E32	Literary Theory	3–5
	M21	Calculus	3–6		H22	Humanities	3–5
	MS21	Military Science	3–0		MS22	Military Science	3–0
		or				or	
	AS21	Air Science	3–0		AS22	Air Science	3–0
			23–25				27–23

Third Year

First Term	5·41	Organic Chemistry I	4–4	*Second Term*	5·62	Physical Chemistry II	4–4
	5·416	Organic Preparations I	6–0		5·621	Physical Chem. Lab. II	4–2
	5·61	Physical Chemistry I	4–4		H74	Sci. & Phil., Galileo—Pres.	3–5
	H73	Sci. & Phil., Gr.–Copernicus	3–5		H76T	Phil. Prob. & Systems	3–5
	H75T	Phil. Prob. & Systems	3–5		M22	Differential Equations	3–6
		Lang. or Humanities Elec. Subj.	3–5			Lang. or Humanities Elec. Subj.	3–5
			23–23				20–27

Fourth Year

First Term	7·03	Genetics & Cytology	6–4	*Second Term*	7·04	Embryology	8–4
	H93	Phil. & Lit. Seminar	3–6		H94	Phil. & Lit. Seminar	1–4
		Sci. or Humanities Elec. Subj.	3–5			††Sci. or Hum. or Lang. Elec. Subj.	8 to 12
		††Sci. or Lang. Elec. Subj.	3–5			Course XXI Elec. Subj.	3–5
		Course XXI Elec. Subj.	16			*Thesis	12
			51				45 to 49

* See Requirements for Bachelor's Degree, page 45.
‡ To be selected from professional subjects of Course VI.
§ See note under Course XXI curriculum.
†† A language above the elementary level permitted by the Biology Department.

RESERVE OFFICERS' TRAINING CORPS
MILITARY SCIENCE AND AIR SCIENCE

THE general object of the Reserve Officers' Training Corps is to qualify students for positions of leadership in time of national emergency, and to provide officers for the various components of the Army and the Air Force. The program consists of two parts, the basic course and the advanced course, each of two academic years, the advanced course including a summer camp. The basic course is required by the Institute; the advanced course is elective.

An Air Force ROTC Detachment and an Army ROTC Detachment have been authorized. The Army Detachment consists of five technical service units: Corps of Engineers, Signal Corps, Ordnance Corps, Chemical Corps, and Quartermaster Corps.

All physically qualified male first-year students who are citizens of the United States and under twenty-three years of age at time of initial enrollment are required to enroll in the two-year basic course, unless exempted therefrom on conscientious grounds as approved by the Faculty; those who enter the Institute as second-year transfer students are required to take one year of the basic course. Students who have satisfactorily completed instruction in an approved ROTC unit at another institution may receive credit therefor upon presentation of suitable evidence to the Professor of Military Science and Tactics or the Professor of Air Science. Also, those who have been members of any of the armed services may receive credit in accordance with established policies.

Basic Course

The Basic Course includes the Military Science or Air Science subjects required in the first two years. Upon initial enrollment, a student elects either the Air Force or the Army program of instruction.

The Basic Course program consists of drill and other general military training. The subject numbers are MS11, MS12, MS21, and MS22 for the Army ROTC program and AS11, AS12, AS21, and AS22 for the Air Force ROTC program.

Advanced Course

The object of the Advanced Course is to prepare well qualified students to become reserve or regular officers in the Army or the Air Force. This course is open to students who have satisfactorily completed two years in the basic course or its equivalent. To be accepted, students must have the approval of the registration officer of the course in which they are registered, and of the Professor of Military Science and Tactics or Professor of Air Science. Students who complete the Advanced Course may be commissioned as Second Lieutenants in the Army Reserve or the Air Force Reserve on graduation. Each year a number of ROTC graduates may be offered commissions in the Regular Army or the Regular Air Force.

For those students enrolled in the Advanced Course, M. I. T. receives a monetary allowance (commutation in lieu of issue in kind of government uniforms) in the amount of one hundred dollars per student which is applied against the cost of the student's uniform. The student receives commutation of subsistence at the approximate rate of ninety cents per day from date of enrollment until the end of the second Institute year thereafter, including one summer vacation, except for the period of the ROTC camp, when he is subsisted by the Government and currently paid at the rate of seventy-eight dollars per month.

To enroll, he must have executed a Deferment Agreement and then must execute a contract to continue the course of instruction for two years, should he remain in school for that length of time. The contract includes the obligation to attend the ROTC camp, which is scheduled during June, July, and August following the first year of the advanced course, at which all expenses, including transportation, are paid by the Government.

The program of subjects required in the Army units and the Air Force detachment of the Advanced Course is given below.

Army Units:

Corps of Engineers: MS312, MS322, MS412, MS422.

Signal Corps: MS313, MS323, MS413, MS423.

Ordnance Corps: MS314, MS324, MS414, MS424.

Chemical Corps: MS316, MS326, MS416, MS426.

Quartermaster Corps: MS318, MS328, MS418, MS428.

Air Force Detachment:

Air Science III and IV: AS31, AS32, AS41, AS42.

Army Advanced ROTC

Army Advanced ROTC students must complete 12 semester hours of subjects selected from the list below, according to the branch in which they are enrolled.

Subject No. and Name		*Semester Hours*	*CE*	*SC*	*Ord C*	*Cml C*	*QMC*
1·40	Structural Analysis	3	x				
or							
1·40T	Statics and Dynamics	3	x				
1·611T	Fluid Mechanics	3	x			† x	
1·771†	Sanitation	2	x				
2·002	Applied Mechanics II	3	x	x	x	x	x
or							
2·04	Strength of Mat.	3	x	x	x	x	x
2·081	Strength of Mat.	3	x	x	x	x	x
2·42	Heat Engineering	3	x	x	x	x	x
or							
2·421	Heat Engineering	3	x	x	x	x	x
2·731	Machine Design	3.5	x	x	x	x	x

† Discontinued 1956–57.

Reserve Officers' Training Corps Continued

	Subject No. and Name	Semester Hours	CE	SC	Ord C	Cml C	QMC
2·791	Int. Combustion Eng.	3	x	x	x	x	x
2·792	Int. Combustion Eng.	3	x	x	x	x	x
2·85	Machine Tools, Int.	2	x	x	x	x	x
or							
2·851	Machine Tool Lab.	2	x	x	x	x	x
3·11	Engineering Metals	5	x	x	x	x	x
3·31	Phys. Metallurgy I	5.5	x	x	x	x	x
4·62‡	Site Plan. & Constr.	4.5	x				
5·41	Organic Chemistry I	4	x		x	x	x
5·42	Organic Chemistry II	4	x		x	x	x
5·61	Physical Chemistry I	4	x	x	x	x	x
5·62	Physical Chemistry II	4	x	x	x	x	x
6·02	Electronic Circuits	5	x	x	x	x	x
6·18	Elec. Eng., Fund.	3.5	x	x	x	x	x
7·01	General Biology I	3				x	x
and							
7·011	General Biology Lab. I	1.5				x	x
7·02	General Biology II	3				x	x
and							
7·021	General Biology Lab. II	1.5				x	x
7·831	Biochem. of Microorg.	5	x			x	x
8·04	Physics (Optics & Atomic Phys.)	4.5	x	x	x	x	x
8·05	Phys.: Atoms, Molec. & Nucl. I	4	x	x	x	x	x
8·07	Thermo. & Statist. Mech.	4	x	x	x	x	x
8·08	Electronics	4	x	x	x	x	x
10·18	Industrial Chemistry	3			x	x	x
10·28	Chemical Engineering	4	x		x	x	x
12·011†	Mineralogy I	2	x			x	x
or							
12·011T	Mineralogy I	5	x			x	x
12·301†	General Geology	7					x
or							
12·301T	Physical Geology	5					x
12·321	Engineering Geology	3	x				x
12·44†	Petroleum Geology	2					x
or							
12·44T	Petroleum Geology	3					x
14·51	International Rel.	3	x	x	x	x	x
14·52	Amer. Diplomacy, Prin. & Prob.	3	x	x	x	x	x
14·63	Labor Relations	3	x	x	x	x	x
14·70	Psychology, Int.	3	x	x	x	x	x
14·73	Org. & Com. in Groups	3	x	x	x	x	x
14·92	Comp. Polit. & Ec. Systems	3	x	x	x	x	x
15·11	Indust. Manage., Int.	3	x	x	x	x	x
15·30	Personnel Admin.	3	x	x	x	x	x
15·61	Business Law	3	x	x	x	x	x
15·70‡	Production	3	x	x	x	x	x
15·71	Production Manage.	3	x	x	x	x	x
16·21	Aircraft Structures	4	x		x		
16·53	Aircraft Propulsion	3			x		
17·22†	Building Constr.	5	x				
19·02	Descript. Meteor. II	3		x		x	
19·21	Meteor. Observations	2.5		x		x	
M831	Analysis	3			x		
M832	Analysis	3			x		

Air Force Advanced ROTC

Air Force Advanced ROTC students must complete 12 semester hours in elective equivalents which will be announced during the sophomore year.

† Discontinued 1956–57.

‡ Discontinued 1955–56.

THE GRADUATE SCHOOL

ADMINISTRATION OF THE GRADUATE SCHOOL

PRESIDENT, JAMES R. KILLIAN, JR., SC.D., LL.D., D.ENG.
DEAN OF THE GRADUATE SCHOOL, HAROLD L. HAZEN, SC.D.
SECRETARY OF THE GRADUATE SCHOOL, ERNEST H. HUNTRESS, PH.D.

COMMITTEE ON GRADUATE SCHOOL POLICY

H. L. HAZEN, SC.D., *Dean of the Graduate School,* Chairman Ex-Officio*
E. H. HUNTRESS, PH.D., *Secretary of the Graduate School, Ex-Officio, Secretary*
B. A. THRESHER, S.B., A.M., *Director of Admissions, Ex-Officio*
J. T. NORTON, SC.D., *Chairman of the Faculty, Ex-Officio*

W. P. ALLIS, SC.D.
Professor of Physics

J. M. AUSTIN, SC.D.
Associate Professor of Meteorology

W. H. BROWN, M.ARCH.
Associate Professor of Architecture

J. H. EVANS, B. ENG.
Associate Professor of Naval Architecture

T. S. GRAY, SC.D.
Associate Professor of Engineering Electronics

T. M. HILL, A.B., M.B.A.
Associate Professor of Industrial Management

J. W. IRVINE, JR., PH.D., SC.D.
Associate Professor of Chemistry

J. H. KEENAN, S.B.
Professor of Mechanical Engineering

C. P. KINDLEBERGER, PH.D.
Professor of Economics

N. LEVINSON, SC.D.
Professor of Mathematics

J. T. R. NICKERSON, PH.D.
Associate Professor of Food Processing

C. H. NORRIS, SC.D.
Professor of Structural Engineering

J. T. NORTON, SC.D.
Professor of the Physics of Metals

S. OBER, S.B.
Professor of Aeronautical Engineering

LLOYD RODWIN, PH.D.
Associate Professor of Land Economics

R. R. SHROCK, PH.D.
Professor of Geology

I. W. SIZER, PH.D.
Professor of Biochemistry

G. C. WILLIAMS, SC.D.
Professor of Chemical Engineering

CHAIRMEN† OF DEPARTMENT COMMITTEES ON GRADUATE STUDENTS

Aeronautical Engineering	S. OBER
Architecture	L. B. ANDERSON
Biology	I. W. SIZER
Building Engineering and Construction	A. G. H. DIETZ
Chemical Engineering	G. C. WILLIAMS
Chemistry	J. W. IRVINE, JR.
City and Regional Planning	F. J. ADAMS
Civil Engineering	C. H. NORRIS
Economics and Social Science	R. L. BISHOP
Electrical Engineering	J. B. WIESNER
Food Technology	B. E. PROCTOR
Geology	R. R. SHROCK
Industrial Management	T. M. HILL
Mathematics	W. T. MARTIN
Mechanical Engineering	J. H. KEENAN
Metallurgy	J. T. NORTON
Meteorology	J. M. AUSTIN
Naval Architecture and Marine Engineering	J. H. EVANS
Physics	P. M. MORSE
Sanitary Engineering	W. E. STANLEY

* Correspondence regarding admission to the Graduate School and graduate scholarships and fellowships should be addressed to the Dean of the Graduate School.
† Inquiries regarding prerequisites for graduate subjects and programs of graduate work in any field of study should be addressed to the Chairman of the Committee on Graduate Students of the appropriate department.

THE GRADUATE SCHOOL

GENERAL INFORMATION

The Graduate School brings together Faculty members and post-baccalaureate students as a community of scholars having a common interest in advanced professional study and creative work. It seeks to provide in the atmosphere of a professional school the widest possible opportunity for advanced study and investigation of a high order and for intimate association among creative workers whose common objective is to extend the boundaries of their professions.

Detailed information regarding the organization, policies, and procedures of the Graduate School is fully given in a 33-page booklet entitled GRADUATE SCHOOL MANUAL, the current issue of which is sent with the official Notification of Admission to all successful applicants. For this reason, the following material in this catalogue is limited to those aspects primarily of concern to potential applicants.

Graduate students may pursue work leading to any of the following degrees:

Doctor of Philosophy, Ph.D.
Doctor of Science, Sc.D.
Engineering Degrees (see page 96)
Master of Science, S.M.
Master in Architecture, M.Arch.
Master in City Planning, M.C.P.

FIELDS OF STUDY

The following major fields for graduate study, grouped by Departments or Courses, are presented in subsequent pages on which are described the programs of graduate instruction offered by the various departments.

AERONAUTICAL ENGINEERING, Course XVI
- Aerodynamics
- Design
- Instrumentation
- Power Plants
- Structures

ARCHITECTURE, Course IV-A

BIOLOGY, Course VII
- Analytical Biology
- Biochemistry
- Biophysics
- General Physiology
- Microbiology

BUILDING ENGINEERING AND CONSTRUCTION, Course XVII
- Building Management
- Materials of Construction
- Structural Design

CHEMICAL ENGINEERING, Course X
- Applied Chemistry
- Engineering Operations
- Fuel Engineering
- Nuclear Engineering
- Chemical Engineering Practice (X-A)

CHEMISTRY, Course V
- Analytical
- Inorganic
- Nuclear
- Organic
- Physical

CITY PLANNING, Course IV-B

CIVIL ENGINEERING, Course I
- Hydromechanics and Hydraulic Engineering
- Photogrammetric Engineering
- Soil Engineering
- Structural Engineering
- Transportation Engineering

ECONOMICS AND SOCIAL SCIENCE, Course XIV
- Economics and Engineering (or Science)
- Industrial Economics
- Industrial Relations

ELECTRICAL ENGINEERING, Course VI
- Automatic Computation and Numerical Analysis
- Communications and Electronics
- Electric Power
- Electronics Applications and Automatic Control

FOOD TECHNOLOGY, Course XX
- Biochemical Engineering

GEOLOGY AND GEOPHYSICS, Course XII
- Geology (Classical Geology, Theoretical Geology, Geochemistry)
- Geophysics

INDUSTRIAL MANAGEMENT, Course XV

MATHEMATICS, Course XVIII

MECHANICAL ENGINEERING, Course II
- Applied Mechanics
- Heat Engineering
- Materials
- Propulsion
- Textile Technology

METALLURGY, Course III
- Ceramics
- Metallurgy
- Mineral Engineering

METEOROLOGY, Course XIX

NAVAL ARCHITECTURE AND MARINE ENGINEERING, Course XIII
- Marine Engineering
- Naval Architecture
- Naval Construction and Engineering (U. S. N. and U. S. C. G.: XIII-A)
- Shipping and Shipbuilding Management XIII-B

PHYSICS, Course VIII

SANITARY ENGINEERING, Course XI

Each graduate student is enrolled in one course which assumes responsibility for his guidance and approval of his program. The work of a student is not limited, however, to that offered in a single department: his actual studies and research may be chosen from among several departments with the aid and counsel of the staff, subject only to the fundamental requirement that his program be designed to achieve a concentration in a major field of study.

In addition to specialized professional competence, graduate students are expected to have or else to acquire a background in non-professional fields such as the humanities and social studies. The Faculty believes that breadth of information and understanding which tend to promote qualities of leadership, along with specialized competence, should characterize the recipients of advanced degrees. As an aid in accomplishing this dual objective, electives are available to graduate students in English, history, economics, international affairs, the fine arts, etc.

Special Facilities

The Institute is widely known for the breadth and excellence of its facilities for scientific and engineering research. Among the large, well-equipped laboratories are the Servomechanisms Laboratory, the Gas Turbine and Sloan Automotive Laboratories, the Dynamic Analysis and Control Laboratory, the Supersonic Laboratory, the Metals Processing Laboratory, the Hydrodynamics Laboratory, the Underwater Ship Propeller Tunnel, the Ship Model Towing Tank, the Digital Computer Laboratory, the Laboratory for Research in Executive Behavior, the High Voltage Research Laboratory, the Laboratory for Insulation Research, the I.B.M. Computation Center, and the Aero-Instrumentation Laboratory. The Institute is one of nine institutions operating the Brookhaven National Laboratory at Upton, Long Island, New York.

A nuclear reactor, heavy-water modulated and cooled and operating at 1000 kilowatts, is to be built at M. I. T. within the next two years. It will be non-secret, and research with the reactor -- and the facility itself — will be open to all qualified students and staff members. The Cambridge Electron Accelerator, a six billion electron volt accelerator made possible by a grant of the Atomic Energy Commission, will be built during the next four years on the Harvard University campus; it is being designed and built and will be operated jointly by M. I. T. and Harvard. Particle accelerators available on the M. I. T. campus include Van de Graaff electrostatic generators with capacities to 8.5 m.e.v., the 7 m.e.v. M I. T. Cyclotron, a 17 m.e.v. linear accelerator, and the 300 m.e.v. electron synchrotron.

Interdepartmental Laboratories. In addition to the many unexcelled research laboratories administered within the several departments, the Institute maintains interdepartmental centers of research which coordinate the activities of various departments in fields of overlapping interest. These interdepartmental laboratories unite the staff and student personnel of the various departments for concerted effort with centralized facilities and services. Among them are the Acoustics Laboratory, the Research Laboratory of Electronics, the Laboratory for Nuclear Science, the Spectroscopy Laboratory, and the Computation Center.

The Division of Sponsored Research, being the contracting agency for sponsored research, makes possible a great variety of established programs of research, providing graduate students with an extensive opportunity for research, and granting to a limited number the opportunity to earn while learning.

The Engineering Practice School at Oak Ridge, Tennessee, in the Diffusion Plant and the Oak Ridge National Laboratory of the Atomic Energy Commission, operated by Union Carbide Nuclear Company, is available for qualified graduate students in any department who are United States citizens, subject to Security clearance by the Atomic Energy Commission. Under the direction of Institute Faculty, resident at the site, the work will emphasize the application of engineering principles to the solution of plant problems and is designed to develop initiative, resourcefulness and cooperative effort in large-scale industrial operations. There are two periods per year, (1) from September to January, and (2) from early February to early June. Each period carries academic credit for 48 units. Application should be made at least four months in advance to allow ample time for clearance. All inquiries should be addressed to Professor J. Edward Vivian of the Chemical Engineering Department.

Graduate Student Organizations and Activities

All graduate students of the Institute are members of the Graduate Student Organization of which the elected Council is the governing body. Council membership includes representatives of all Courses, of the Graduate House, of Westgate, and of off-campus graduate residents. The several specific functions of the Organization concern broadly the general welfare, the social and extracurricular activities, and the relations with the Institute of the graduate student body as a whole.

Through its Executive Committee the Graduate House Student Organization functions autonomously in a parallel way for Graduate House residents.

All athletic facilities are available for the entire student body. Likewise, graduate students are welcome as members of the Nautical Association which maintains an extensive fleet of sailing dinghies. Other campus organizations such, for example, as those concerned with dramatics, music and outings welcome graduate student participation.

Organization

The Faculty of the Graduate School is the Faculty of the Institute. Its officers are the President of the Institute, the Dean of the Graduate School, the Secretary of the Graduate School and the Committee on Graduate School Policy, comprising a Faculty member of each department which offers graduate subjects of instruction. For each of these departments, there is at least one Graduate Registration Officer to guide the choice of subjects for which its graduate students register.

Details of admission, registration, acceptance of fees and recording of grades are administered by the regular authorities of the Institute as a whole. Student conduct is the concern of the Dean of Students.

The Dean of the Graduate School will welcome any graduate student at his office, 3-136, at any time on any matter.

ADMISSION

Admission to Graduate School as Graduate Student

To be admitted as a Graduate Student, an applicant must have received a Bachelor's degree from a college, university, or technical school of standing acceptable to the Director of Admissions of the Massachusetts Institute of Technology, and his academic record and other credentials must be such as to indicate that he has the ability to accomplish satisfactorily an approved program of graduate study and research.

For acceptance to work toward a Master's degree, the applicant shall, in addition to the above requirement, have been ranked in the upper two-thirds of his class at graduation; for a Doctorate, in the first third of his class, or have satisfactorily completed the equivalent of requirements for a Master of Science degree in an institution acceptable to the Director of Admissions.

Admission to Graduate School as Provisional Graduate Student

Admission as a Provisional Graduate Student may be granted to an applicant who, although unable to meet the above requirements for acceptance as a graduate student, *is judged by a Department Committee on Graduate Students probably to be able to pursue successfully graduate studies*, with or without additional preparation in prerequisite subjects.

Provisional Graduate Student status will be changed to that of Graduate Student upon demonstration of ability necessary to pursue successfully graduate studies by completion of either of the following requirements:

(1) Completion with a satisfactory grade in one academic term of not less than 45 units of regular subjects, of which at least 32 units are of "A" classification, or, when particular conditions preclude registration satisfying the condition above,

(2) Completion with a satisfactory grade in two academic terms of not less than 36 units of "A" subjects.

Admission to Graduate School as Special Student

A duly qualified applicant who desires to enroll for graduate subjects with a clearly defined objective, but not as an applicant for a degree, may be admitted as a Special Graduate Student by approval of the Dean of the Graduate School and of the chairman of a departmental committee on graduate students. Such a student will be enrolled as of the department which has approved his admission. The subjects for which a Special Graduate Student may register are limited to those for which specific written approval has been granted in advance of enrollment.

Procedure for Making Application for Admission to Graduate School

Before an applicant will be considered for admission to the Graduate School, he must file an "Application for Admission to the Graduate School," which may be secured by writing to the Director of Admissions, Massachusetts Institute of Technology, Cambridge 39, Massachusetts.

Admission, in general, will be restricted to the beginning of an academic year in the Fall. For early consideration, an application for such admission, together with all credentials, should be submitted by March 1. Applications received between March 1 and June 1 will receive consideration until enrollments are filled in the departments specified by the applicants.

Applications from non-citizens of the United States received previous to May 1 will be appraised at that time only for admission in the following Fall Term.

Applicants who file requests for admission during their final year of work toward a Bachelor's degree will be considered for admission and may be accepted conditional upon subsequent filing of evidence of having been awarded said degree.

Notices of decisions made on regular applications for Fall admissions, together with notification of scholarship awards for an ensuing academic year, will be mailed on or after April 1.

All students admitted to the Graduate School will receive with their notification of admission a copy of the booklet entitled *Graduate School Manual.* In the interests of good operation and economy of effort, each graduate student is expected to be familiar with the contents of this *Manual.* Additional copies of the booklet may be secured from the Information Office or the Admissions Office.

Correspondence concerning admissions should be addressed to the Director of Admissions. Inquiries concerning preparation or subject matter in courses should be addressed to the chairman of the appropriate Departmental Committee on Graduate Students (see page 89).

Graduate Record Examination

As additional evidence in support of an application for admission to the Graduate School, an applicant who has taken the Area Tests of the Graduate Record Examinations of the National Program for Graduate School Selection may offer an official report of these examinations. It is entirely optional whether such evidence be offered by the applicant. For M. I. T. admission it is generally unnecessary to take any of the various Advanced Tests also offered by the National Program.

For a student desiring to undertake graduate work at the Institute, the results of the Graduate Record Examination Area Tests are often useful in informing him and the admissions authorities of his competence in cultural subjects, particularly. Correspondence relative to the conditions and places of examination should be addressed to the Graduate Record Examinations, Educational Testing Service, 20 Nassau Street, Princeton, N. J., or 4640 Hollywood Boulevard, Los Angeles 27, California.

UNDERGRADUATE PREPARATION FOR ADVANCED DEGREES

General Requirements for Admission

Except as stated below under requirements peculiar to an individual field, evidence of satisfactory preparation will ordinarily be required in the following undergraduate subjects:

Mathematics. Mathematics substantially equivalent to the Institute's subjects of the first and second undergraduate years, namely Calculus M11, M12, M21 and Differential Equations M22.

Chemistry. College chemistry substantially equivalent to the Institute's first-year chemistry, 5·01, 5·02.

Physics. College physics substantially equivalent to the Institute's first and second year physics, 8·01, 8·02, 8·03, and 8·04.

Cultural Subjects. At least six semester courses in English, history, economics (or allied subjects) or other cultural subjects equivalent in scope to those included in the undergraduate curricula of the Institute. Deficiencies may be satisfied by presenting satisfactory grades in the Area Tests of the Graduate Record Examination or by completing appropriate subjects from fourth-year or graduate electives in the humanities and social studies.

Professional Subjects. As specified below, particular professional subjects are required by individual departments.

Deficiencies in Preparation

Deficiencies in quantity or quality of training in prerequisite general or professional subjects must be removed before the student may proceed with graduate work dependent thereon.

If an applicant for admission to the Graduate School lacks so many undergraduate requirements that the attainment of the advanced degree is likely to be unduly protracted, he may be advised to postpone his application until his deficiencies have been reduced. Minor deficiencies in his preparation may be removed while he is pursuing graduate study.

In exceptional cases, the Committee on Graduate School Policy will pass upon a proposal for modification of certain specified requirements if initiated by a Departmental Committee on behalf of an applicant for an advanced degree in a specialized field, and may modify any of the above requirements.

RESIDENCE

Residence requirements are specified, not in terms of elapsed time, but in terms of amount of registration during which it is anticipated that residence benefits may be acquired.

Residence credit may be achieved by the satisfactory completion of approved subjects of instruction or thesis for which the applicant is registered while in the status of regular student or of Special Student who is also an Institute Staff member, or, in unusual cases, by accepted substitutions therefor, as set forth below.

For the degrees of Master in Architecture, Master in City Planning, or Master of Science, the entire thesis and at least two thirds of the remainder of the 72 "A" units must be completed with residence credit.

For a degree of Engineer, the equivalent of substantially two terms of full-time graduate work, including thesis, must be completed with residence credit.

For a doctorate, the equivalent of at least two years of full-time graduate work must ordinarily be completed with residence credit unless advanced work, completed otherwise, is accepted by a student's major department in lieu of similar work in residence, but in no case may the required amount of work in residence be reduced to less than the equivalent of one full-time academic year.

Transfer of Special Student Credits

Subjects completed by a Special Student, whether or not at the same time a member of the M. I. T. Academic or D. S. R. Staffs, may be subsequently offered in partial fulfillment of requirements for an advanced degree by such a student who has achieved regular graduate student status, and the student's major department will in each case determine to what extent such subjects are acceptable, with or without residence credit.

THE DEGREES MASTER OF SCIENCE, MASTER IN ARCHITECTURE, AND MASTER IN CITY PLANNING

The degrees Master of Science, Master in Architecture, and Master in City Planning are awarded by the Corporation upon recommendation of the Faculty, based upon approval of the Committee on Graduate School Policy, upon the satisfactory completion of a course of advanced study and research approved by the department in which the student has been enrolled and upon compliance with the regulations as set forth hereunder, during residence of at least one academic year.

Students who complete the requirements for the Bachelor's degree at the Institute, together with substantial extra advanced credits in graduate subjects, may, upon application, be granted a relaxation of the normal residence requirement and may be recommended for the Master's degree upon completion of the requirements therefor.

A graduate of the Institute in the department in which he enrolls for the Master's degree, or others with equivalent preparation, may attain that degree in one year. Others with less direct and extensive preparation will require a longer time according to the number of prerequisites which must be satisfied.

College students desiring to undertake work for an advanced degree at the Institute will find it advantageous to select electives which will satisfy the prerequisites for the advanced work which they intend to undertake. Advice on such electives may be secured by correspondence with the Chairman of the Committee on Graduate Students of the department in which he desires to enroll. Attention is called to the statement of professional prerequisites under the appropriate department in the following pages.

Degree Requirements. The degrees Master of Science, Master in Architecture, and Master in City Planning are awarded upon the satisfactory completion of an approved program of at least 96 units, of which 72 units, including a thesis of not less than 20 nor more than 40 units (in Architecture 24 to 36 units) shall be "A" subjects. (See "Subjects of Instruction Tabulated" for "A" subjects.)

The choice of field of specialization must be approved by the Committee on Graduate Students of the department in which the student is enrolled. The choice of subjects is not restricted to those offered in a single department: subjects in more than one department may be selected, provided that the resultant program is approved as being integrated and well-balanced.

Approval of the entire program must be obtained from the student's Registration Officer and the Committee on Graduate Students of the department in which the student is enrolled, or by a special interdepartmental committee appointed by the Dean of the Graduate School to supervise his program if it be in a field which concerns two or more departments.

Credit is rarely granted for thesis work done in absentia: all thesis work must be done under the supervision of a member of the Institute's Academic Staff.

To be recommended for a Master's degree, a student must not only have a clear record in a program of graduate study and research as defined above, but his scholastic standing must be of a distinctly high grade.

Degrees With and Without Specification

In a program for a Master of Science degree, if 64 units of "A" subjects, including thesis, in an approved program are in a single field of science or engineering as determined by a departmental Committee on Graduate Students, the degree will be recommended with specification in the field in which the student has thus specialized; otherwise, the degree will be recommended without specification. The same high standard of academic performance is required in either case.

ENGINEERING DEGREES

The following degrees are awarded for the satisfactory completion of a program comprising at least 192 units of advanced study and research, including a thesis of not less than 20 nor more than 50 units, approved by the appropriate department of the School of Engineering: Civil Engineer (C.E.), Mechanical Engineer (Mech.E.), Metallurgical Engineer (Met.E.), Mineral Engineer (Min.E.), Electrical Engineer (E.E.), Chemical Engineer (Chem.E.), Sanitary Engineer (San.E.), Marine Mechanical Engineer (Mar.Mech.E.), Naval Architect (Nav.Arch.), Naval Engineer (Nav.E.), Aeronautical Engineer (Aer.E.), and Building Engineer (Bldg.E.).

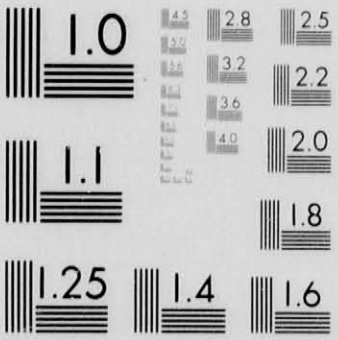
A graduate of the Institute who enrolls for an Engineering Degree in the same department in which he received his Bachelor's degree, or others with equivalent preparation, may complete the requirements for that degree in four academic terms; students with less direct or less extensive preparation will require a longer time.

The objective of a program leading to one of these degrees is a higher level of professional engineering competence than is required by the program for the Master's degree, without the emphasis on creative research which is characteristic of a doctoral program.

THE DOCTORATES

The degrees Doctor of Philosophy in fields of science and Doctor of Science in fields of applied science or of engineering certify to performance of original research of high grade and to creditable completion of an approved program of advanced study, principally at the Institute.

If at any time a Department Committee on Graduate Students is convinced that one of its applicants for a doctorate has not demonstrated those abilities necessary to meet the requirements for this degree, he may be required to change his registration to that of an applicant for a lower degree or to discontinue his registration in the Graduate School.



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

M.I.T. ANNUAL CATALOGUES AND BULLETINS
1956/57

02
OF
03

The four basic requirements for the award of a doctorate are as follows:

(1) Completion of a Major program of advanced work, concluding with a General Examination.

(2) Completion of a Minor program of study in an area distinct from that of the Major field.

(3) Demonstration of proficiency in reading the technical literature of his field in modern foreign languages.

(4) Preparation of a thesis on original research.

The Major Requirement

The Major, consisting of advanced study and research, may be selected in any field of science or engineering approved by the department in which the student is enrolled. The Thesis will be in this same field. The program of the Major need not necessarily be confined to subjects offered in a single department.

When the Major field involves a program made up of subjects in several departments, there may be appointed a special committee to supervise the applicant's work.

A general examination upon the field of the Major will be held for each applicant for a doctorate at such time and in such manner as his Department Committee shall approve, except that each examination shall comprise both written and oral parts.

The Minor Requirement

The Minor requirement for the Ph.D. or Sc.D. degree comprises at least three subjects (not less than 24 units of credit) in some field other than that in which the Major lies. All of these subjects shall be more advanced in character than required in the prescribed undergraduate curriculum of the department in which the student majors. Subjects elected to satisfy this requirement will be selected with the primary objective of contributing broadly to the development of professional leadership rather than merely improving technical competence in a particular region of major interest; they will usually be offered by some department other than that in which the student is registered.

The full program of subjects comprising the Minor should be specifically agreed upon before it is begun. The field of the Minor must have the approval of the student's registration officer, and the components must have the approval of the Chairman of the Committee on Graduate Students of that department in which a plurality of the Minor subjects is given. The chairman of the Minor department shall file with the Registrar a record of the anticipated program as soon as it is determined. Any modification of the Minor program shall be reported promptly to the Registrar by the Minor department.

Occasionally, a student may desire to offer as a Minor a program of subjects which, although complying with both the letter and spirit of the first paragraph under this heading, involves components which, for administrative reasons, are offered within the department of which the student's Major field constitutes a portion. Such programs, if approved by the corresponding Departmental Committee and by the Dean of the Graduate School, shall be administered through the student's registration officer.

Subjects required for the completion of the Minor program should be approved in advance of enrollment therein. However, credit for appropriate subjects previously taken at the Institute or elsewhere as a graduate student, may be given to any extent satisfactory to the Minor department.

An examination to be based on the field of the Minor may be required, especially if credit for a part of the Minor requirement is granted for work done elsewhere.

The Language Requirement

Each candidate for a doctorate must demonstrate to the Department of Modern Languages his ability to read in English and two other modern languages the scientific literature of his field of specialization. These languages must be acceptable to the department in which he is enrolled and must be languages in which there is important literature in the field of his specialization. Accordingly, a student from a non-English-speaking nation may expect acceptance of his native tongue as one of the approved languages only if there is in that language a sufficient amount of important and pertinent literature.

Examinations in reading scientific literature in modern languages are held at intervals stated by the Department of Modern Languages.

Thesis

The calibre and scope of the doctoral research will in general be such as to require the equivalent of the full time of a student for at least one academic year. Each doctoral candidate is expected to register for the appropriate number of units of thesis in all periods during which his investigation is actually in progress.

The thesis must be carried out under the direction of a member of the Faculty. Work already accomplished elsewhere not under supervision of a member of our Faculty cannot be accepted in partial fulfilment of thesis requirement, nor can credit be granted for thesis work done in absentia.

A final oral examination on the thesis and its field will be held after the thesis has been accepted and tentatively evaluated by the examiners.

Award of the Degree

Upon completion of the above requirements, with the approval of the candidate's supervisory committee, and upon recommendation to the Faculty by the Committee on Graduate School Policy, the degree will be awarded by the Corporation of the Institute.

COOPERATIVE ARRANGEMENT WITH HARVARD UNIVERSITY

A student enrolled in the Graduate School at the Massachusetts Institute of Technology who is engaged full-time in study or in a combination of study and academic staff duties together equivalent to full-time, may by permission enroll for advanced work exclusive of research at Harvard University or Radcliffe College without payment of additional tuition, provided that such exchange enrollment may not exceed one-half of his total registration. In the above category are included Fellows and full-time Special Graduate Students who are carried on the rolls of the Graduate School at M. I. T.

A student desiring to avail himself of this privilege must present to the Dean of the Graduate School at M. I. T. a written request from his Registration Officer, specifying the name and number of the Harvard subject desired, and whether for credit or for auditing without formal grade; the Dean's office will issue to the petitioner certain forms which must first be presented by him to the Instructor in the course desired, and then to the Dean of the appropriate Graduate School at Harvard. Registration must be completed within two weeks of the Registration Day specified by Harvard University for each term.

Permission will be granted for attendance at only such classes as are not so crowded that this additional registration creates an undue load on the instructors.

Requests should be confined to subjects not available in our own institution, and if there be apparent duplication of a requested subject in the two schools, acceptable reasons for the request must be presented.

Procedure for Harvard Students

A student enrolled in a graduate school at Harvard must obtain on appropriate forms the endorsement of the dean of his school and the written consent of the instructor in charge of each M. I. T. subject he plans to take. This approved request must then be presented at the office of the Dean of the Graduate School at M. I. T., Room 3-136. If the request is granted, the student must call for a letter of authorization which he must present at the Office of the Registrar, Room 7-142, in order to obtain registration material.

Such requests on behalf of Harvard students will not be granted after the end of the second week of a term at M. I. T.

COOPERATIVE ARRANGEMENT WITH LOWELL TECHNOLOGICAL INSTITUTE

Opportunity is afforded by a cooperative arrangement with Lowell Technological Institute for interchange in the use of facilities in connection with undergraduate and graduate classes, summer programs of instruction, and the library, as well as interchange of staff members for lectures.

I. CIVIL ENGINEERING

THE Department of Civil and Sanitary Engineering provides opportunity for study and research to satisfy the requirements for the degrees of Master of Science in Civil Engineering, Civil Engineer, or Doctor of Science in Civil Engineering. It also offers graduate programs in Sanitary Engineering (see Course XI) and in Building Engineering and Construction (see Course XVII).

In Civil Engineering programs of study may be selected from the following fields:

Structural Engineering: advanced subjects dealing with methods of analysis and design of statically indeterminate and other complex structures

Soil Mechanics: theoretical treatment and experimental technique

Hydraulics: theoretical and experimental work in fluids, and *Hydraulic Engineering*

Transportation Engineering: design, construction and economics of airports, highways and railways

The Structural Analysis Laboratory offers facilities for instruction and research in the static and dynamic behavior of structures. The Soil Mechanics Laboratory is available for instruction in experimental technique and for investigations of soils of various kinds. The Hydrodynamics Laboratory has facilities for fundamental studies in fluid mechanics and special investigations on hydraulic models.

Departmental Requirements for Graduate Work

In addition to the general requirements as set forth on page 92, the applicant must present evidence of training in professional subjects considered essential for all Civil Engineers and corresponding approximately to the following Institute subjects:

1·01, 1·02	Surveying
1·40, 1·41	Structural Analysis
1·44T	Structural Engineering, Elementary
1·441	Structural Design
or	
1·442	Reinforced Concrete Design
1·601T, 1·602T	Fluid Mechanics
2·001	Applied Mechanics I

He must also present evidence of having had, in addition to the subjects listed above, sufficient undergraduate training to prepare him for the advanced subjects which he desires to take.

Further specific professional requirements prerequisite for graduate study in the various branches of Civil Engineering are as indicated below:

For *Soil Mechanics*, *Fluid Mechanics*, and *Hydraulic Engineering:*
No additional requirements.

For *Structural Engineering:*
1·42 Structural Analysis.

For *Transportation Engineering:*
1·201 Transportation Planning.
1·202 Transportation Engineering.

Deficiencies in prerequisites may be removed by the student while pursuing a program of graduate work but must be removed by him before proceeding with advanced subjects dependent upon them.

The Degree, Master of Science in Civil Engineering

At the discretion of the Department, up to 24 units of the more advanced subjects in the undergraduate curricula may be accepted in partial fulfillment of the requirements for the degree of Master of Science.

The Degree, Civil Engineer

Programs of study leading to the degree of Civil Engineer provide opportunities for students to obtain training broader than that required for the Master's degree and better preparation for undertaking professional practice in Civil Engineering. The rigor of the program and the quality of academic performance required are substantially those demanded of students working toward the Master's degree or those preparing for the general examination for the Doctor's degree. It is expected that the normal period of study for this degree should be two full years after the Bachelor's degree has been obtained.

The Degree, Doctor of Science in Civil Engineering

Only students who have shown promise of outstanding performance in work of a creative nature are encouraged to study for the doctorate. Where the records of students entering on graduate work do not yield evidence of this ability, they are usually advised to qualify first for the Master's degree. The thesis research for the doctorate is expected to make a contribution to professional knowledge in the field of Civil Engineering.

The general requirements for the doctor's degree are as given on page 93.

Each applicant for the doctorate in Civil Engineering is required to demonstrate his ability to read scientific literature in English and in two other modern languages, with German and French usually specified.

II. MECHANICAL ENGINEERING

The Department of Mechanical Engineering is equipped to provide opportunities for graduate work leading to the degrees of Master of Science in Mechanical Engineering, Mechanical Engineer, Doctor of Science in Mechanical Engineering, and Master of Science in Textile Technology.

II. Mechanical Engineering Continued

Laboratory facilities for experimental work are available in Photoelasticity and Experimental Stress Analysis, Materials Testing and Plasticity, Metal Cutting and Processing, Lubrication and Wear, Dynamics and Control, Fluid Mechanics, Temperature Measurements, Heat Transfer, Low Temperature, Refrigeration, and Heating and Ventilating. Through the Sloan Automotive Laboratory and the Gas Turbine Laboratory special facilities are available for design and research activities in Internal Combustion Engines and Gas Turbines with particular emphasis on flow and combustion phenomena.

The Department, in cooperation with other departments of the Institute, operates a Practice School at the Atomic Energy Plant, Oak Ridge, Tennessee, where a number of graduate students take for four months a course of work under the supervision of resident M. I. T. staff members, enjoying all of the technical facilities available at Oak Ridge. For further information see page 91.

The Institute also offers opportunity for advanced study and research in the field of textiles.

Departmental Requirements for Graduate Work

The general admission requirements are those set forth on page 92. A statement concerning transfers from other colleges is given below.

The Degree, Master of Science in Mechanical Engineering

The principal object of the study program leading to the degree of Master of Science in Mechanical Engineering is to broaden the student's background of engineering science in order to enable him to approach rationally any problem that may arise in the mechanical engineering field.

This object precludes specialization in any one narrow field as well as the development of general practical skills. To reach this objective within the present limit of 96 units, it is necessary to place certain limitations on the freedom of the student to select his program. With this purpose in mind, the subjects available to graduate students in the Mechanical Engineering Department have been grouped under seven major categories, including the Thesis, as shown below. Minimum requirements of units are prescribed for four of these categories. Since the prescribed number of units makes a total of 65, the student may have complete freedom of choice for a maximum of 31 units within the standard program of 96 units.

Subject Group	*Minimum Number of Units*
1. Mathematics	18 (Two Terms)
2. Applied Mechanics and Fluid Mechanics	18 (Two Terms)
3. Thermodynamics and Heat Engineering	9 (One Term)
4. Design	..
5. Materials Testing, Processing, and Metallurgy	..
6. Manufacturing and Production	..
7. Thesis	20
	65

The choice of subjects within any one subject group is intended to be as free as possible but must be made so as to insure a logical program.

The programs for transfer students must necessarily differ from those of graduates of the Mechanical Engineering Department. In general, a transfer student is required to take undergraduate subjects in those fields where this is necessary to bring his background up to the level required for graduates of the Mechanical Engineering Department. However, the student is encouraged to take the most advanced subject which his previous training justifies. Satisfactory grades in a graduate subject will permit the elimination of undergraduate deficiencies in subjects which cover the corresponding field at the undergraduate level. Experience shows that the majority of transfer students without previous graduate training should take 2·081, 2·25, and 2·43, or their equivalents.

Attention is called to the five-year program leading to the S.B. and S.M. degrees described under the Course II undergraduate schedule.

The Degree, Master of Science in Textile Technology

Graduates of the Institute, or of other institutions which award the Bachelor's degree on the basis of a course essentially equivalent in breadth and training to that offered by the Institute in the fields of Chemical Engineering, Chemistry, Mechanical Engineering, Business and Engineering Administration, Industrial Physics, or General Science and Engineering may obtain the Master's degree in Textile Technology in from one to two years depending upon preparation. Graduates of high standing, of technical schools or textile schools offering less extensive preparation in science or engineering, will, in general, require a minimum of two years to fulfill the requirements for the degree.

The Degree, Mechanical Engineer

For students wishing to pursue a program of study more advanced than the Master's degree permits, but without the emphasis on creative research required for the Doctorate, the Department offers the degree of Mechanical Engineer.

The requirements for this degree include those of the Master's degree with the addition of another year of advanced study for further development of engineering competence.

The Degree, Doctor of Science in Mechanical Engineering

Admission to candidacy for the Doctorate is granted only after the successful passing of a Qualifying Examination to be taken as soon as possible after the awarding of the Master's degree. The requirements for the Doctor's degree include a Major program, a Minor program, a Thesis, and proficiency in two languages.

The major program, consisting of advanced study and research, may be selected in any field of science or engineering approved by the Departmental Committee on Graduate Students. While no fixed number of units of subjects is prescribed, the usual program includes some subjects in the student's area of principal interest in addition to those taken to satisfy the requirements for the Master's degree; these with the minor program will normally constitute about two terms of work.

The thesis is a major effort in which the candidate undertakes a program of work which will result in a significant contribution to the major field of his interest. The major program and the thesis will be under the supervision of a Doctoral Committee selected by the student and his thesis supervisor. The Doctoral Committee will make an annual evaluation of the progress of the candidate and will conduct a final examination based on the thesis.

The field of the minor must have the approval of the student's Doctoral Committee. The minor program must conform to the provisions stated above for the Graduate School in general.

Unless specifically approved by the Chairman of the committee on Graduate Students of the Mechanical Engi-

II. Mechanical Engineering Continued

neering Department, the Qualifying Examination and the Language Requirement must be completed before the program of research is undertaken. Whenever possible, the Language Requirement should be fulfilled in the first or second terms of the graduate program so that scientific literature in at least one important foreign language may be available to the candidate for the Major program of study.

III. METALLURGY

(Including Mineral Engineering and Ceramics)

The Department of Metallurgy offers graduate work leading to the degrees of Master of Science in Metallurgy, Master of Science in Ceramics, Metallurgical Engineer, Mineral Engineer, and Doctor of Science in the field of Metallurgy, Mineral Engineering, or Ceramics.

The Physical Metallurgy laboratories provide general facilities for research on the constitution of metals and alloys, diffusion and reactions in the solid state, phase transformations, equilibrium diagrams of alloy systems, and the physical and mechanical properties of metals and alloys. The facilities include complete metallographic equipment, testing apparatus, heat treating furnaces, X-ray units for diffraction studies and radiography, and numerous special items such as dilatometers and magnetometers.

The Process Metallurgy laboratories provide a wide variety of facilities for advanced study in such fields as roasting, extraction, reduction, smelting, distillation, and the many chemical reactions involved in these processes. Equipment for the preparation of experimental steels and other alloys on a scale up to 150 pounds is available.

The Mechanical Metallurgy laboratories include forging and rolling equipment, a modern foundry, a welding laboratory, and equipment for powder pressing, metal spraying and other special forming methods.

Other laboratories of the Department provide for research in corrosion and electrochemistry, thermodynamics, high-temperature metals, ferromagnetism, surface hardening, and steelmaking. As a further aid to its research activities, the Department maintains an analytical laboratory and machine and instrument shops.

In the Mineral Engineering laboratories facilities are available for research on crushing, grinding, screening, classification, thickening, filtration, tabling, jigging, electrostatic and magnetic separation of ores, fuels and minerals. In addition, complete microscopic equipment is available for the investigation of mill products. Special attention has been given to flotation for the study of which a modern laboratory is available. The equipment is designed not only for the study of batch or continuous operations of the various processes, but also for the analysis of the basic physical and chemical phenomena on which the processes rest. Opportunity also is given to explore new fields in mineral identification and in mineral separation.

The Ceramics laboratories are well equipped to carry out advanced research in the field which includes abrasives, cermets, coatings, electrical ceramics, glass, heavy clay products, pottery, and refractories. Facilities are available for Process Ceramics studies in fields such as raw material properties, forming processes, drying, melting, phase equilibria, chemical reactions, firing and sintering of ceramic materials. Facilities are also available for Physical Ceramics studies in fields such as thermal properties, diffusion, surface properties, solid state reactions, physical and mechanical properties, and electrical and magnetic properties of ceramic materials.

Departmental Requirements for Graduate Work

The general admission requirements are those set forth on page 92.

As a basic preparation for research work in the department, it is required that all incoming graduate students register for subject 3·25, Experimental Methods in Metallurgy, in the first term in which it may be scheduled. This requirement may be waived upon presentation of evidence of similar training elsewhere.

Professional subjects prerequisite for graduate study in the Department of Metallurgy are given below.

For students in *Metallurgy:*

3·01	Metallurgical Engineering I
3·31	Physical Metallurgy I
3·32	Physical Metallurgy II
5·61	Physical Chemistry I
5·62	Physical Chemistry II
6·18	Electrical Engineering, Fundamentals

For students who are graduates of Mechanical Engineering or Physics and who wish to specialize in Mechanical Metallurgy or Physical Metallurgy, a special program will be arranged in lieu of the above requirements in Chemistry and Metallurgical Engineering.

For students in *Mineral Engineering:*

3·01	Metallurgical Engineering I
3·81	Mineral Engineering I
5·61	Physical Chemistry I
5·62	Physical Chemistry II
12·011T	Mineralogy I

For students who are graduates of other courses and wish to specialize in Mineral Engineering, a special program will be arranged as partial substitution for the above requirements.

For students in *Ceramics*:

There are no special prerequisites for graduate study in Ceramics — each applicant will be considered individually. In general, graduates of courses in Ceramics, Ceramic Engineering, Chemistry, Chemical Engineering, Mechanical Engineering, Metallurgy, or Physics will be qualified. All entering graduate students are required to register for subject 3·70, Ceramics, in the first term scheduled, or present evidence of similar training elsewhere.

The Degree, Master of Science

The specifications for the degrees of Master of Science in Metallurgy or Master of Science in Ceramics are as set forth on page 93.

The Degree, Metallurgical Engineer

The specifications for the degree of Metallurgical Engineer are as set forth on page 93.

The Degree, Mineral Engineer

The specifications for the degree of Mineral Engineer are as set forth on page 93.

The Degree, Doctor of Science

The specifications for the degree of Doctor of Science in Metallurgy or in Ceramics are as set forth on page 93.

IV-A. ARCHITECTURE

The Department of Architecture offers work leading to the degree of Master in Architecture.

Graduate study in Architecture affords students who have demonstrated professional promise an opportunity for advanced work in the further application to creative design of the contributing fields of study that formed part of their undergraduate curriculum. There is also an opportunity for participation with students of related disciplines in the exploration of important problems whose solution appears to require the contributions of more than one profession. The work is arranged to enable the

IV-A. Architecture Continued

student to devote large units of time to research and design under the guidance of the School and with the assistance of Institute specialists in the related fields. This activity is enriched by the availability of unusual laboratory and library facilities and by the association with graduate students from other backgrounds.

DEPARTMENTAL REQUIREMENTS FOR GRADUATE WORK

Undergraduate preparation in Architecture usually differs from that required for the scientific degrees, and in place of the requirements on page 92, the following are set up as prerequisites for graduate study.

ARCHITECTURE. Bachelor in Architecture or equivalent degree with high academic standing from a professional undergraduate course in architecture at an institution of recognized standing, or S.B. or A.B. degree with high standing and enough professional work in a school of architecture of recognized standing to indicate promise of competence in the profession.

Evidence of satisfactory preparation in the following undergraduate subjects will be required for all Graduate students in Architecture.

MATHEMATICS AND PHYSICS. Two years of college work which includes subjects in one or more of the fields of Mathematics and the Physical and Natural Sciences.

HUMANITIES. At least six semester courses in English, history, economics (or allied subjects) or other subjects equivalent in scope to those included in the undergraduate humanities curricula of the Institute.

PROFESSIONAL SUBJECTS IN ARCHITECTURE. Two full years of subjects in mechanics and structural design and one full year of subjects in other engineering aspects of building; a completed program of work in history of architecture, visual design, and architectural design equivalent to these subjects as required in the Institute's curriculum for the Bachelor in Architecture.

Deficiencies in mathematics and physics may be removed by the enrollment in special sections in subjects offered by the Institute. A student whose deficiencies are of minor extent will be permitted graduate registration while taking the appropriate subjects at the Institute to remove them. Where such subjects are at the professional level, they may contribute, up to 24 units if approved by the Department, toward the requirements for the Master's degree.

THE DEGREE, MASTER IN ARCHITECTURE

The degree of Master in Architecture is awarded upon satisfactory completion of a course with a minimum of 96 units of advanced study, subdivided as set forth on page 93, including a minimum of two terms of architectural design and a thesis of from 24 to 36 units. Completion ordinarily involves twelve months of residence for graduates of five-year professional courses.

IV-B. CITY PLANNING

The Department of City and Regional Planning offers work leading to the degree of Master in City Planning.

The Graduate Course in City Planning is designed to train practitioners or staff men in the fields of city and regional planning. It offers to the advanced student a broad survey of the entire field of planning, and practice work in the library, drafting room, and field. It is intended primarily for students with undergraduate training in city planning, architecture, landscape architecture, civil engineering, or one of the social sciences; but those whose undergraduate preparation has been in other fields may also be admitted provided that they make up certain deficiencies ordinarily required in undergraduate courses. Graduates of undergraduate courses leading to professional degrees in City Planning, if accepted for admission to the Graduate School, should be able to complete the requirements for the degree of Master in City Planning in one year. Students with degrees in other professional fields would normally take two academic years.

DEPARTMENTAL REQUIREMENTS FOR GRADUATE WORK

Undergraduate preparation in City Planning usually differs from that required for the scientific degrees, and in place of the requirements on page 92, the following are set up as prerequisites for graduate study:

MATHEMATICS AND PHYSICS. Two years of college work which includes subjects in one or more of the fields of Mathematics and the Physical and Natural Sciences.

CULTURAL SUBJECTS. At least six semester courses in English, history, economics (or allied subjects) and other cultural subjects equivalent in scope to those included in the undergraduate curricula of the Institute.

PROFESSIONAL SUBJECTS IN CITY PLANNING. Acceptable subjects of at least one term's credit each in basic design or freehand drawing, sociology, transportation engineering, statistics, public administration, economics, and city planning principles.

Deficiencies in any of the above subjects may be removed by the enrollment in special sections in subjects offered by the Institute. A majority of the students take several subjects classed as prerequisites during the first year of graduate registration in the Department. Where such subjects are at the professional level they may contribute, up to 24 units described on page 93, toward the requirements for the Master's degree.

THE DEGREE, MASTER IN CITY PLANNING

The degree of Master in City Planning is awarded upon satisfactory completion of a course with a minimum of 96 units of advanced study, subdivided as set forth on page 93. Normally, a student taking the two-year curriculum will devote about half of his time to project work in city and regional planning (including thesis during his last term), and the balance in seminar and classwork, including such subjects as planning techniques, planning legislation and administration, housing, and land economics. The requirement of three months of office practice is usually satisfied by regular employment during the summer between his two academic years.

V. CHEMISTRY

The Department of Chemistry offers graduate programs leading to the degrees of Master of Science, Doctor of Philosophy, or Doctor of Science in Chemistry. Details of these programs, which differ according to whether the candidate chooses to specialize in Analytical, Inorganic and Nuclear, Organic, or Physical Chemistry are recorded below. Students working toward the Doctorate are expected to choose one of these four fields of specialization; students working toward the Master's degree may make a similar selection, or may take a program in chemistry including study in an approved combination of these fields.

Attainment of the Master's degree is not prerequisite to a program of study leading to a Doctorate. Master's candidates may, by permission, change to the corresponding Doctorate without loss of credit.

There is a demand for chemists to serve as investigators and to direct investigational work in academic institutions, in industry, in endowed research institutions, and in

V. Chemistry Continued

government bureaus. The numerous industries, in particular, have nearly all come to realize the desirability and even necessity of supporting fundamental scientific investigations relative to their processes as a basis for future development.

Teaching Assistants

The Department appoints a number of Teaching Assistants who are candidates for the degree of Doctor of Philosophy in Chemistry. Teaching Assistants serve in the laboratories of the Department, and may be asked to conduct recitation sections on a part time regular schedule throughout the academic year. For information in regard to appointments, address correspondence to the Head of the Department.

Physical Chemistry

Graduate courses in physical chemistry cover the fundamentals of thermodynamics, statistical mechanics, kinetic theory and molecular structure. The Minor in mathematics and physics broadens this fundamental basis. The research gives intensive specialization in a narrower field and develops experimental technique and ability to carry on independent investigations.

Research in Physical Chemistry is being carried out in the following fields and the laboratory is especially well, often uniquely, equipped for such research:

Pressure-volume-temperature relations of gases and liquids.
The absolute temperature scale.
Heat capacities and latent heats at low temperatures.
Properties of gases at low pressures.
Diffusion of gases.
Scattering and other properties of molecular beams.
Electromotive force in concentration cells, and oxidation-reduction potentials.
Vapor pressures of liquid solutions.
Infra-red, ultra-violet and Raman spectroscopy.
Precision photometry.
Kinetics of thermal and photochemical reactions.
Spectrophotometric studies of the nature of metallic ions in water.
Properties of high polymers.
Properties of protein solutions.
Properties of ion exchangers.
Optical and electrical properties of thin metal deposits.
Study of crystal structure by X-ray diffraction.
Nuclear resonance studies of the constitution of molecules and crystals.
Lattice dynamics and low temperature elastic constants.
Absorption spectra of adsorbed molecules.

Organic Chemistry

In the graduate program, subjects are offered which aim to develop in the student a sound knowledge of fundamentals and familiarity with current progress in the most active and important branches of Organic Chemistry. Each student undertakes a research problem which forms the nucleus of his graduate work, and through the experience of conducting an experimental investigation leading to the Ph.D. or S.M. thesis, acquires the research attitude and method of approach, and training in the specialized techniques of organic research. Basic graduate subjects in Organic Chemistry cover broadly organic reactions and their application to synthetic and structural problems, and theoretical organic chemistry.

Fields of research in Organic Chemistry which are being investigated in the department include carbohydrates; heterocyclic compounds; organic peroxides; organometallic compounds; amino acids; synthetic alkaloids; polymerization; reactions of active methylene compounds; reaction mechanisms; synthetic methods; tracer studies; relation of structure to reactivity; vitamins; terpenes; sterols; other natural products and physiologically active compounds.

Inorganic and Nuclear Chemistry

Inorganic Chemistry. The remarkable advances which have been reported in recent years in the utilization of the less familiar elements, such as titanium, niobium and tantalum, the rare earth metals, uranium and the "artificially" prepared heavier elements; the isolation of small quantities of the compounds of other hitherto unknown elements, such as technetium (element No. 43) and promethium (element No. 61), as well as progress in the utilization of certain non-metallic elements such as selenium and fluorine, have called attention to the fact that the opportunities for research in inorganic chemistry, nuclear chemistry, and allied fields of interest were never more abundant.

Inorganic chemistry is not to be considered as primarily concerned with a method or limited body of methods. It is rather an area of interest in which all useful methods are to be utilized as fully and ingeniously as possible. It has two aspects, the preparative and the physico-chemical, which are by no means separate in practice. It is, of course, necessary for the inorganic chemist to be skilled in the preparation of substances in a reasonably high state of purity, and ample opportunity is provided for training of this type.

In addition to the impetus which has resulted from the increased accessibility to study of new areas of the periodic table, the theoretical or physico-chemical side of inorganic chemistry has been offered challenging new means of attack on basic problems by recent developments of techniques and advances in theory. Infrared and Raman spectroscopy, visible and ultraviolet spectrometry, magnetic studies of various types including nuclear and electron resonance, as well as new methods for dealing with such problems as the kinetics of the many very fast inorganic reactions are becoming a part of the inorganic chemist's basis of essential techniques.

The contributions of the laboratory, therefore, will be found to include the isolation and study of numerous inorganic compounds, and physical-chemical investigations of the structures, bonding and reactivities of inorganic compounds. Particular attention is being given to the chemistry of some of the less familiar elements, to the elaboration of the chemistry of some of the common elements and to physical-chemical and preparative studies of the complexes of transition metals. The initiative of the student in suggesting problems in other areas is encouraged.

Nuclear Chemistry. The Institute's Laboratory for Nuclear Science provides access to outstanding facilities for the prosecution of research in nuclear chemistry; a large cyclotron, synchrotron, linear accelerator, and Van de Graaff accelerator are available for the study of nuclear reactions and the preparation of radionuclides. A cooperative arrangement with the Brookhaven National Laboratory also exists.

The research worker may undertake detailed studies of nuclear reactions in the low or high energy regions, including fission and spallation, or studies of nuclear properties as a function of nuclear structure, including search for and identification of new species. The radiochemical resources are favorable for a variety of studies of chemical properties by tracer methods, including the properties of elements at very low concentration and the factors to be controlled

V. Chemistry Continued

in the development of new separation methods for constituents of radioactive mixtures. Other studies involve the physical-inorganic principles underlying the chemical problems of nuclear science and the applications of radiotracer techniques to general chemical problems. Modern counting equipment is available in the department.

Analytical Chemistry

The graduate curriculum in Analytical Chemistry is designed to prepare men for leadership both in industrial and in academic laboratories. The program provides a broad background in inorganic, physical and organic chemistry and places emphasis upon both organic and inorganic aspects of analytical chemistry. The subjects stress principles and methods; the thesis aims at providing a varied research experience, as well as specialization in a field of limited scope.

The laboratory is unusually well equipped for studies involving modern instrumental methods. The student is able to employ a wide variety of methods, as well as to compare the performances of a number of different instruments designed to carry out the same general technique. Research is being carried on in polarography, electrodeposition of trace elements, fluorescence, spectrophotometry, flame photometry, ion exchange, complex formation, separation chemistry, non-aqueous titrations, thermometric titrations, and photometric titrations. Many of the problems are concerned with the analytical chemistry of the fission and spallation elements, and the determination of organic functional groups. The program of the division is by no means limited to these fields, however, and the initiation of work on other subjects is encouraged.

Departmental Requirements for Graduate Work

The general admission requirements are those set forth on page 92, with the following exceptions and additions:

Mathematics. Doctoral candidates with their Major in Analytical, Inorganic or Organic Chemistry need not present M22.

Professional Subjects. All candidates for admission to graduate work in this department must present equivalents of the following subjects:

Analytical Chemistry: 5·10, 5·13
Organic Chemistry: 5·41, 5·414, 5·42, 5·424
Physical Chemistry: 5·61, 5·613, 5·62, 5·623

The Degree, Master of Science

In addition to the general requirements set forth on page 93, a reading knowledge of German is required.

The Doctorates

For the degree of Doctor of Philosophy or Doctor of Science in a field of chemistry, each candidate must fulfill the requirements listed below.

Candidates for the Doctorate in any field of Chemistry are required to complete a written qualifying examination which is offered twice each year, at the end of the week preceding the opening of the fall term and in the week following the Spring vacation. Doctoral candidates admitted for the Summer or Fall terms will take the examination just before the Fall term begins, and those admitted at the beginning of the Spring term will take the examination in the Spring.

Successful completion of the examination upon entrance will enable the student, with the advice of his registration officer, to select a program of graduate subjects more advanced in character than would be possible otherwise, and to make more rapid progress toward the doctoral degree. Students who fail any part of the examination may select a program that includes more elementary subjects in any field where such registration seems advisable, and are required to repeat the part of the examination which they failed when it is next offered. Qualifying examination grades are not entered on the student's permanent record.

Satisfactory completion of the qualifying examination automatically certifies the candidate in all the undergraduate deficiencies in subjects in Chemistry and a passing grade is prerequisite for the subsequent Major Examination in the candidate's field of specialization.

In order to complete the Language Requirement, the student must pass written examinations in scientific French and German before taking his Major Examination.

To fulfill the Minor requirement the student must take at least 24 units of subjects outside of his field of specialization. Candidates majoring in Physical Chemistry are expected to take the Minor in Mathematics or Physics.

Each candidate must complete or be certified in the following subjects in the Course V curriculum: viz., 5·01, 5·02, 5·061, 5·10, 5·13, 5·41, 5·42, 5·43, 5·414, 5·424, 5·61, 5·62, 5·613, 5·623, 5·71.

In addition to the general requirements indicated above, candidates for the Doctor's degree pursue a program of graduate subjects. The specific content of these programs varies according to the major field in which the candidate is registered, but ordinarily will include selections from the following subjects:

Analytical Chemistry: 5·062, 5·15, 5·151, 5·192, 5·193, 5·194, 5·196, 5·426, 5·67, 5·71, and during each year of residence 5·915, 5·916, 5·951 and 5·952.

Inorganic Chemistry: 5·062, 5·68, 5·71, together with at least 14 units in approved subjects, such as X-rays and Crystal Physics, Nuclear Physics, Radiochemistry, X-ray Metallography, or Crystallography, and during each year of residence 5·071, 5·912, 5·941, and 5·942.

Organic Chemistry: 5·44, 5·51, 5·54, 5·55, and during each year of residence 5·913 and 5·914.

Physical Chemistry: 5·71, 5·75, and two of the three sequences: 5·72 and 5·73, 5·76 and 5·77, 5·78 and 5·79; and during each year of residence 5·931 and 5·932.

After completing the program of major subjects, the candidate must pass a comprehensive examination, including both written and oral parts, in his major field.

In the interpretation of these requirements, the Department will consider the candidate's previous academic record and professional experience together with his particular aims and objectives, and will take a liberal attitude toward substitution of other subjects of equivalent educational and scientific value. Graduate students are urged to select a research supervisor during the first or second academic term of residence and to plan their program of study in consultation with him and with the chairman of the departmental graduate committee.

Inquiries should be addressed to the Chairman, Departmental Committee on Graduate Students, Department of Chemistry.

VI. ELECTRICAL ENGINEERING

The Department of Electrical Engineering offers advanced work leading to the degrees of Master of Science in Electrical Engineering, Electrical Engineer, or Doctor of Science in Electrical Engineering.

There are no fixed programs of study toward these degrees. Particular effort is made with each student to develop his program of graduate study along the lines of his individual special interest. Such a program provides him with a strong incentive to a high level of accomplish-

VI. Electrical Engineering Continued

ment and gives him a specialized ability that is immediately useful. This specialized ability, however, is deemed a less significant result of graduate study than is the clearer insight into and better integration of fundamental principles so generally gained by the graduate student. Soundly conceived advanced work rarely fails to send the student back to deepen his understanding of elementary but basic principles. These ideas influence both the methods of approach used in graduate engineering subjects and the counsel given to students to include in their programs further formal study of mathematics and physics.

At the graduate level the Department offers a wide choice among a number of areas of activity. Several of these are interdepartmental in scope, representing a trend emphasized by the war and regarded most desirable. The Department regards active research projects as a dominant influence in its graduate program provided each is so conceived and administered that the graduate student can and does have full opportunity to associate himself with it while retaining his scientific individuality and initiative. This educational principle is vigorously enforced.

Graduate work tends to center about a number of especially active areas in the broad field associated with electrical engineering. Each of these areas is characterized by an active research program, and in general by graduate class and laboratory programs. Some of these are mentioned in the following paragraphs.

In servomechanisms and automatic control a large research and development program is closely coupled with extended graduate study covering numerous and varied phases of this subject. Close integration of electronic and electric circuits, electromechanical, hydraulic, and mechanical elements in single dynamical systems provides excellent educational breadth in a currently active field. Electronic instrumentation, particularly nuclear-reactor control instrumentation, is a closely allied field in which there is research, development and associated graduate study.

In the Research Laboratory of Electronics sponsored jointly by the Departments of Electrical Engineering and Physics particular attention is currently given to microwave techniques and their applications in such fields as communications, television, acoustics, generation of high-energy radiation, electronic computation, gaseous conduction, and atomic structure. Much activity centers also about the new field of statistical theory of communication.

Advanced network theory is an important area in its own right and contributes to several other areas, for example, servo theory, communications, and power transmission.

In the Energy Conversion Laboratory a group is engaged in a study of the design and control of energy-conversion systems, including airborne applications.

Digital and analogue computation are taught through subjects developed from research in the Computer and Control Systems Laboratory and the Dynamic Analysis and Control Laboratory. Specific subjects are available in machine logic, numerical analysis, and electronic computer circuits. Subjects related to machine computing applications are taught also in other departments of the Institute.

The Departments of Architecture, Physics and Electrical Engineering are engaged in an extensive program of research and development in the field of acoustics, both fundamental and applied.

Fundamental research and development work on dielectrics are concentrated in the Laboratory for Insulation Research. Insulators, semiconductors, and conductors are studied in all states of aggregation by means of the techniques of electrical engineers, physicists, and chemists. The work aims at a deeper understanding of the properties of dielectric materials and at the development of new fields of application.

The development of generators in the several-megavolt-range and their use in the generation of high-energy particles and radiation are subjects both of research and development and of graduate study. High-precision measurements of the properties and effects of such radiations, the problems of very-high-voltage insulation, and therapeutic applications in cooperation with medical research groups are emphasized.

Certain aspects of nuclear energy and machines for producing extremely high-energy particles constitute another focus of activity as a part of the Laboratory of Nuclear Science. This laboratory is another project in which several departments cooperate.

A facility differing in kind from the centers of new development but equally essential in the Department's educational program is the Vail Library. This Library is one of three great electrical libraries of the world. The original Vail Collection (30,000 volumes), presented to the Department in 1912 through the interest of the late Theodore N. Vail, was combined with other electrical literature in the Institute Library to form the Vail Library of Electrical Engineering which now comprises approximately 50,000 volumes and is now one of the three units constituting the Engineering Library. It contains the works of all writers who have made significant contributions to electrical science and engineering since the time of William Gilbert (1600). The Vail Library staff gives instruction in library usage and bibliographic research, and is available for consultation on individual problems of literature searching.

From the emphasis given to the graduate student's association with active projects it is evident that his graduate study is considered to include much more than class exercises and assignments pursued in a routine manner. He is expected to conceive of his program as a coordinated whole, having as its objective the advancement of his professional preparation and providing for a substantial amount of independent and correlative study in current literature and independent investigation in the laboratories. Such study and investigation are essential parts of thesis research, affording the student an opportunity to develop his ability to do sound constructive reasoning, and to contribute to the advancement of engineering.

ASSISTANTSHIPS. Each year a limited number of appointments to assistantships are available to men especially qualified by training and natural endowment for teaching or research. Every effort is made to arrange the assigned work of an assistant so that he may progress toward his degree at a rate approximately forty per cent of that of a full-time student. Should his research assignment result in material appropriate for a graduate thesis, a research assistant is permitted to make use of it with possible acceleration of the program.

DEPARTMENTAL REQUIREMENTS FOR ADMISSION TO GRADUATE WORK

The general requirements are as set forth on page 92, without exceptions.

In addition to the general requirements for all graduate students, a candidate for the degree of Master of Science in Electrical Engineering, Electrical Engineer, or Doctor of Science in Electrical Engineering must present evidence of training in certain professional areas considered essential

VI. Electrical Engineering Continued

for Electrical Engineers. These areas are indicated approximately by the following Institute subjects:

2·001, 2·002	Applied Mechanics
2·40	Heat Engineering
or	
8·051	Atomic & Nuclear Physics I
6·00, 6·01	Introductory Circuit Theory
6·02	Electronic Circuits
6·03	Fields, Energy, and Forces
6·04	Electrical Energy Conversion
6·05	Applied Electronics
6·06	Electromech. Power Modulators
6·07	Energy Transmission and Radiation
M351	Advanced Calculus for Engineers

Credit is not usually allowed for undergraduate subjects in which the applicant's grades are low. High-grade work in undergraduate mathematics and physics is considered to be particularly important.

Selected subjects considered to be prerequisites for graduate studies may be included in a graduate program and counted up to a total of 24 units for credit toward the Master's degree.

The Degree, Master of Science

The general requirements for the Master's degree are given on page 93.

Students working for the Master's degree are expected to devote themselves to a few subjects, not more than four each term, in addition to their research. The subjects of study are wholly elective and not restricted to those given by the Department of Electrical Engineering; however, the program of study must be well balanced, emphasizing one or more of the mathematical, economic, and experimental aspects of electrical engineering.

Course VI-A, listed under the undergraduate course schedules, leads to the degrees of Bachelor of Science and Master of Science.

The Degree, Electrical Engineer

Able students who are desirous of preparing for creative application of engineering and scientific principles in engineering practice, who desire more extensive training than is possible within the 96 units required for the Master's degree, yet are not interested in acquiring the training in research afforded by doctoral study, are encouraged to study for the Electrical Engineer degree. Programs for this degree are elective except for Thesis, and will ordinarily require at least four terms of graduate study beyond the Bachelor's degree level.

The general requirements for the Electrical Engineer degree are given on page 93.

The student is required to participate in a seminar for oral reporting on his work and objectives in the field of his specialty. In this seminar he is expected to demonstrate competence in orderly and creative application of science and technology in engineering.

The Degree, Doctor of Science

Only students who have shown promise of outstanding performance in work of a creative nature are encouraged to study for the doctorate. Students entering on graduate work who do not have records that show evidence of this outstanding ability are usually advised to qualify first for the Master's degree. The thesis research for the doctorate is expected to make a substantial and noteworthy contribution in Electrical Engineering or a related field.

The general requirements for the Doctor's degree are given on page 93.

The General Examination is divided into a first and second part. The first part is both written and oral. It should be taken within one year after entering graduate work. It is normally offered each fall and spring, and its purpose is to determine whether, in terms of command of the basic sciences and practices of Electrical Engineering, the candidate is qualified to take advanced study and research of doctoral caliber. The second part is wholly oral and is taken after the problem for the thesis research has been chosen and the related preparatory program of specialized graduate study has been completed.

Each applicant for the doctorate in Electrical Engineering is required to demonstrate his ability to read scientific literature in English and in two other modern languages selected from German, Russian, and French. Ordinarily this requirement in one of the modern languages should be satisfied by the time the first part of the General Examination is taken, and in both modern languages before undertaking the thesis research. Special one-term subjects are offered in these languages to assist graduate students in obtaining the required reading knowledge for their field (see description of subjects L17, L57, and L97). However, more extensive study of these foreign languages is preferred. When a choice can be made, German is preferred, since German literature in the field of Electrical Engineering is at present the most extensive of the three, with Russian as a second choice.

The field of the Minor is not prescribed by the Department, but usually Mathematics, Physics, or Economics is chosen.

VII. BIOLOGY

The Department of Biology offers graduate work leading to degrees of Master of Science in Biology or Biochemistry or Biophysics, or to the degree of Doctor of Philosophy in a field of specialization. Graduate majors may be selected in one of the following fields: Analytical Biology, General Physiology, Microbiology, Biochemistry, and Biophysics.

Attainment of the Master's degree is not a prerequisite to a program of study leading to a doctorate. Master's candidates may, by permission, change to a doctorate program without loss of credit.

Graduate Study and Research Facilities

The field of Biology has undergone an impressive development during the last twenty years. From the conventional fields of classical botany and zoology has evolved a new field of scientific endeavor. Today, Biology is an exact science, utilizing physics and chemistry and surpassing both these fields by its width and its immediate importance to man's life and health. New scientific concepts have emerged from this development; the experimental means of the classical biologist are supplemented, today, by modern research methods, and the research laboratory of the biologist comprises electronic and optical systems of all kinds, electron microscopes, mass spectrographs, and methods from the arsenal of electrical and nuclear instrumentation. It is safe to predict that in the field of Biology discoveries of considerable theoretical and practical importance will come within the next fifty years.

The Biology Department at M. I. T. offers exceptional facilities for graduate education, not only in basic analytical biology but also in many specialized fields of biology as a preparation for future work in academic teaching, in pure and applied biological research, in medical research, and in many fields of industry and industrial research such as biophysical, biochemical, pharmaceutical, leather, oil, fermentation, and other industries. The educational program is based upon a number of general and specialized subjects and assignments and upon the student's active participation in the Department's research projects or his own research work.

Research facilities are available for a wide variety of fields in analytical biology, biochemistry, and biophysics.

VII. Biology Continued

Analytical Biology. The laboratories of biology apply chemical and physical methods to modern problems of biology. Major areas of research include molecular biology, analytical cytology, physiological genetics, cellular physiology, growth, and differentiation. Specific current research projects include the chemistry and structure of nerve tissue, connective tissue and chromosomes, electrical properties of nerve and muscle, and the study of tissues in culture.

Biochemistry. The laboratories of the Division of Biochemistry are equipped with the most modern tools for teaching and research. Special equipment for the isolation and characterization of enzymes, a radioactivity center, and a mass spectrograph are some of the devices in current use in these laboratories for the solution of problems in enzymology, biosynthesis of proteins, nucleic acids and co-enzymes, intermediary metabolism, and microbiology.

Biophysics. The physical aspects of biological problems are approached in the biophysical laboratories through the use of techniques such as X-ray diffraction, electron microscopy, ultracentrifugation, electrophoresis, and spectroscopy as well as through the development of new instruments. Current research problems lie in the area of the structures of proteins, polysaccharides, and nucleic acids; the physical chemistry of proteins and their interactions; and instrumentation for use in biology and medicine.

Attention is directed to the cooperative arrangement with Harvard University described on page 94.

Assistantships

The department appoints each year a number of Teaching Assistants and Research Assistants. Such Assistantships are available to qualified students. A Research Assistant may be permitted to make use of the results of his assigned research work for a graduate thesis with possible acceleration of the program. For information with regard to such assistantships the head of the department should be consulted. Application for the fall term must be made before March 31.

Departmental Requirements for Graduate Work

The general Institute requirements (page 92) are modified as follows:

Mathematics: M11, M12.

Physics: One year of college physics.

Chemistry: 5·41.

Professional Subjects: 7·05 and 7·06 or their equivalent.

Deficiencies in subjects listed above may be removed, if not too extensive, while the student is pursuing a graduate program.

The Degrees Master of Science or Doctor of Philosophy

There are no specified programs for degree work since the subjects required vary with the field of specialization. The graduate work offered by the Department encompasses many fields, therefore a student is allowed to select his program, according to certain broad principles, after consultation with the Graduate Committee of the Department.

The general requirements of the Graduate School for a Master's or Doctor's degree are given on pages 93 and 94. The Department requires all students to take subjects 7·31 and 7·32 (Biology Seminar). A reading knowledge of French and German is required for a Doctor's degree in this Department.

VIII. PHYSICS

The Department of Physics offers work leading to the degrees of Master of Science, Doctor of Philosophy, or Doctor of Science in Physics. No stated curriculum of subjects is required for any of these degrees, but they are to be chosen in consultation with the registration officer, subject to certain broad principles.

Graduate Study and Research Facilities

During the last fifty years of extraordinary progress, physics has advanced far beyond its conventional fields of mechanics, sound, heat, light, and electricity and magnetism, and has led to very complete understanding of the structure of atoms, molecules, and matter in bulk, of electronics and gas discharges, of atomic spectra and the nature of light. The discovery of radioactivity, of induced radioactivity, of nuclear fission and of cosmic rays, has led to an understanding of the nature of the atomic nucleus, and of high energy particles, which is far from complete, but which is bound to lead to further far-reaching discoveries. The fundamental laws governing the nature of matter and energy are partly understood as a result of recent work, almost certainly within reach in the near future.

Along with this remarkable advance in basic knowledge has come very widespread application of new principles and methods to practical problems. The methods of electronics have revolutionized communications and instrumentation. Relatively old fields like acoustics have become revitalized. Physical tools arising from researches in X-ray diffraction, electron diffraction, electron microscopy, and modern spectroscopy, have opened completely new approaches to problems of chemistry, metallurgy, and biology. Applied nuclear physics, with its use of induced radioactive tracers, brings a tool of the greatest power to bear on biological, chemical, and geological problems. The day has passed when any branch of physics can be considered as merely of academic interest. The physicist, with his broad knowledge of principles and methods, is particularly equipped to undertake new problems in the industrial laboratory, to apply his science to practical ends.

The Physics Department is aware of the vital importance of maintaining an active research program in the pursuit of fundamental knowledge. Excellent research facilities are available and extensive research programs are carried on in many fields of active interest. Four interdepartmental research laboratories, the Laboratory for Nuclear Science, the Research Laboratory of Electronics, the Spectroscopy Laboratory, and the Acoustics Laboratory, serve to correlate the research in the various departments in these fields, and their facilities are available to graduate students in physics. Electronuclear machines capable of producing high energy particles are available in connection with the Laboratory for Nuclear Science; these include the cyclotron, electrostatic generators, and a synchrotron. There are active research programs in nuclear structure, applied radioactivity, and in cosmic rays and high energy physics. The Research Laboratory of Electronics provides unequaled facilities for research in microwave electronics and related branches of physics. The laboratory is equipped for the production of very high magnetic fields and of very low temperatures, and these are used actively in research programs. The Acoustics Laboratory works both in low frequency acoustics and in ultrasonics. The Spectroscopy Laboratory is unique in the field of spectroscopic measurements and analysis. Research is carried on actively in the fields of solid state and molecular theory, color measurements, in X-ray

VIII. Physics Continued

diffraction and crystal structure, electron microscopy, and the structure of dielectrics.

Subjects of study include work in almost all of these experimental fields, and in the various branches of theoretical physics as well. It is expected that the graduate student will gain real familiarity with several of the branches of physics, not merely with one specialty. Whether he plans to go into academic work, or into industrial research, the training includes a broad and thorough understanding of the fundamentals of physics, as well as of its more advanced applications.

Departmental Requirements for Graduate Work

General requirements are those set forth on page 92 with the following additions:

Professional Subjects. The equivalents of the following subjects, which are not credited in fulfillment of degree requirements:

8·05	Phys.: Atoms, Molec. & Nucl. I
8·06	Phys.: Atoms, Molec. & Nucl. II
8·07	Thermodyn. & Statis. Mech.
8·08	Electronics

The following advanced undergraduate subjects may be credited (to the extent of 24 units) toward and are required for advanced degrees:

8·11	Experimental Physics
8·71, 8·72	Introduction to Theoretical Physics

Deficiencies in subjects required for admission or for advanced degrees may be removed while engaged in graduate work before undertaking advanced subjects dependent upon them.

The Degree, Master of Science

In addition to general requirements set forth on page 93 a reading examination in either scientific French or scientific German is required.

The Doctorates

The degrees of Doctor of Philosophy or Doctor of Science require examination for reading knowledge of scientific literature in either German and French or German and Russian.

The student is expected to take graduate subjects to prepare himself for the general examination but there are no stated required subjects.

X. CHEMICAL ENGINEERING
(Including Nuclear Engineering)

Graduate study in this Department leads to the degrees of Master of Science in Chemical Engineering or in Chemical Engineering Practice or in Nuclear Engineering, Chemical Engineer, or Doctor of Science in Chemical Engineering or Doctor of Science in Nuclear Engineering.

Because of the breadth of the field of Chemical Engineering the undergraduate Course must be devoted primarily to training in fundamentals, and strictly professional subjects are necessarily elementary in character. Postgraduate work is therefore of particular importance and value to the chemical engineer.

The program for the S.M. degree, particularly in Chemical Engineering Practice, is usually arranged as a continuation of the broad professional training on a more mature basis. Work for the Sc.D. degree is more specific in character and the Department offers coordinated programs in four fields: Engineering Operations of Chemical Engineering, Applied Chemistry, Fuel Engineering, and Nuclear Engineering. Special programs are developed for individual cases.

School of Chemical Engineering Practice

Integrated programs which include Engineering Practice are offered for the degrees of Master of Science, Chemical Engineer, and Doctor of Science. The Course leading to the degree of Master of Science in Chemical Engineering Practice (designated as X-A) requires completion of the three field stations described below.

In the School of Chemical Engineering Practice a selected group of graduate students who have completed at least four years of undergraduate study at the Institute or elsewhere spend eighteen weeks at three field stations located at Bangor, Me., Parlin, N. J., and Buffalo, N. Y. At these stations four different concerns open their plants for the instruction of students who at each station are under the direct charge of two members of the Institute staff. Since the time is devoted wholly to their education, students receive no compensation. Their attention is directed chiefly to the application of theory to practice and to the cultivation of resourcefulness and of effectiveness in cooperative effort under industrial conditions.

The quantitative aspects of Chemical Engineering are intensively studied in the Practice School. In addition to tests on industrial equipment, plant investigations are carried out by the students on some special phase of one of the unit operations, or on some problem of industrial chemistry which is particularly important at the station in question.

Finally, the School of Chemical Engineering Practice offers exceptional opportunity for graduate engineering research: first, by affording an opportunity for comparing laboratory data, formulae, and conclusions with observations on plant apparatus operating under practical working conditions; and second, by extending, from laboratory scale at the Institute to commercial scale in the various plants, the range of investigations possible.

The following program will be taken by men graduating in Chemical Engineering from the Institute. Starting in September following graduation, students are at the field stations (10·81, 10·82, and 10·83). They then return to the Institute at the end of January to complete the program for the Master's degree by graduate professional subjects and thesis during the spring term.

A similar Practice School program at the field stations starts early in February and extends to mid-June.

The Engineering Practice School at Oak Ridge, described on page 91, is similar in educational philosophy and technique to the School of Chemical Engineering Practice. Although it does not lead to the Practice School degree, it operates on the same schedule and for chemical engineering students may be regarded as an alternative experience to that of the School of Chemical Engineering Practice.

For graduates in Chemical Engineering from other institutions the usual program of study for the Master's degree in Chemical Engineering Practice involves one or two terms at the Institute followed by the field station work in the Practice School. Graduates in chemistry from other institutions normally require an additional term. Students are usually not admitted to the Practice School until they have spent at least one term at the Institute.

Fields of Study

Engineering Operations. Graduate subjects in the several important unit operations such as heat transmission, distillation, and absorption are offered, emphasizing the engineering phases of the students' professional training.

X. Chemical Engineering Continued

Applied Chemistry. A group of subjects in Applied Chemistry, such as colloidal chemistry and chemical kinetics, comprise an integrated program for students whose primary interests are on the side of industrial Chemistry.

Fuel Engineering. While the important group of industries involving the processing and utilization of fuels demand the training and viewpoint of the chemical engineer, many of their problems can be handled by men who have majored in non-chemical branches of engineering, provided they prepare themselves adequately for fuel engineering work by graduate study. The Department offers a group of subjects on fuel processing and utilization as the core of a program of graduate study in Fuel Engineering, the balance of the work being in science, engineering or economics. The facilities of the Buffalo Station of the Practice School can be utilized for advanced investigations in fuel engineering practice.

Since the program in any of these fields will depend on undergraduate training and industrial experience, anyone interested is requested to furnish information permitting individual consideration.

Nuclear Engineering. Because of the increased need in government and industry for engineers familiar with nuclear science and the engineering problems of nuclear reactors, a series of subjects (N10, N20, N21, N22, N23, N31, N41, and N90) is being offered for students desiring training in Nuclear Engineering. An integrated program of graduate instruction in Nuclear Engineering may be arranged around these subjects, with additional work in related fields of engineering or science. Work at the Oak Ridge Engineering Practice School can be combined advantageously with instruction in Nuclear Engineering.

Departmental Requirements for Graduate Work

The requirements for graduate study are dependent on the degree to which the student wishes to specialize. The broadest training is required in Chemical Engineering and in Chemical Engineering Practice as it is assumed that the student is preparing himself for any phase of chemical engineering. Students who plan definitely to major in Applied Chemistry, Nuclear Engineering, or Fuel Engineering will be expected to meet requirements in chemistry and in engineering to an extent justified by the field of specialization. The subjects in Nuclear Technology: N1, N2, N3, N10, N21, N22, N23, N31, and N41 are accepted toward graduate degrees in Chemical Engineering.

The general requirements are as set forth on page 92, with the following additions:

Chemistry: the substantial equivalent of the undergraduate subjects in Course X.

Engineering: (*a*) a one-year problem course in heat engineering or chemical engineering thermodynamics, and (*b*) preparation in applied mechanics or elements of electrical engineering.

Chemical Engineering: problem courses in industrial chemistry and in unit operations.

The Degree, Master of Science in Chemical Engineering or Chemical Engineering Practice

The requirements for the degree of Master of Science are as specified on page 93.

The Degree, Chemical Engineer

For the degree of Chemical Engineer, see the general statement on Engineering Degrees on page 93.

The Degree, Doctor of Science in Chemical Engineering

The degree of Doctor of Science requires examinations for reading knowledge of scientific literature either in German and Russian or in German and French.

The student is expected to take graduate subjects, which may include the School of Chemical Engineering Practice or the Engineering Practice School at Oak Ridge, in preparation for the general examination, but no specific subjects are prescribed.

The Degree, Master of Science in Nuclear Engineering

This program is intended primarily for students with undergraduate degrees in physics, chemistry, metallurgy, or chemical, civil, electrical or mechanical engineering. The course of study is designed to present the basic principles of nuclear reactions and reactors and to show the student how his field of specialization may be applied to nuclear engineering problems.

Emphasis is placed on advanced instruction in Nuclear Reactor Engineering, Nuclear Measurements and Heat Transfer. In addition, each student will have the opportunity to engage in advanced study in his field of undergraduate specialization, preferably in topics related to nuclear engineering. The objective is to give instruction in nuclear engineering to students with basic training in one of the established scientific or engineering professions rather than to develop an entirely new type of engineer.

The curriculum makes maximum use of subjects offered by present M. I. T. departments, and supplements them with subjects concerned specifically with nuclear reactors and the phenomena, materials and processes associated with them. These subjects in nuclear technology are available also to students in other departments.

The Engineering Practice School, at Oak Ridge, Tennessee, affords an unusual opportunity for graduate students to participate in the solution of plant problems of a nuclear engineering nature. The Practice School provides the student with a variety of excellent instrumental and pilot-plant equipment.

The subjects in nuclear technology, with the exception of the Oak Ridge Engineering Practice School, are open to all students, from the United States or abroad, with the requisite training. A large fraction of available thesis topics do not come under security restrictions of the Atomic Energy Commission; other topics are classified and may be considered by individuals approved by the Atomic Energy Commission.

In addition to the general requirements for admission to graduate study, a candidate for the degree in Nuclear Engineering should have undergraduate preparation substantially equivalent to:

Atomic and Nuclear Physics, 8·051 and 8·052.
Advanced Calculus, M351 and M352.
Thermodynamics, 2·40, 2·403, 3·20, 8·07 or 10·28.
Heat Transfer, such as is taught in 2·43, 2·50, or 10·31.

The general requirements for this degree are as specified on page 92.

Subjects which are recommended for all candidates are:

		Units
N20	Biological Effects of Nuclear Radiations	9
N21	Nuclear Reactor Theory, I	12
N23	Nuclear Reactor Engineering	12
8·531	Nuclear Physics for Engineers I	9
8·532	Nuclear Physics for Engineers II	9
either 10·50	Heat Transmission	6
or 2·521	Advanced Heat Transfer	12

X. Chemical Engineering Continued

Substitutions for one or more of these subjects may be desirable in individual cases.

The remaining subjects may be chosen in accordance with the student's inclination and undergraduate training. Suggested fields of study include: Civil and Sanitary Engineering, Mechanical Engineering, Metallurgy, Chemistry, Electrical Engineering, Biology, Physics, Chemical Engineering, or Mathematics.

The Degree, Doctor of Science in Nuclear Engineering

For students in Nuclear Engineering, the requirements for the degree of Doctor of Science are as specified on page 93. Before beginning doctoral research, students in Nuclear Engineering will be required to pass a general examination.

Although no set program of study is required, most candidates for the doctor's degree will find it advantageous to follow a coordinated program of study in Nuclear Engineering, Physics, and one of the standard engineering departments such as Chemical, Civil, Electrical or Mechanical Engineering. For properly qualified students, this program may include study at the School of Chemical Engineering Practice or at the Oak Ridge Engineering Practice School.

XI. SANITARY ENGINEERING

Graduate study and research are offered by the Department of Civil and Sanitary Engineering, as Course XI — Sanitary Engineering, to satisfy the requirements for the degrees of Master of Science in Sanitary Engineering, Sanitary Engineer, or Doctor of Science in Sanitary Engineering.

Special Sanitary Engineering subjects are offered dealing with: water supply and treatment; sewerage, sewage, refuse and industrial waste processing and disposal; air pollution control; sanitary chemistry and chemical examination of water, sewage and industrial wastes; sanitary biology, bacteriological examination of water and sewage, and other applications of sanitary bacteriology; environmental sanitation; and public and industrial health engineering.

There are also available Civil Engineering subjects, such as advanced hydraulics, soil mechanics and foundations, structural theory and design, and others, of value to Sanitary Engineers, and a number of closely related subjects in other departments, that may be pursued to complete a particular plan of study.

Programs of study may be arranged to provide the fundamental training required for professional careers in the special fields of Sanitary Engineering, including: engineering design and construction of sanitary facilities, and consulting engineering practice; process or functional design for water, sewage, and industrial waste treatment, refuse disposal and stream sanitation; operation and management of waterworks, sewage treatment plants and other sanitary facilities and services; and environmental sanitation with private corporations or in public health agencies.

Sanitary Engineering Laboratories

The Sedgwick Laboratories of Sanitary Science provide well equipped facilities for instruction and research in sanitary chemistry, sanitary biology, sanitary bacteriology, environmental sanitation in relation to health and comfort, and engineering problems relating to water, sewage and industrial waste treatment.

Departmental Requirements for Graduate Work

In general, graduates from approved courses in Civil Engineering will have the necessary undergraduate preparation to undertake graduate study in preparation for any of the special fields of Sanitary Engineering. Graduates in Chemical Engineering approved courses will be well prepared to take up Sanitary Engineering in the fields of operation and environmental sanitation, but if they desire to prepare for Sanitary Engineering design and construction, they should take some study of surveying, preferably before starting their graduate programs, and should include additional studies in hydraulics and structural theory as part of their graduate programs. A graduate from any other course in engineering, or in chemical or biological science, will need additional undergraduate preparation depending upon his previous training and the program of study proposed or may qualify for study leading to a degree without specification.

The general requirements are those given on page 92, except that the requirement for Differential Equations M22 may be omitted.

In addition to the foregoing general requirements the applicant for a degree in Sanitary Engineering must present evidence of undergraduate training considered essential for all Sanitary Engineers, substantially equivalent to the following Institute subjects:

1·601T	Fluid Mechanics
1·751	Water Supply and Purification
1·761	Sewerage and Sewage Treatment
2·001	Applied Mechanics I

In addition to the above, students with undergraduate training in Civil Engineering shall present evidence of preparation substantially equivalent to the following subjects as given at the Institute:

1·01, 1·02	Surveying
1·40	Structural Analysis
1·44T	Structural Eng., Elem.
1·602T	Fluid Mechanics

A student whose undergraduate training has been in some other field, such as Chemical Engineering, may substitute for the above subjects required for Civil Engineering, other subjects well adapted to the training of a Sanitary Engineer engaged in process work in such fields as the treatment of industrial wastes.

The Degree, Master of Science in Sanitary Engineering

In meeting the requirements for the degree of Master of Science in Sanitary Engineering, certain of the subjects listed above may be accepted, at the discretion of the Department, up to 24 units, in partial fulfillment of degree requirements.

In general, students with proper preparation may expect to complete the requirements for the degree of Master of Science in Sanitary Engineering in two terms.

The Degree, Sanitary Engineer

Programs of study leading to the degree of Sanitary Engineer provide opportunities for students to obtain training broader than that required for the Master's degree and better preparation for undertaking professional practice in Sanitary Engineering. The rigor of the program and the quality of academic performance required are substantially those demanded of students working toward the Master's degree or those preparing for the general examination for the Doctor's degree. It is expected that the normal period of study for this degree should be two full years after the Bachelor's degree has been obtained.

XI. Sanitary Engineering Continued

THE DEGREE, DOCTOR OF SCIENCE IN SANITARY ENGINEERING

Only students who have shown promise of outstanding performance in work of a creative nature are encouraged to study for the doctorate. Where the records of students entering on graduate work do not yield evidence of this ability, they are usually advised to qualify first for the Master's degree. The thesis research for the doctorate is expected to make a contribution to professional knowledge in the field of Sanitary Engineering.

The general requirements for the Doctor's degree are as given on page 93.

Each applicant for the doctorate in Sanitary Engineering is required to demonstrate his ability to read scientific literature in English and in two other modern languages, with German and French usually specified.

XII. GEOLOGY AND GEOPHYSICS

The Department of Geology and Geophysics offers a wide choice of graduate study and research for specialization in the following fields: basic geology; crystallography; engineering geology; geochemistry; geophysics; mineralogy; mineral industry; mineral deposits; mineral fuels; petroleum geology; petrology; sedimentation, stratigraphy, and paleontology; structural geology; and theoretical geology. In the borderland between geology, geophysics or geochemistry, and another science, the student may arrange a program of study and research under supervision of a special interdepartmental committee. Advanced work in the fields mentioned leads to one of the following degrees: Master of Science in Geology and Geophysics, or Doctor of Philosophy or Doctor of Science in the field of specialization.

The Department is equipped to offer the graduate student an unusual opportunity to pursue study and research in both theoretical and applied geology, X-ray crystallography, and geochemistry, and in geophysics. Modern laboratory facilities, research instruments, and extensive collections of specimens and materials are available to qualified graduate students. Field studies are included as an essential part of the graduate curriculum in geology, geophysics and geochemistry, and special arrangements may be made for summer employment and field research with industrial organizations and governmental agencies.

TEACHING AND RESEARCH ASSISTANTS

The Department appoints a number of teaching and research assistants who are candidates for a graduate degree. Teaching Assistants conduct laboratories, grade papers, and prepare lecture and laboratory materials, and under special circumstances may be permitted to give a few lectures. Research Assistants are assigned specific duties on one of the Department's sponsored research projects and are expected to carry out these duties on a regular schedule. In some cases part of the work done may be used by the student in his own thesis investigation. For information in regard to assistantships, address correspondence to the Head of the Department of Geology and Geophysics.

SCHOLARSHIPS AND FELLOWSHIPS

The Department usually has one or more industrial fellowships that are awarded to outstanding graduate students. Incoming graduate students are also urged to apply for National Science Foundation fellowships, and for the Institute-wide fellowships and scholarships described in Appendix A.

DEPARTMENTAL REQUIREMENTS FOR GRADUATE WORK

The general admission requirements are those given on page 92.

In addition, the Department requires preparation essentially equivalent to the program of subjects leading to the degree of Bachelor of Science in Geology and Geophysics at the Massachusetts Institute of Technology. If the student is not fully prepared in certain of the required subjects, he usually will be asked to extend his preparation in these, along with his advanced work. The subjects to be taken for this purpose will be designated by the Committee on Graduate Students of the Department after the student's preparation and proposed program of study have been considered. The actual program of advanced subjects and research leading to a graduate degree is arranged by the student and his Faculty Adviser, to whom he is assigned at the time he first registers and who will generally direct the major part of his program.

THE DEGREE, MASTER OF SCIENCE

In addition to the general and departmental requirements stated in the preceding paragraphs, the candidate for the degree of Master of Science in Geology and Geophysics is required to pursue a program of advanced study and research in an area approved by the Committee on Graduate Students of the Department. Possible fields of specialization are listed above.

THE DOCTORATES

The general requirements for the degrees of Doctor of Philosophy or Doctor of Science are given on page 93. Departmental requirements for graduate work leading to these degrees are given in a preceding section. In addition, candidates for doctorates may be asked to meet certain other requirements in study or research. Possible fields of specialization are indicated in the introductory paragraph.

The preparation and research ability of any candidate for the doctorate must be such as to satisfy the Committee on Graduate Students of the Department that he is qualified to undertake advanced study and research. The thesis is expected to be a publishable contribution in the field of the candidate's specialization.

Soon after the student registers in the Department as a doctoral candidate, he will be given an informal examination, which may be partly oral and partly written, to survey his training and attainments and to serve as a basis for arranging his graduate program.

The program of graduate work may, with the approval of the Committee on Graduate Students of the Department, include subjects in other departments for which the student has adequate preparation. Also open to M. I. T. graduate students are certain advanced subjects in geology, mineralogy, and geophysics given at Harvard University.

Each candidate for the doctorate must demonstrate to the Department of Modern Languages that he can read scientific literature in his field of specialization in English, and in two of the following languages: French, German, Russian, or such other languages as are appropriate. Ordinarily this requirement should be satisfied by the time the general examination is taken, and before undertaking thesis research.

The Minor requirement is generally satisfied by taking in another department at least 24 units of approved study.

XIII. NAVAL ARCHITECTURE AND MARINE ENGINEERING

The Department of Naval Architecture and Marine Engineering offers opportunities for graduate study leading

XIII. Naval Architecture and Marine Engineering Continued

to the following advanced degrees: Master of Science in Naval Architecture and Marine Engineering, Master of Science in Shipping and Shipbuilding Management, Master of Science (without specification), Naval Architect, Marine Mechanical Engineer, Naval Engineer (restricted generally to commissioned officers of the United States Navy and United States Coast Guard, on active duty) and Doctor of Science.

Departmental Requirements for Graduate Work

In addition to the general requirements for admission described on page 92, the undergraduate preparation should be equal, in quality and quantity, to the Institute's undergraduate curriculum in Naval Architecture and Marine Engineering. Successful prosecution of an acceptable program of graduate study requires a competence substantially equivalent to that represented by this curriculum in each of the following areas:

Strength of Materials
Dynamics
Heat Engineering
Engineering Materials
Naval Architecture
Ship Structures
Marine Engineering
Ship and Engineering Design

If undergraduate preparation has been significantly less intensive in any of these areas, the deficiencies must be removed prior to the award of any of the degrees implying specification. This may be accomplished concurrently with graduate work if the deficiencies are not extensive. Undergraduate subjects so required will in some cases be accepted by the Department in partial fulfillment of the advanced degree requirements. Accepted subjects will generally be restricted to those offered by this Department in the normal fourth year program and 2·081, Strength of Materials. A strictly limited number of subjects, in no case exceeding 24 units of registration, will be accepted on this basis. Somewhat less intensive undergraduate work in areas represented by subjects of instruction given in this Department is appropriate for candidates for the degree of Master of Science without specification, if accompanied by correspondingly increased competence in other areas.

The Degree, Master of Science

A candidate for the degree of Master of Science in Naval Architecture and Marine Engineering normally pursues a program including several graduate subjects offered by this Department, together with related subjects in other Departments. Appropriate areas of study are mathematics, physics, applied mechanics, fluid mechanics, thermodynamics, industrial management, economics, etc. Emphasis may be placed on either naval architecture or marine engineering, if desired. The requirements can usually be met in one year by a candidate who has a Bachelor of Science degree in Naval Architecture and Marine Engineering.

The Course XIII-B program leading to the degree Master of Science in Shipping and Shipbuilding Management is described on page 73.

The degree Master of Science (without specification) represents the same high level of accomplishment as the corresponding degree with specification, but the total objective may be less directly integrated with the fields of naval architecture and marine engineering. Therefore, while some graduate subjects offered by this Department should be included, the major part of the program may consist of graduate subjects having application to these fields or other activities in shipbuilding and the marine industry, but which are given in other Departments.

The general requirements for the Master of Science degrees are given on page 93.

The Degrees, Naval Architect and Marine Mechanical Engineer

These degrees are intended to provide a terminal graduate program for students who expect to take up a career in industry and represent about two years of academic work beyond the degree of Bachelor of Science in Naval Architecture and Marine Engineering. The program is usually an extension of the work done in fulfilling the requirements of the degree of Master of Science in Naval Architecture and Marine Engineering.

The program of study of the candidate for the degree of Naval Architect must include a comprehensive design problem (at least 20 units of 13·031 and/or 13·032) and the following subjects or equivalents: 1·40, 1·42, 13·03, 13·04, 13·73, 14·63, 15·501, M351 and M352. The thesis must be in the field of naval architecture. The program of study should also include one or more subjects from the following group: 13·05T, 13·74, 13·791. The balance of the program may consist of work in structures, applied mechanics, hydrodynamics, business or economics which has some application to the design and construction of ships or the business of shipbuilding or ship operation.

The program of study leading to the degree of Marine Mechanical Engineer should include the following subjects or equivalents: 2·25, 2·43, 13·73, 14·63, 15·501, M351 and M352. The thesis should be in some aspect of marine engineering. The balance of the program may consist of subjects having application in marine engineering or the marine industry offered in the Department of Naval Architecture and Marine Engineering or in other Departments.

The general Institute requirements for these degrees are stated on page 93.

The Degree, Naval Engineer

The course of study leading to this degree, designated Course XIII-A Naval Construction and Engineering, is restricted generally to commissioned officers of the United States Navy and United States Coast Guard. They must have completed the prescribed course of studies at the United States Naval Academy, United States Coast Guard Academy or their equivalent.

Course XIII-A includes five different curricula leading to specialization in four different fields of engineering involved in naval construction and engineering. Each of the curricula requires three years for completion. Approximately three-quarters of the term subjects are common to all of the curricula. The remaining quarter is in the specially designated field. Student officers are assigned to the field of specialization of their choice insofar as practicable and within limits to meet quotas established by the Navy Department and the United States Coast Guard.

The subjects which are common to all five curricula are given below:

2·046	Strength of Materials and Dynamics	6–8
2·081	Strength of Materials	3–6
2·402	Heat Engineering	4–8
3·391	Properties of Metals	3–3
3·392	Properties of Metals	3–3
8·03S	Physics	4–6
8·051	Atomic and Nuclear Physics I	4–5
10·311	Heat Transfer	3–3
13·012	Naval Architecture	5–7
13·12	Warship General Arrangements	3–5
13·13	Warship Structure, Theory I	3–6
13·15	Warship Basic Design I	5–6
13·16	Warship Basic Design II	3–6
13·17	History of Warships	3–4

XIII. Naval Architecture and Marine Engineering Continued

13·20	Elementary Ship Design	5–0
13·21	Warship Form Design	5–0
13·22	Warship General Design	5–0
13·26	Preliminary Design of Warships	9–0
13·75	Warship Propulsion I	5–6
13·76	Warship Propulsion II	6–4
M351	Adv. Calculus for Engineers	3–6
M352	Adv. Calculus for Engineers	3–6
M73	Review of Mathematics	8–12
	Thesis	20–0

In addition to the above subjects, the following subjects are required of students who do not take them or their equivalent in their field of specialization:

1·612	Fluid Mechanics	3–6
13·241	Warship Structure, Design I	3–0
13·54	Marine Engineering Dynamics	2–4
13·90	Warship Electrical Engineering	3–4
15·11	Industrial Management, Introduction	3–6

The remainder of the program is devoted to subjects determined by the student's registration in one of the following specialized curricula:

Hull Design and Construction
Marine Electrical Engineering
Electronics Engineering
Ship Propulsion Engineering
Nuclear Propulsion

The Degree, Doctor of Science

Ordinarily a period of residence of three years is the minimum in which a student holding the degree of Bachelor of Science in Naval Architecture and Marine Engineering can expect to complete the requirements for the degree of Doctor of Science in this Department. A student having a baccalaureate in some other field will probably require a longer period of residence. The program of study for the major requirement should be similar to those for the degrees of Naval Architect and Marine Mechanical Engineer but involve additional theoretical work in one of the following fields: structural design, engineering mechanics, thermodynamics, or fluid dynamics. The minor should be in some non-engineering field.

XIV. ECONOMICS AND SOCIAL SCIENCE

The Department of Economics and Social Science offers work leading to the degrees of Doctor of Philosophy in Industrial Economics, Master of Science in Economics and Engineering or Master of Science in Economics and Science.

The Degree, Master of Science in Economics and Engineering (or Economics and Science)

The undergraduate preparation for this degree should include the substantial equivalent of the Economics subjects required for the Institute's bachelor degree in this field. The other admission requirements are those set forth on page 92, with the following exceptions:

Mathematics. M22 Differential Equations is not a prerequisite.

Physics. A complete college course in Physics of at least one year is required.

Science and Engineering Subjects. A substantial number of science or engineering units is required, comparable to the number required in the undergraduate Course XIV.

Deficiencies in prerequisites for admission or for the receipt of the Master's degree may be taken along with graduate work.

Graduates of Courses XIV-A or XIV-B or of a similar undergraduate course of study elsewhere may ordinarily expect to complete the requirements for the Master's degree in one year. Graduates of other Institute Courses, or of their equivalent elsewhere, will undertake a two-year program. The first year of study is devoted to the satisfying of Economics prerequisites. The second year is given wholly to graduate work, in accordance with the general requirements for the Master's degree.

The Doctorate in Industrial Economics

In place of the general requirements for admission set forth on page 93, the following requirements have been established as prerequisites for graduate study leading to the degree of Doctor of Philosophy in Industrial Economics.

Mathematics. One full year of college mathematics, including at least one term of calculus.

Science. One full year of college work in science.

Cultural Subjects. At least six semester courses in English, history, economics (or allied subjects) and other cultural subjects equivalent in scope to those included in the undergraduate curricula of the Institute.

Professional Subjects. Three full-year subjects in social science chosen from the following: economics, psychology, sociology, and history. One of these subjects must have been economics; and history subjects to be acceptable must have stressed economic and technological developments.

A deficiency in mathematics may be removed by completing a special one-semester subject, Mathematics for Economists (14·101). A deficiency in science may be removed by completing any suitable one-semester subject in science at the Institute. A student whose deficiencies are of minor extent will be permitted graduate registration while taking the appropriate subjects at the Institute to remove them.

In studying for the Ph.D. in Industrial Economics, the candidate must prepare himself for a general examination covering five fields. Unless Statistics and Economic History are among these fields, he must, in addition, demonstrate an elementary knowledge in Statistics and have taken one graduate subject in Economic History. Possible fields include Economic Theory, National Income and Fluctuations, Industrial Organization and Policy, Economics of Innovation, International Economics, Economic Development, Labor Economics and Labor Relations, Human Relations in Industry, Economic History, Statistical Theory and Methods, and others. Two or three of the candidate's five fields, designated as *primary*, require more intensive preparation than the other two or three, which are designated as *secondary*.

There are no formal requirements of a stated number of graduate subjects in the Economics Department; but ordinarily the candidate will need two full academic years of course work to prepare himself adequately for his general examinations and to meet the other pre-thesis requirements for the doctorate.

Following the Institute rules, the candidate for the Ph.D. degree will be required to take a Minor in a field other than economics. Possibilities include: Business Administration, Mathematics, History, Biology, or the like.

The candidate will be required to demonstrate his ability to read professional literature in two modern foreign languages. Ordinarily these languages will be German and French, but substitution may be permitted in appropriate cases.

XV. INDUSTRIAL MANAGEMENT

The course leading to the degree of Master of Science in Industrial Management is designed to prepare the science or engineering graduate for ultimate executive responsibilities. Its objective is the development of men whose intelligence, motivation, and character promise executive ability and whose training and experience combine the fundamentals of science and engineering with an understanding and appreciation of the social, political, and economic implications of industry. Its aim is not that of training functional specialists. Instead, the course stresses the professional aspects of administration and seeks to develop an ability in planning, organizing, and working effectively with others.

The curriculum is closely correlated with the graduate subjects in the Department of Economics and Social Science. The resources of all departments of the Institute may be drawn upon. Every effort is made to provide opportunity for mature and realistic study at the advanced level through a variety of educational means including executive conferences, group field work, individual field investigation, and special seminars as well as regular classes. Men active in management participate as members of the faculty and as visiting lecturers. Students go to industry where they study the problems of day-to-day industrial management and observe and consult with industrial leaders. Thus, every effort is made to give the student a sense of the realities of industrial management so that when he has completed his basic theoretical preparation he will have a more mature comprehension of the practical necessities which that theory is designed to serve.

Graduate work in Industrial Management ordinarily requires two years of study at M. I. T. Students who have combined substantially one year of study of fundamental business subjects with their science or engineering programs may secure the Master's degree in one year. The first year of the two-year program is used to give the students a fundamental understanding of the problems and contributions of important functional divisions of the typical industrial enterprise and the orientation of the individual firm in the broader industrial structure. It includes study in the areas of economics, accounting, finance, statistics, marketing, industrial relations, psychology, production, and administration. The second year is given wholly to advanced work, in accordance with the general requirements for the Master's degree. Each program is worked out individually in consultation with members of the staff, in order to maintain flexibility and to permit each student to make the most of his individual skills and interests.

Typical First Year Program*

First	14·381	Statistical Method
Term	14·771	Interpersonal Relations Sem.
	or	
	15·371	Social Psychology
	15·501	Accounting
	15·511	Economics of the Firm
	15·201	Prob. in Amer. Pol. Econ.
Second	14·117	Econ. & Indust. Mgt.
Term	15·312	Labor Management Rel.
	15·412	Finance
	15·502	Industrial Accounting
	15·712	Production Management
	15·812	Marketing

* For men who have done no previous work in this field.

Sloan Fellowships

In addition to the regular graduate program outlined above, the School of Industrial Management, under grant from the Alfred P. Sloan Foundation, offers a special Executive Development program for men on leave from present business employment. These men typically have engineering and science backgrounds, with ten to fifteen years of business experience, and are nominated by the top managements of their companies. They are selected for this twelve months' program through a nationwide competition. A part of this program is taken in conjunction with the regular graduate program, and it may lead to the degree of Master of Science in Industrial Management. Specific inquiries concerning this program should be addressed to the Director, Executive Development Program, School of Industrial Management, M. I. T.

Requirements for Graduate Work

The general admission requirements are those set forth on page 92, with the following additions and exceptions:

Admission Test for Graduate Study in Business. All applicants for admission to candidacy for the degree of Master of Science in Industrial Management (other than applicants for the Executive Development Program) are required to take the Admission Test for Graduate Study in Business. This test is administered by the Educational Testing Service, Princeton, New Jersey. Information relative to dates and locations at which the test will be administered may be obtained from that agency.

Science or Engineering. Applicants for graduate study in the School of Industrial Management will usually have a college degree in some recognized field of science or engineering. This program must have included regular college courses in Physics and Calculus of not less than one year each, and normally one year of Chemistry.

XVI. AERONAUTICAL ENGINEERING

Advanced study in this Department leads to the degrees of Master of Science in Aeronautical Engineering, Aeronautical Engineer, or Doctor of Science in Aeronautical Engineering.

Emphasis is laid on individual study and research. Each student must follow a consistent program of work directed toward some particular part of the aeronautical field, such as aerodynamics, design, instrumentation, structures or power plants. Since most phases of the graduate work in Aeronautical Engineering rest heavily upon mathematics and mechanics, aptitude in these subjects is required.

Students may also elect subjects given in other departments, but bearing a useful relation to their program of aeronautical studies. The selection of such subjects must be approved by the registration officer.

The facilities for research in aeronautical engineering are listed below. All are available for student theses provided obligations for departmental and sponsored research projects permit the use of these facilities.

Wind Tunnels: Naval Supersonic Tunnel, 10,000 horse power, rectangular throat 18 by 24 inches, operating pressures ¼ to 4 atmospheres, velocities up to four times sonic speed; Wright Brothers Tunnel, 2,000 horse power, elliptical throat 7½ by 10 feet, operating pressures ¼ to 4 atmospheres, velocities up to 350 miles per hour; Transonic Tunnel, blowdown type, 18 inch throat; Supersonic Tunnel, blowdown type, 14 by 25 inches, Mach 1.2–2.0; Flutter Tunnel, rectangular throat 5 by 7½ feet, atmospheric, velocity 130 miles per hour, fitted with special oscillograph equipment for the study of oscillating models; Student Tunnel, rectangular throat 4½ by 6 feet, atmospheric, fitted with six component balance, velocity 120 miles per hour; Turbine Component Tunnel, 1,500 horse

XVI. Aeronautical Engineering Continued

power, rectangular throat 8 by 8 inches, velocities up to three times sonic speed, provided with pressure and humidity controls, schlieren and interferometer apparatus for mapping flow fields; Shock Tube, 8 by 24 inches, Mach up to 1.3.

Structures Laboratory: Materials test equipment. Facilities for static test of aircraft components. Electro-thermal furnace equipment suitable for study of high temperature gradients and transient effects. Dynamic load and instantaneous load equipment. Instrumentation and data recording equipment suitable for all phases of experimental structures research. Model construction facilities.

Aeroelastic Laboratory: Model construction facilities and test equipment for study of the interrelation between aerodynamic and elastic forces. Experimental work is performed largely on models constructed to be dynamically, elastically and aerodynamically similar to full-scale structures. Extensive instrumentation permits analysis of the response of such structures in still air or in a wind stream. Wind tunnels available for aeroelastic studies at subsonic and supersonic speeds. Shock tube available for transient aeroelastic studies.

Instrumentation Laboratories: Equipment for the study of the performance of measuring and control systems. One of these laboratories provides instruction in the fundamentals of such systems. It has special equipment for studying aircraft instruments, including an electronic simulator, harmonic synthesizer, and apparatus by which flight conditions can be reproduced. A second laboratory is equipped for the measurement of vibratory displacement, acceleration and strain. It is provided with calibration apparatus and vibration-testing machines. A third laboratory is devoted to fire control apparatus and systems.

Gas Turbine Laboratory: 8 by 8 inch turbine component tunnel, as well as equipment for the study of phenomena of fluid mechanics involved in turbines, compressors and combustion chambers, boundary layer flow and mixing of jets.

Sloan Automotive Laboratory: Equipment for research of all kinds on reciprocating engines and their components, as well as equipment for investigating combustion, for measuring rapidly fluctuating pressures, air flow, and temperature, for taking high-speed photographs, etc.

Departmental Requirements for Graduate Work

The general requirements for admission and degrees are those set forth on pages 92 through 94 with the following additions:

Professional Subjects. Applicants for a degree with specification in Aeronautical Engineering must have preparation substantially equivalent to the following Institute subjects:

2·40	Heat Engineering
6·18	Electrical Engineering, Fund.
16·02	Aerodynamics
16·10	Aerodynamics, Applied
16·20	Aircraft Structures
16·30	Automatic Control, Prin.

For advanced work in various fields professional preparation is required as follows:

For *Aerodynamics:* 16·13, 16·65, 16·72
For *Aeronautical Design:* 16·13, 16·21, 16·65, 16·72
For *Aeronautical Structures:* 16·13, 16·21, 16·72
For *Instrumentation and Control:* 6·19, 16·13
For *Aeronautical Power Plants:* 2·48, or 2·792 and 2·7942; 16·53

If applicants have not had the specified undergraduate preparation before entrance, they may remove deficiencies while engaged in graduate work, provided that advanced work may not be undertaken until prerequisites therefor have been satisfied.

The Degree, Master of Science

For the degree of Master of Science in Aeronautical Engineering at least one year of an approved program is required, including thesis. Two terms of advanced mathematics (beyond M22) must be included.

The five-year program in Aeronautical Engineering, leading to the degrees of Bachelor of Science and Master of Science simultaneously, is described under the Course XVI undergraduate schedules.

The Degree, Aeronautical Engineer

For the degree of Aeronautical Engineer the student must satisfactorily complete at least two years of an approved program, including thesis, planned to provide a broad foundation in both aeronautical science and its engineering applications.

Requirements for admission to candidacy for the degree of Aeronautical Engineer are more rigorous than for the degree of Master of Science in Aeronautical Engineering.

The Degree, Doctor of Science

For the degree of Doctor of Science the student is required to complete an approved program, including thesis, more extensive than that for the degree of Aeronautical Engineer. The general examination includes both written and oral parts. The Doctor's thesis must demonstrate the ability of the student to do original research of high grade on a problem of aeronautical science or engineering.

XVII. BUILDING ENGINEERING AND CONSTRUCTION

Graduate study and research are offered by the Department of Civil and Sanitary Engineering, as Course XVII — Building Engineering and Construction, in the fields of Structural Design, Materials and Building Management leading to the degree of Master of Science in Building Engineering and Construction or to the engineering degree of Building Engineer.

Graduate work is divided into the following major fields of study:

Structural Design:
Reinforced Concrete and Structural Steel
Materials of Construction:
Plastics, Engineering Laminates, Masonry Materials
Management:
Job Management — Building Maintenance

The Department encourages graduate work which combines two or all of the above fields. Students will be expected to include in their programs approved graduate subjects such as mathematics, theory of elasticity, theory of structures, photoelasticity, structural laboratory, chemistry, physics, and business administration.

Departmental Requirements for Graduate Work

In addition to the general requirements for all graduate students, as set forth on page 92, a candidate must present evidence of training in professional subjects which are equivalent to those included in the undergraduate course in Building Engineering and Construction and which correspond approximately to the following Institute subjects:

1·01	Surveying
1·40, (1·41) (1·42)	Structural Analysis
2·002	Applied Mechanics
2·371	Testing Materials Laboratory
17·43	Building Construction

XVII. Building Engineering and Construction Continued

17·40	Job Management
1·44T, (17·53T), (17·54T)	Steel, Wood and Concrete Design
17·73, 17·74	Materials

If the student has not completed, before entering upon his graduate work in this Course, all of the subjects in the above list, or any others listed as prerequisites for graduate subjects in this Course, deficiencies may be made up during his attendance at the Institute; the subjects, shown in parentheses in the above list, up to a total of 24 units, will count for credit toward either degree, if not already accepted for credit toward the Bachelor's degree.

To meet the requirements for the engineering degree of Building Engineer a candidate must include, in addition to the general requirements given above, a program of graduate studies which will provide an extended basis for professional competence in structural design, materials and management.

XVIII. MATHEMATICS

This Department offers courses leading to the degrees of Master of Science, Doctor of Philosophy, or Doctor of Science in Mathematics.

A wide range of graduate subjects in various branches of mathematics is offered. Graduate seminars are conducted regularly by members of the staff, and colloquia and lecture series on topics of current mathematical interest are held at frequent intervals throughout the academic year. Candidates for the doctorate are encouraged to obtain a broad general knowledge of mathematics together with sufficient depth in a field of specialization to enable them to pursue research effectively. The seminars, colloquia, general lectures and informal conferences with members of the staff, along with formal graduate subjects, offer excellent means of achieving these ends.

Candidates for advanced degrees who work in the field of pure mathematics will, aside from the minor program, ordinarily take most of their subjects in the mathematics department. In addition to their advanced specialization, they will be encouraged to acquire breadth by taking basic courses in analysis, algebra, geometry and topology.

Candidates for advanced degrees who work in the field of applied mathematics will be encouraged to follow a course of study covering important aspects of one or more engineering and scientific fields which are closely related to research in applied mathematics, together with a selected sequence of mathematics subjects. Assistance or even collaboration in problems in applied mathematics being investigated by members of the staff may constitute part of graduate programs.

Departmental Requirements for Graduate Work

The general admission requirements are those set forth on page 92, with the following additions and exceptions:

Chemistry. Students who present two semesters' college work in biology, geology, meteorology, or astronomy need not present 5·01 and 5·02.

The Degree, Master of Science

For the Master's degree, 96 units beyond the Bachelor's degree are required, including M381 and M382 (Theory of Functions), two additional 12-unit "A" subjects offered by the Department, and thesis (usually 20–24 units). In addition, either as an undergraduate or as a graduate student, each student is expected to have four subjects (or their equivalents) from the following group: M39, M411, M442, M50, M62, M831, M832, 8·71. Of the four subjects elected from this group of eight, two may be counted for credit toward the Master's degree if taken at M. I. T. while a graduate student.

The Doctorate

The general requirements for the Doctor of Philosophy or Doctor of Science are those set forth on page 93. As soon as possible after beginning graduate work, each student who plans to take a doctorate in mathematics should elect one of the following two plans of study:

Plan A. Written qualifying examination on the material covered by M381, M382, M62, M442, M831, M832. In addition, students who elect this plan will take eight additional subjects chosen from M50, M833, and the Department's 12-unit subjects other than those included in the qualifying examination.

Plan B. Written qualifying examination on the material covered by M381, M382, M39, M50, M411. In addition, students who elect this plan will take M421, M422, M571, M591, M791, M792, 8·71 or 2·003; one additional term in hydromechanics, elasticity, or plasticity; and one additional 12-unit subject given by the Department.

XIX. METEOROLOGY

This Department offers advanced courses of study leading to the degrees of Master of Science in Meteorology, Doctor of Philosophy, and Doctor of Science in Meteorology. The educational program is designed to prepare the student for a professional career in research, teaching, or applied meteorology. Emphasis is placed on the theoretical and quantitative approach supplemented by empirical and observational methods. The complexity of the subject and its application to a wide variety of problems in other fields of science and technology make graduate training an important prerequisite to a successful professional career.

Sound preparation in mathematics and the physical sciences is essential to success in the graduate work and is even more important than previous training in meteorology. Undergraduates at the Institute who wish to prepare for graduate training in Meteorology are advised to register in Courses VI, VIII, IX, XII, or XVIII and to select as electives certain basic subjects in meteorology. Undergraduate programs of similar content and caliber at other recognized institutions may also provide an adequate background for graduate work. Students with no previous training in Meteorology may be admitted provided that they satisfy the general requirements and have had good preparation in mathematics and the physical sciences. Such students will be required to take certain basic meteorology subjects as a preparation for graduate work and hence must expect to be in residence for a somewhat longer period in order to complete the requirements for an advanced degree.

Formal subjects of instruction are offered in all of the major areas of meteorology as well as in certain specialized and peripheral subjects such as radar meteorology and oceanography. Facilities are available for research in all of the principal fields as well as in specialized areas. Current weather data are collected on teletypewriter circuits covering North America, Western Europe, and the adjacent oceans. Extensive files of back data and analyzed maps are available that cover most areas of the world. Some of these data are already in form for use on modern computing machines. Access is available to desk computers, I.B.M. card equipment, and a high-speed digital computer. The application of modern statistical techniques to atmospheric problems is carried out in cooperation with the Department of Mathematics.

The Department maintains a number of radar systems and associated equipment which are used in an extensive program of research and instruction in radar meteorology.

XIX. Meteorology Continued

Files of radar-oscilloscope photographs and related data provide an excellent source of information for a variety of stimulating studies.

The Meteorological Instrumentation Laboratory contains standard and specialized instrumentation for the measurement and recording of atmospheric phenomena. Included are equipment for radio-meteorograph and radio-wind soundings and calibration chambers for use over a wide range of pressure, temperature, humidity, and air speed. Laboratory facilities are available for research in physical meteorology, especially in the fields of cloud and precipitation physics. A well-equipped shop provides facilities for the construction of special instruments and apparatus.

The Department carries on an extensive program of sponsored research. Opportunities are available to graduate students to participate in this program as either full-time or part-time Research Assistants. Such active participation is considered to be a valuable supplement to the student's formal academic program and also provides some financial assistance.

Meteorological seminars, sponsored jointly by the Department and the American Meteorological Society, are held at regular intervals during the academic year. At the meetings recent developments in meteorology and allied sciences are discussed by guest speakers, members of the staff, and graduate students. Close cooperation is maintained with the United States Weather Bureau, the United States Air Force Cambridge Research Center, the Woods Hole Oceanographic Institution, the Blue Hill Meteorological Observatory of Harvard University, and other similar institutions.

Departmental Requirements for Graduate Work

The general requirements for admission to graduate work in Meteorology are those set forth on page 92.

Candidates for advanced degrees in Meteorology must present evidence of training substantially equivalent to that provided by the following Institute subjects:

19·01, 19·02	Descriptive Meteorology
19·601	Introduction to Theoretical Meteorology

Deficiencies in the above subjects may be removed while pursuing a program of graduate study.

The Degree, Master of Science

The required 72 units of "A" subjects may be selected from those offered in Meteorology and those in closely-related fields offered by other Departments. Undue specialization in one branch of the field is discouraged. All candidates will be expected to register for at least one term of Meteorological Seminar. There are no foreign language requirements for the degree, Master of Science.

The Doctorate

The general requirements for the degrees, Doctor of Science and Doctor of Philosophy, are those set forth on page 93.

Candidates for the Doctorate in Meteorology are required to demonstrate their ability to read scientific literature in English and in two other modern languages, at least one of which shall be German or Russian. The second language must be one in which there exists important meteorological literature. The following, among others, are considered to meet this requirement: German or Russian (if not chosen as the first language), French, Norwegian, Swedish, Spanish, Italian, and Japanese.

XX. FOOD TECHNOLOGY

The Department of Food Technology offers advanced courses leading to the degrees of Master of Science or Doctor of Philosophy or Doctor of Science in Food Technology. It also offers graduate programs in Biochemical Engineering (see Course XX-B).

Graduate work in food technology for the doctorate offers opportunity for advanced study and experimental work in the chemical, biological, engineering, or economic aspects of food production, and development or control of new processes relating to product improvement or conservation of nutritive quality. Such work may be combined with subjects in chemical engineering, chemistry, mechanical engineering, physics, business administration, or others.

The new Samuel Cate Prescott Laboratories of Food Technology are housed in a modern, newly constructed, multi-story building called the John Thompson Dorrance Building. These new facilities provide adequate space and equipment for research in the investigations of food processing, packaging, food engineering, development of new food products, fisheries technology, nutritional biochemistry, industrial microbiology, flavor evaluation and radiation sterilization, in which this Department has pioneered.

Modern equipment, utilizing the latest developments in electronics, physics and electrical engineering, is available for objective evaluation of new processing technology.

Research in food technology includes the following: various aspects of food processing, plant design, product control, instrumentation, objective measurements for evaluation of food quality, packaging research, electronic applications in the food industry, utilization of by-products, sanitation and bacteriology of foods, unit processes in food manufacture, fisheries technology, radiation preservation of foods and drugs, biochemical engineering including the production of important metabolic products of microorganisms. The evaluation of food flavors and the relation of processing methods to flavor development and conservation are also fields of research of primary interest to the Department of Food Technology.

Another basic field of research of interest to the Department is the application of ionizing energy for the "cold" sterilization of foods, drugs and pharmaceuticals. In addition, various aspects of food engineering, including concentration, thermal processing, heat exchange and other important engineering operations are considered.

Departmental Requirements for Graduate Work

The general requirements for admission are those set forth on page 92.

Applicants for admission to graduate work in food technology are required to meet as prerequisites the general equivalent of the undergraduate program in food technology. Graduates from accredited institutions presenting evidence of scholarship of high order in contiguous professional fields may be permitted equivalent substitutions for such prerequisites, or the privilege of advanced standing examinations in the case of deficiencies.

The Degree, Master of Science

The requirements for the degree of Master of Science in Food Technology are as set forth on page 93. A five-year course leading to the degrees of Bachelor of Science and Master of Science in Food Technology is outlined under the undergraduate course schedules. This course is open only to those undergraduate students who have demonstrated special aptitude and high scholarship during their first three years.

XX. Food Technology Continued

The Doctorates

For students working toward the degree of Doctor of Science or Doctor of Philosophy in Food Technology, graduate subjects should be taken in preparation for the general examinations, but no specific subjects are prescribed. The choice of subjects is determined by the preparation and field of interest of the individual in consultation with his graduate registration officer.

Requirements for the doctorate include the satisfactory completion of oral and written examinations prescribed by the Department which demonstrate the competence and thorough understanding of the basic scientific phases of food technology and their application in certain specified fields.

XX-B. BIOCHEMICAL ENGINEERING

Graduate study and research are offered by the Department of Food Technology, as Course XX-B — Biochemical Engineering, to satisfy the requirements for the degree of Master of Science or Doctor of Science in Biochemical Engineering.

Graduate work in biochemical engineering offers opportunity for advanced study in biochemistry, microbiology, nutrition, enzymology, and chemical engineering with emphasis being placed on their correlation in such fields as food production, fermentation, chemurgy, and waste disposal.

The laboratories provide facilities for investigations involving the application of such chemical engineering unit-operations as heat transfer, evaporation, drying, filtration, extraction, distillation, and ion-exchange to biological processes, and for investigations of the effects of operating variables on fermentations.

Research in biochemical engineering includes the following: equipment design, product development, process development, instrumentation, and process control. A field of research offering wide opportunities is the fermentation of natural materials to produce foods, solvents, organic acids, antibiotics, vitamins, and enzymes.

Departmental Requirements for Graduate Work

The general requirements for admission are those set forth on page 92.

Applicants for admission to graduate work in biochemical engineering are required to meet as prerequisites the general equivalent of the undergraduate program in biochemical engineering. Graduates from accredited institutions presenting evidence of scholarship of high order in contiguous professional fields may be permitted equivalent substitution for such prerequisites, or the privilege of advanced standing examinations, in the case of deficiencies.

The Degree, Master of Science

The requirements for the degree of Master of Science in Biochemical Engineering are as set forth on page 93.

The Degree, Doctor of Science in Biochemical Engineering

Since the award of this degree implies exceptional breadth of professional competence, students working toward the degree of Doctor of Science in Biochemical Engineering will pursue a program of subjects approved by an Interdepartmental Committee, which, in addition to members from the Department of Food Technology, includes representatives of the Departments of Biology and Chemical Engineering. Such a program will be formulated to meet the particular needs and interests of each individual candidate, taking into account his previous preparation and experience. The eventual general major examination for such a doctorate, prepared and conducted by the Interdepartmental Committee, will require demonstration of thorough understanding of and competence in the basic aspects of Biochemical Engineering and their application to certain specific fields, and will devote substantially equivalent attention to appropriate, relevant aspects of Biology, Chemical Engineering and Biochemical Engineering.

DESCRIPTION OF SUBJECTS

The list below is subject to change. The prerequisites, units of exercise and preparation, and instructors in charge of each subject will be found under "Subjects of Instruction Tabulated."

CIVIL AND SANITARY ENGINEERING

Subjects 1·00 to 1·99

1·001. Conservation of Natural Resources. Survey of one of the great social problems of modern civilization — the wise use of our natural resources. Distinction between renewable resources — such as water, soil, animal life, and plant life, and nonrenewable resources — such as minerals and petroleum. Study of the impact of modern technological society on the vital natural resources by which man lives, with emphasis on the principles of proper management.

1·01. Surveying I. Development of the principles and theories fundamental to engineering measurements. Comprehensive studies of directional measurements, linear observations, engineering leveling and topographic operations. Field and office work illustrative of basic principles.

1·02. Surveying II. Engineering applications of theories and principles developed in Surveying I. Covers horizontal control data, measurement of areas and volumes, route surveys and staking out of engineering works. Application of contour maps to the areal aspects of engineering. Field and office work illustrative of applications discussed.

1·04. Advanced Surveying. Use of advanced surveying methods, such as precise triangulation, traverse and leveling in the layout and control of civil engineering projects. Principles of photogrammetry, including methods of preparing planimetric and topographic maps from aerial photographs with applications to planning and design of highways, airports, dam sites, and other civil engineering works. (Not offered 1956–57.)

1·06. Photogrammetric Engineering. Introduction to theoretical and applied photogrammetry as a method of making space measurements and obtaining technical data. Aerial photography, ground control surveys, aerial triangulation, theory of automatic stereoplotters, stereotopographic mapping, non-topographic photogrammetry, interpretation of aerial photographs. Special attention to the planning and design of photogrammetric engineering projects and to civil engineering applications.

1·201. Transportation Planning. Principles of planning, finance, operation, administration, regulation, and design of facilities for highway, railway, and air transportation with some attention to pipe lines and waterways. Traffic studies, location problems. and economic considerations. Relationship of transportation planning to regional and city planning. Mass transportation in metropolitan areas. Coordination of different forms of transportation. Field trips and planning problems.

1·202. Transportation Engineering. Design, construction, and maintenance of transportation facilities. Highway and airport design criteria, traffic estimates, layouts, drainage, pavements, materials, and construction. Railway maintenance of way, yards, and terminals, signals and communications. Problems in highway, railway, and airport design. Field trips and laboratory demonstrations.

1·251. Traffic Engineering (A). Application of engineering principles to the flow of highway traffic. Characteristics of vehicles, drivers, and pedestrians. Traffic counts, origin and destination surveys, accident studies, traffic estimates, application to planning studies. Highway and intersection capacities. Traffic control, signs, signals and markings. Geometric design principles for highways and intersections. Parking studies and layout of parking facilities.

1·252. Highway Location and Geometric Design. (A). Principles of highway location, rural and urban, with applications to specific problems. Geometric design of intersections, rotaries, and interchanges. Economic considerations, evaluation of alternate designs.

1·261. Airport Planning and Administration (A). Consideration of the basic data required for the design of an airport and its terminal, including air traffic potentials, development of future aircraft, air traffic control and airport zoning. Study of field and terminal layouts, passenger and cargo circulation, apron activities, highway access, automobile parking, airport management, finance and maintenance.

1·262. Airport Design (A). Development of a layout for an airport on a given site including the location of runways and taxiways, zoning of runway approaches, design of airport paving, drainage, lighting systems, and site planning for terminal area, access roads and parking lots.

1·27. Special Studies in Transportation Engineering (A). Advanced study in a particular phase of highway, railway, or airport engineering, selected with the approval of instructor.

1·28. Highways and Airports. Principles and practice in the planning, design and construction of highways, streets and airports.

1·282. Highway and Airport Pavements (A). Soils explorations and base courses; thickness design formulas for flexible and rigid types. Current research on pavement design. Design and control of bituminous concrete mixes. Design of concrete paving mixes, joints, and reinforcing. Airport paving requirements. New developments in construction methods.

1·30. Soil Mechanics and Foundation Engineering. Physical and mechanical properties affecting soil action in engineering problems; coefficients of permeability, capillarity and compressibility and their application in practical problems relative to seepage, uplift, liquefaction and the settlement of building located above buried compressible soil strata; shearing strength and bearing capacity and their application in problems relative to stabilities of embankments, cuts, retaining walls, shallow footings and pile foundations; pressure distribution on retaining walls and footings; and case studies of foundation problems. Reading assignments on soil sampling, excavation, cofferdams, caissons, types of piles and types of foundations. Laboratory work covering the important soil tests.

1·31. Soil Engineering. Theoretical and practical aspects of various soil engineering subjects determined in part by special interests of class members. Soil engineering for highways, airfields, earth dams, and building foundations considering subsurface exploration, stability of earth embankments, seepage and drainage, frost action, soil stabilization, and footings, piles and other foundation types. (Not offered 1956–57.)

1·35. Soil Mechanics and Foundation Engineering. Physical and mechanical properties affecting soil action in engineering problems; coefficients of permeability, capillarity and compressibility and their application in practical problems relative to seepage, uplift, liquefaction and the settlement of buildings located above buried compressible soil strata; shearing strength and bearing capacity and their application in problems relative to stabilities of embankments, cuts, retain-

ing walls, shallow footings and pile foundations; pressure distribution on retaining walls and footings; and case studies of foundation problems. Reading assignments on soil sampling, excavation, cofferdams, caissons, types of piles and types of foundations. Laboratory work covering the important soil tests.

1·354. Soil Engineering. Theoretical and practical aspects of various soil engineering subjects determined in part by special interests of class members: subsurface exploration, stability of earth embankments, seepage and drainage investigations, frost action, soil stabilization, bearing capacity, considerations of footings, piles and other foundation types. Terzaghi and Peck, *Soil Mechanics in Engineering Practice.*

1·361. Soil Mechanics (A). Physical and mechanical properties of soil governing its behavior as an engineering material. Basic soil classifications; laws of permeability, capillarity and seepage; compressibility and consolidation theory; relationships of stresses, strains, and shearing strengths in cohesive and cohesionless soils. (Designed for students not specializing in Soil Engineering.)

1·363. Mechanics of Soil (A). Considerations of soil properties; classifications; and exploration and subsurface sampling procedures. Uses of theory of elasticity for estimating stresses in soil masses. Stress-strain-time characteristics of soil under static and dynamic loading; including theories and practical aspects of consolidation characteristics and shearing characteristics of the basic soil types under various conditions of loading and drainage. (Designed for students specializing in Soil Engineering.)

1·365. Seepage through Soil; Frost Action (A). Permeability and capillarity of soil; the mechanics of steady and non-steady seepage; method of solution of seepage patterns, including flow net sketching, analytical and numerical methods, and analogies; application to dams, slopes, wells, and drainage problems. Frost and other thermal problems. (Designed for students specializing in Soil Engineering.)

1·366. Embankments; Highways; Earth Dams (A). Analysis of stability of natural slopes, earth dams and other embankments; soil engineering phases of earth dam, highway and airfield design.

1·367. Soil Technology (A). Consideration of origin, composition, and particle surface characteristics of soil as an engineering material. Treatment of the following subjects in classroom and laboratory exercises: colloidal phenomena in soils; clay and non-clay mineralogy; ion exchange reactions; soil weathering; compositional analysis of soils; alteration of soil surface characteristics.

1·368. Foundations; Lateral Earth Pressure (A). Determination of lateral earth pressure; design of retaining walls and cofferdams. Load bearing capacity of foundations; considerations of footings, rafts, piers, caissons and piles; foundations subjected to dynamic loadings; construction problems.

1·37. Soil Mechanics Laboratory (A). Techniques of soil testing and soil identification, covering first the simple, conventional tests for specific gravity, limits of consistency, grain size, permeability, and compaction and California Bearing Ratio; later emphasis placed on the tests for consolidation characteristics and for shearing strength, both by triaxial apparatus and by direct shear apparatus, and for drained and undrained conditions.

1·40. Structural Analysis. Introductory theory of stress analysis for civil engineering structures, such as buildings and bridges. Loadings, reactions, shears, bending moments, analysis of simple trusses, graphic methods, influence lines for stress in girders and trusses with applications to computation of maximum stresses caused by systems of live loads, and introduction to the use of the moment distribution procedure.

1·40T. Statics and Dynamics. Fundamental engineering applications of the analysis of static equilibrium. Study of resultant force distributions in structures and mechanisms under static conditions. Emphasis on free body technique. Fundamental engineering applications of the analysis of plane dynamics of particles and rigid bodies. Kinematics of particles and rigid bodies in translation, rotation and plane motion; moments and products of inertia.

1·41. Structural Analysis. Continuation of 1·40. Stress analysis for statically determinate trusses of various forms including three hinged arches, cantilevers and space frames, statically indeterminate structures of certain types such as building frames, trusses with multiple web systems and portal frames by approximate methods. Cables and elementary suspension systems are considered and also gravity type dams and retaining walls. Determination of deflections of trusses and beams by methods of Virtual Work, Moment Area and Williot-Mohr.

1·41T. Materials and Mechanics. Introduction to elastic analysis through presentation of concepts of stress and strain in tension, torsion, compression and flexure. Development of Mohr's circle construction with extensive applications. Detailed study of beams and columns with attention to analytical and graphical methods of determining bending and shear stresses and deflections under a variety of loading and support conditions. Introduction to the concept of combined stress and the resultant deformations commonly encountered in beams and columns. Examination of the mechanical properties of common structural materials with attention to yielding, work hardening, fatigue, creep and theories of strength. Study of anisotropy arising from inherent structure or mechanical working. Laboratory work on materials testing and photoelastic techniques, to develop a more comprehensive sense of judgment in the choice of structural materials.

1·42. Structural Analysis. Continuation of 1·41. Elementary treatment of analysis of statically indeterminate structures by Superposition Equations, Castigliano's Theorem, Slope-Deflection Method, and Moment Distribution. Continuous structures, rigid frames, and arches among those considered.

1·42T. Materials and Mechanics. Properties of masonry materials, woods and metals and their influence on the uses of the materials in engineering and structural applications. *Masonry Materials:* physical and chemical properties of cements and aggregates, physical and mechanical properties of structural units such as brick, tile and stone, and relation of the properties of these structural elements to the performance of the ultimate structure. Design of concrete mixes and effect of design and of ingredients on the workability, strength and durability of the concrete. Inter-relations existing between properties of units, of mortars and of unit masonry with emphasis on the factors causing efflorescence, wet walls and lack of durability. Laboratory work on the preparation of mortars, plain and air entrained concretes, and the physical and mechanical testing of concretes, mortars and units. *Wood:* Mechanical and physical properties of wood and characteristics of laminated timber and plywood. *Metals:* Mechanical and metallurgical properties of ferrous and certain non-ferrous materials with emphasis on their structural applications and behavior. Effects of alloy content, heat treatment, fabrication process, and joining methods such as welding. Corrosion problems and remedies.

1·43. Advanced Materials. Materials of construction supplemental to those studied in 1·42T. Half of subject: inorganic, non-metallic construction materials such as ceramic tile, glass, ornamental terra cotta, plasters, stuccoes, wall and plaster boards, and insulating materials. Emphasis on fire resistance, acoustical behavior and thermal insulating characteristics. Effects of such properties as thermal and moisture expansion, porosity and soundness upon the cracking, discoloration and deterioration of the structure. Balance of subject: Properties of laminated materials such as plywood and reinforced plastics, with discussion of those plastics and coatings becoming increasingly important in building work. Uses of plywood as plates, stressed skin or covers and as components in built-up beams. (Not offered 1956–57.)

1·44T. Elementary Structural Engineering. Application of the tools of static analysis, structural mechanics and behavior of materials to solve simple structural design problems. Fundamentals of design in wood, concrete and steel. Development of proper perspective of analysis and design in

Civil and Sanitary Engineering Continued

the solution of structural engineering problems. Laboratory work with qualitative models to develop understanding of behavior of typical structural types.

1·441. Structural Design. Extension of elementary concepts of structural design introduced in 1·44T to design of typical steel and wood structures. Comparative design of different types of framing for a gymnasium roof such as steel beams and girders, steel beams and trusses, and timber roof trusses. Design of steel plate girder railway bridge on timber bents. Design of small multi-story steel building frame.

1·442. Reinforced Concrete Design. Extension of elementary concepts of structural design introduced in 1·44T, with application to the design of specific reinforced concrete structures such as retaining wall, footing, beam bridge, one-way slab, two-way slab, flat slab, arch or rigid frame. Introduction to elementary concepts of plastic theory and prestressed concrete.

1·443. Structural Design. More comprehensive treatment of subject matter of 1·441. (Not offered 1955–56.)

1·444. Reinforced Concrete Design. More comprehensive treatment of subject matter of 1·442. (Not offered 1956–57.)

1·451. Structural Analysis. Introductory theory of stress analysis for civil engineering structures, such as buildings and bridges. Loadings, reactions, shears, bending moments, analysis of simple trusses, and influence lines for stress in beams, girders and trusses with application to computation of maximum stress produced by moving load systems. Stress analysis of statically determinate trusses of various forms including three hinged arches, cantilevers, and space frameworks. Approximate analysis of certain statically indeterminate structures such as building frames and portal frames. Cables, simple suspension systems, and gravity dams, also considered. (Not offered 1956–57.)

1·452. Structural Analysis. Continuation of 1·451, Determination of deflections of trusses and beams by methods of Virtual Work, Moment Area and Williot-Mohr. Elementary treatment of analysis of statically indeterminate structures by Superposition Equations, Castigliano's Theorem, Slope-Deflection Method, and Moment Distribution. Continuous structures, rigid frames, and arches. (Not offered 1956–57.)

1·521. Structural Laboratory (A). Lectures, conferences, assigned reading and laboratory work, covering the theory and practice of structural analysis by the use of models. Fundamentals of the entire field.

1·531. Special Problems in Structural Engineering (A). Individual study of advanced subjects not otherwise provided for in the curriculum, under supervision of a member of the staff. Arrangement of each program to suit the particular requirements of the student and interested members of the staff, subject to the approval of the instructor in charge.

1·541. Advanced Reinforced Concrete Design (A). Advanced treatment of the theory underlying the design of reinforced concrete structures in general, starting with a brief review of elementary theory, and proceeding to consideration of deflections, torsion, shrinkage, plastic flow, ultimate strength theories, and pre-stressed structures.

1·542. Advanced Reinforced Concrete Design (A). Continuation of 1·541, with application of theory to the design of civil engineering structures such as precast decking, slabs, rigid frames, arches, tanks, hipped-plate roofs, etc.

1·551. Advanced Structural Design (A). Important problems of a general nature encountered by structural designers, such as choice of type, general proportions, economics, methods of preliminary design, organization of design procedure, influence of erection methods, etc., with special reference to statically indeterminate structures.

1·552. Advanced Structural Design (A). Continuation of 1·551, with applications to structures of complicated types such as suspension bridges, arch dams, building frames, etc. Theory to supplement design procedures given as required. The exact content adaptable to the interests of the class.

1·561, 1·562. Advanced Structural Mechanics (A). Introduction to problems in advanced mechanics with applications to structural analysis. Among the subjects considered are Theory of Elasticity, Theory of Elastic Stability, Thin Plates and Shells, and Vibrations of Structures.

1·571, 1·572. Statically Indeterminate Structures (A). Rigorous treatment of the analysis of Statically Indeterminate Structures, starting with a brief review of elementary theory and proceeding to the analysis of internally indeterminate trusses, continuous trusses, arches, building frames, suspension bridges, etc. Effect of variable stiffness and the subject of secondary stresses included. Methods of Virtual Work, Castigliano, Slope Deflection and Moment Distribution considered.

1·59. Structural Engineering Seminar (A). Practice for graduate students in presentation of technical papers and opportunity for discussion of subjects of current interest to structural engineers.

1·601T, 1·602T. Fluid Mechanics. Elementary mechanics of incompressible and compressible fluids. Properties of fluids. Fluids at rest, geometry of fluid motion, general equations of motion. Dynamic similarity for inertia, gravity and viscous forces, laminar and turbulent flow, skin friction, lift and form-drag. Basic principles applied to steady flow through orifices, nozzles and other flow meters. Fluid flow in pipes and open channels. Flow through pipe systems. Dynamic similarity for elastic and surface tension forces, dynamics of immersed bodies, circulation and lift, cavitation, theory and operation of hydraulic machinery. Non-uniform flow in open channels, hydraulic jump and backwater curves. Unsteady flow in open and closed conduits, water-hammer problems.

1·611T. Fluid Mechanics. Elementary mechanics of incompressible and compressible fluids. Properties of fluids. Fluids at rest, geometry of fluid motion, general equations of motion. Dynamic similarity for inertia, gravity and viscous forces, laminar and turbulent flow, skin friction, lift and form-drag. Basic principles applied to steady flow through orifices, nozzles and other flow meters. Fluid flow in pipes and open channels. Flow through pipe systems.

1·612. Fluid Mechanics. Introduction to theoretical fluid mechanics with emphasis on problems in naval architecture; properties of fluids, equations of motion, dynamic similarity, laminar and turbulent flow, skin friction, flow resistance in conduits, forces on floating and submerged bodies, cavitation and propulsion.

1·613. Fluid Resistance and Turbulent Diffusion. Fundamental dynamics of real fluids with emphasis on the physical processes of fluid resistance, turbulent diffusion and mixing common to many fields of technology. Principles of fluid mechanics and dynamic similarity applied to turbulent diffusion, mass transfer, and jet mixing. Fluid resistance in laminar and turbulent motion, boundary layer development, separation and secondary flow phenomena.

1·621. Fluid Mechanics Lab. Experiments concerned with basic flow phenomena including surface resistance, lift and drag forces, turbulent diffusion, waves and surges, as well as with engineering applications such as pressure conduits, open channel flow, fluid meters, pumps, and turbines.

1·63. Applied Hydromechanics (A). General equations of motion, potential flow, conformal mapping applied to hydraulic structures, laminar and turbulent motion in conduits, boundary layer phenomena, surface and form resistance, theories of turbulence, turbulent mixing and transfer of matter in fluid streams.

1·64. Hydraulic Machinery (A). Treatment of various turbomachinery types of hydraulic machines, including centrifugal and axial flow pumps, blowers and fans, and impulse, reaction, and propeller turbines. Basic theory of turbomachinery and its application, performance analyses of the several types, design criteria, and design procedures, field requirements and selection of machinery.

1·65. Free Surface Flow (A). Steady and unsteady flow in open channels and reservoirs, backwater curves in natural and artificial channels, hydraulic jump, surges and

Civil and Sanitary Engineering Continued

waves, standing waves in supercritical flow, transportation of sediments.

1·66. Design of Hydraulic Structures (A). Preparation of integrated designs of selected hydraulic structures, such as penstocks, siphons, tunnels, spillways, stilling pools, movable weirs and gates, shore protection works, canals, locks, and river improvements.

1·67. Seminar in Hydromechanics (A). Study of recent advances in all fields of Hydromechanics. Application of developments in related branches of fluid mechanics to hydraulics. Lectures and reports.

1·681. Experimental Hydromechanics (A). Theory of similitude, dimensional analysis, practical methods of establishing dynamic similarity, models of streams with sediment load, model studies of typical hydraulic structures.

1·682. Experimental Hydromechanics (A). Experimental techniques and laboratory practice, experimental studies of fundamental phenomena such as: turbulence, boundary-layers, surface and form resistance, cavitation, wave motion, bed-load movement, density currents. Use of models in hydraulic design exemplified by studies on: spillways, bridge piers, river channels, harbor-basins, hydraulic machinery.

1·683. Experimental Hydromechanics (A). Abridgment of 1·682 with emphasis on experimental problems related to Naval Architecture.

1·69. Rivers and Harbors (A). Hydraulics of river flow, improvements with respect to flood control and navigation, studies of tides and tidal currents, wave action, beach erosion, methods of shore protection, layout of channels and harbor basins.

1·70. Hydrology. Components of the Hydrologic cycle such as precipitation, surface runoff, infiltration, evaporation. Analysis and prediction of basic quantities required for engineering design, ground water flow, variations in stream flow, storage requirements, flood flows and routing. Importance of sedimentation in streams and reservoirs. Supervised problems in applied hydrology.

1·701. Hydrology and Hydraulic Engineering. Same as 1·70 with supervised problems omitted.

1·702, 1·711. Hydraulic Engineering. Dams and weirs, spillways and energy dissipators. Conveyance by canals, flumes, tunnels and pipe-systems. Characteristics and selection of turbines and pumps. Case studies of integrated projects in water supply and sewerage, water power, irrigation and river regulation. (1·702 not offered 1956–57.)

1·71. Hydraulic Engineering. Same as 1·702 with addition of supervised exercises in hydraulic design.

1·711. Hydraulic Engineering. See 1·702.

1·72. Hydrology and Hydraulic Engineering. Condensation of 1·70 and 1·71 omitting the design problems but including the more important phases of the theory.

1·731. Water Power Engineering (A). Correlation of hydrology and power output; design of principal features of plants, including dams, intakes, waterways, surge tanks, and powerhouses; types of turbines and their characteristics; principles of speed and pressure regulation.

1·732. Water Power Engineering (A). Forecasting power demands; economic comparisons of thermal and hydroelectric plants; load characteristics and integration within systems; estimating potential production; operation problems; adaptation of general plan to topographic features, including underground plants.

1·75. Water Supply and Purification. Principles of water supply engineering including rainfall and runoff, water consumption, surface and ground water supplies, dams and impounding reservoirs, supply and distribution works, principles of water treatment and design; investigations, computations, and an engineering report on the preliminary design of a gravity water supply for a small community; also group inspections of nearby water works construction and water treatment works operation.

1·751. Water Supply and Purification. Same as 1·75 with design exercises omitted.

1·76. Sewerage and Sewage Treatment. Principles of design of sanitary and storm water sewers, methods of estimating sewage quantities and storm water runoff, procedures for the design and construction of sewerage systems, principles of sewage and industrial waste treatment and design and construction of sewage treatment works. Design of sanitary sewers for new areas, relief sewers and an intercepting sewer for a small community followed by the design of storm water sewers for a small area; also group inspections of nearby sewage works.

1·761. Sewerage and Sewage Treatment. Same as 1·76 with additional computation problems in lieu of the design exercises which are omitted.

1·77. Water Supply and Sewerage. Water consumption, water sources and their development, including wells, dams, reservoirs, supply and distribution mains; procedures for estimating sewage quantities, principles of sewerage design and construction; principles of water and sewage treatment and the design and construction of water and sewage treatment works.

1·781. Sanitary Science. Lectures, demonstrations and field studies on elements of sanitary science. Broad physical, chemical and biological aspects of sanitary engineering practice, such as development and control of water resources, disposal of gaseous, liquid and solid wastes, and control of environment for prevention of transmission of disease. (Not offered 1956–57.)

1·782. Sanitary Engineering. Water consumption, water sources and their development, including wells, dams, reservoirs, supply and distribution mains; procedures for estimating sewage quantities, principles of sewerage design and construction; principles of water and sewage treatment and design and construction of water and sewage treatment works. (Not offered 1956–57.)

1·79. Sanitary Engineering Design. Elements of engineering investigation and report covering the design of a water supply system for a small city, including pumping station, long force main, elevated storage and distribution network; and the design of an outfall sewer, sewage pumping station and treatment works for a small community.

1·811. Advanced Sanitary Engineering (A). Principles of modern water treatment and engineering practices, including coagulation, sedimentation, filtration, sterilization, softening, corrosion control, and removal of tastes and odors. Also group inspection of nearby water treatment works.

1·812. Advanced Sanitary Engineering (A). Principles of modern sewage treatment and engineering practices, including screening, grit removal, sedimentation, removal of colloids and stabilization by contact surfaces and by aeration with activated sludge, chlorination of sewage, digestion, treatment and disposal of sludge, and collection and utilization of gas. Also group inspection of nearby sewage treatment works.

1·821. Sanitary Engineering Laboratory (A). Lectures and laboratory studies concerned with the following phases of water supply and purification: rapid sand filtration, sedimentation, chemical coagulation, water softening, demineralization, chlorination, corrosion control, and microbiology. Lectures on special topics.

1·822. Sanitary Engineering Laboratory (A). Lectures and laboratory studies concerned with the following phases of sewage treatment and purification: sludge digestion, sludge gas analysis, chemical treatment, biology, biochemical oxygen demand, sludge conditioning for filtration, nitrogen analyses, grease analysis, activated sludge plant operation, and plant efficiency studies. Lectures on special topics.

1·831. Sanitary Chemistry. Lectures, demonstration and laboratory exercises dealing with chemical principles, analyses and control tests involved in purification of water and treatment of sewage and industrial wastes. Discussion of the applications, limitations and interpretation of the tests as used in practice.

1·832. Chemistry and Industrial Waste Treatment (A). Lectures on chemistry for Sanitary Engineers followed by lectures on industrial waste treatment practice. Laboratory

Civil and Sanitary Engineering Continued

work on methods of analysis applied to industrial wastes followed by analysis and treatment of typical industrial wastes.

1·84. Sanitary Microbiology. Fundamental and applied aspects of sanitary microbiology covering bacteria, protozoa, fungi and algae. Laboratory work with stress on application of microbiology to water supply and purification, sewage and industrial waste purification and stream pollution from the engineering and public health viewpoints.

1·85. Sanitary Biochemistry (A). Fundamental biochemistry of microorganisms involved in waste treatment processes and its relationship to the practical design of waste treatment units. Laboratory work involving biochemical analytical techniques as applied to sanitary engineering and biochemical unit operations in waste treatment.

1·86. Public Health Engineering (A). Lectures and discussions dealing with sources of infection, modes of transmission, principles of immunity, antibiotic agents, and application of engineering principles to the control of environmental sanitation. Some sanitary problems studied: refuse and garbage collection and disposal, rural water supply and sanitation, swimming pools and bathing beaches, food and milk control, housing, entomology and parasitology with relation to mosquito and malaria control, and control of atmospheric pollution.

1·861. Industrial Health Engineering and Atmospheric Pollution (A). Lectures, demonstrations, and discussions in causes and effects of atmospheric pollution within industrial plants and communities, with emphasis on the health and welfare of the public. Engineering principles of cleaning of industrial effluents of various types, legislative, economic and health factors involved in community air pollution control, and organization and operation of air pollution control agencies.

1·87. Public Health Statistics (A). Vital statistics including population estimates and forecasts, census, index numbers, sources of vital data, construction of life tables and their applications to public health studies. Application of theory of probability and mathematical statistics to the collection, analysis, and interpretation of data obtained in studies of water and sewage treatment processes, stream pollution, epidemiology, and other phases of sanitary engineering and public health.

1·871. Public Health Administration (A). Lectures, discussions and problems pertaining to public health administration, epidemiology and vital statistics including organization and proper functioning of municipal, county, state and federal health agencies; functions of interstate agencies for water pollution control in relation to state health departments and Federal Water Pollution Control Act; case histories of specific epidemics of particular significance to the sanitary engineer; application of vital statistics to problems of epidemiology and control of environmental sanitation by public health agencies.

1·872. Public Health Engineering Fieldwork (A). Field trips under professional guidance and for purposes of study and report of public health engineering activities that are included in the program of municipal, state and federal health agencies. Field trips covering the items enumerated under 1·86.

1·881. Advanced Sanitary Design (A). Functional design of a modern water treatment plant effecting the proper treatment of a given water for domestic and industrial consumption. Conducted in parallel with 1·811.

1·882. Advanced Sanitary Design (A). Functional design of a modern sewage treatment plant effecting the proper treatment of a given raw sewage. Conducted in parallel with 1·812.

1·883, 1·884. Special Studies in Sanitary Engineering (A). Advanced studies aimed at coordinating certain theoretical, experimental and practical phases of sanitary engineering and sanitary science. Some choice in selection of problems with approval of instructor.

1·891, 1·892. Sanitary Engineering Seminar (A). Designed to give graduate students experience in the preparation and presentation of technical papers and to afford to the students and members of the staff an opportunity to discuss and exchange ideas on matters of current interest to Sanitary Engineers.

1·901, 1·902. Civil Engineering Projects I and II. Introduction to the civil engineering profession by study of the general features of planning, design and construction of civil engineering projects through assigned studies and exercises, field inspections, laboratory exercises, and class discussions. Consideration of structural, transportation, hydraulic, foundation, and sanitary engineering. Importance of the need of a broad approach to the solution of civil engineering problems, aimed at developing engineering perspective and appreciation of the importance of the more detailed subjects that follow in the civil engineering curriculum.

1·911. Engineering Construction. Construction of buildings and civil engineering works such as highways, airports, dams, waterworks and sewer projects, including economic comparisons, financing, engineering organizations, contracts and specifications. Discussion of methods and equipment for earthmoving, foundations, steel and reinforced concrete. Quantity surveys for construction projects and field trips.

1·921. Building Construction. Discussion of engineering and architectural details within the framework of a building. Relation of framework and interior details. Floor systems and flooring materials. Roof systems and roofing materials. Masonry bearing and non-bearing walls. Prefabricated curtain wall construction. Relationship of the mechanical trades to the building engineer. Selected field trips. Staley, *Semi-Fireproof Construction.* Voss, *Fireproof Construction.* (Not offered 1956–57.)

1·922. Construction Management. Studies in the field of heavy and building construction, including owner-engineer-architect-contractor relationships, contract types and relations, including subcontracts; job planning and organization, supervision, superintendence, job records, labor relations and safety procedures. Quantity surveying and estimating. (Not offered 1956–57.)

1·931. Dwelling House Construction. Conventional and mass production methods for the construction of residential buildings. Assembly of materials, sequence of erection, use of new materials, advanced methods in construction techniques, insulation and condensation problems and planning and field techniques. Introduction to modular coordination of building materials and framing details. Relation of mechanical services and equipment to building structure. Selected field trips. Dietz, *Dwelling House Construction.* (Not offered 1956–57.)

1·94. Professional Problems. Methods of setting up engineering problems; interrelation of various phases of an engineering project; written and oral presentation of professional ideas; placement problems; non-professional qualifications; professional ethics and professional societies. Lectures by several members of the faculty and by practicing engineers.

MECHANICAL ENGINEERING

SUBJECTS 2·00 TO 2·99

2·001. APPLIED MECHANICS I. Fundamental engineering applications of the analysis of static equilibrium including simple elastic stress systems. Study of resultant force distributions in structures and machines, followed by analysis of the internal stress distribution in individual structural elements such as beams and shafts. Emphasis on free body technique. Simple statically indeterminate systems. Work and energy methods.

2·002. APPLIED MECHANICS II. Fundamental engineering applications of the analysis of plane stress and strain in elastic systems and of plane dynamics of particles and rigid bodies. Review of simple stress systems; plane stress and strain; Mohr's circle; combined stresses and strength theories; deflection of beams; statically indeterminate beams. Kinematics of particles and rigid bodies; dynamics of particles and rigid bodies in translation, rotation and plane motion; moments and products of inertia.

2·003. APPLIED MECHANICS III. Continuation of plane dynamics. Work-energy and impulse-momentum equations, with engineering applications on plane motion of rigid bodies. Jets, rockets and gyroscopes. Motion of particles referred to moving coordinate systems. Free and forced vibrations of one degree of freedom systems, including damping. Natural modes and frequencies of lumped parameter systems of two and more degrees of freedom.

2·04. STRENGTH OF MATERIALS. Elementary analysis of stress and strain in two dimensions. Torsion of circular bars. Theory of bending including shearing and bending stresses. Deflection of beams. Statically indeterminate problems in bending. Combined loading. Column theory. Theories of strength.

2·046. STRENGTH OF MATERIALS AND DYNAMICS. Elementary analysis of stress and strain in two dimensions; torsion of circular bars; bending of beams; statically indeterminate problems; theories of strength; strain energy; kinematics of particles and rigid bodies; dynamics of particles and rigid bodies in plane motion; work and energy; impulse and momentum. (Primarily for selected officers of the U. S. Navy and Coast Guard.)

2·06. VIBRATIONS. Review of vibrations in lumped systems. Application to problems of technical importance. Further analysis of lumped and continuous systems emphasizing modern methods adapted to machine computation. Applications include vibration measurement and control, mechanical filters, critical speeds and balancing of machinery. Case studies of actual vibration problems.

2·07. DYNAMICS. Formulation of differential equations in mechanical, electrical, hydraulic and other systems with emphasis on rigid body dynamics. Solutions and engineering applications of single degree of freedom systems. Vibration measurement and isolation. Simple control systems. Multiple degree of freedom systems without damping. Distributed mass systems. Analog computer demonstrations. Gyroscopes.

2·081. STRENGTH OF MATERIALS. Review of stress and strain at a point in two dimensions. Failure theories. Stress analysis from strain gage measurements. Energy methods. The torsion problem and the membrane analogy. Thick cylinders and rotating disks. Beams on elastic foundations and the analysis of bending of cylindrical shells. Miscellaneous applications to problems of industry such as rotating machinery, railroad tracks, pressure vessels, etc.

2·082. MECHANICAL ENGINEERING PROBLEMS. Broad review of the several fields of Mechanical Engineering. Problems from industry requiring the application of more than one of the principal Mechanical Engineering disciplines. Lectures by senior members of the department faculty dealing with the professional areas of special interest to the lecturers. Emphasis on the historical development of each field and its contemporary position in engineering practice.

2·09. HISTORY OF MECHANICS. Critical review of development of mechanics, including Archimedes, Stevinus, Galileo, Huygens, Newton, Hamilton, Einstein, and others. Emphasis on the significance of the basic principles, studied in the light of their historic background.

2·11. INDUSTRIAL PLANT ENGINEERING. Fundamentals of the construction of buildings, including foundations, superstructure, materials, heating, ventilation, air conditioning, and mechanical equipment. Particular emphasis on principles of safety and fire protection. Presentation of subject matter by authorities in each major field. Blake, *Industrial Safety*.

2·121. PHOTOELASTICITY. Use of commercial photoelastic apparatus with applications in the analysis of common engineering problems in two and three dimensions, with lectures on modern photoelastic theory, materials, and methods.

2·125. RESEARCH IN EXPERIMENTAL STRESS ANALYSIS (A). Opportunity for graduate students to apply experimental methods to the solution of special problems, or to take part in current development of theory and technique.

2·126. EXPERIMENTAL STRESS ANALYSIS. Introduction to some of the more common experimental methods of analyzing stress distributions. Photoelasticity, brittle lacquers, strain gage techniques and instrumentation, and analogies, as applied to problems involving static, dynamic, and residual stress distributions.

2·128. EXPERIMENTAL STRESS ANALYSIS. Similar in content to 2·126, with more time assigned for greater detail in the laboratory exercises.

2·211. ADVANCED MECHANICS (A). Stress and strain at a point in three dimensions. Introduction to the theory of elasticity with examples of solutions in two dimensions. Bending of flat plates. Energy methods in elasticity. Elastic stability problems. Applications to stress analysis of important engineering structures.

2·212. ADVANCED MECHANICS (A). Development of the foundations of dynamics leading to Lagrange's equations and Hamilton's principle. Gyroscopic effects in mechanical systems. Analysis of the stability of steady motions. Self-excited vibrations and non-linear vibrations. Applications to important engineering problems of dynamics and vibration.

2·213. GAS TURBINES (A). Application of engineering science to the design and development of gas turbines. Review of thermodynamics and fluid mechanics for flow phenomena in turbines and compressors. Review of problems of mechanical strength and vibrations encountered in rotating machinery and blading of turbines and compressors. Fundamentals of design of turbines, compressors, heat exchangers and combustion chambers. Operating characteristics of gas turbine power plants. Special problems encountered in aircraft applications.

2·214. GAS TURBINES (A). Detailed study of the design of a component of a gas turbine. Lectures supplemented by group discussions in an effort to solve a specific design problem. Preparation of a report on one phase of the problem by each student

2·215. METHODS OF ENGINEERING ANALYSIS (A). Survey of problem types encountered in engineering analysis with discussion of practical solution techniques. Emphasis on the reduction of complex physical problems to computation programs for hand or machine calculation. Particular applications to structures, hydraulics, electric networks, vibrations, heat transfer, elasticity, plasticity, acoustics, electromagnetism, compressible flow, etc. Study of approximate and numerical methods including iteration, relaxation, perturbation, finite difference and variational methods. Brief description of computing equipment with inspection tours of large-scale computing machines.

2·216. PLATES AND SHELLS (A). Bending stresses and deformation in flat plates of circular, rectangular, and other shapes. Large deflections in plates. General theory of curved thin-walled shells with applications to engineering structures.

2·221. PLASTICITY (A). Mechanics of the plastic state of materials. General discussion of yield criteria and stress-strain relations, including experimental evidence. Applications to the deformation and residual stresses in bars, beams, and

Mechanical Engineering Continued

tubes. Problems in plane strain. Limit design. Other engineering applications of current interest. R. Hill, *Mathematical Theory of Plasticity.*

2·222. Seminar in Plasticity (A). An opportunity for further study in branches of plasticity of special interest to the student. Discussion by students of their problems, progress, and results with the class at frequent meetings.

2·225. Physics of Strength and Plasticity (A). Cohesive forces in solids; elasticity. Fracture of brittle materials; Griffith theory of fracture. Ductile types of fracture. Notch brittleness. Cyclic and static fatigue phenomena. Permanent deformations in amorphous materials; viscosity. Grain boundary viscosity in metals.

2·226. Physics of Strength and Plasticity (A). Mechanism of plastic deformation in crystals. Plasticity of polycrystalline metals. Dynamics of slip; dislocation theory. Strain hardening; anelastic effects. Creep and creep testing. Theory of transient creep; dependence of the stress-strain curve upon strain rate and temperature. Mechanical behavior of polymers. Recrystallization and recovery. Martensitic transformations.

2·228. Research in Materials (A). Opportunity for undergraduate and graduate students to carry out experimental or theoretical research work on mechanical properties (strength, plasticity, etc.) of metallic and non-metallic materials.

2·231. Theory of Elasticity (A). Continuation of 2·211. Elastic bodies in contact. Plates and shells. Problems involving the joining of several elastic shapes, such as arise in design. Buckling. Wave propagation and related problems, such as impact and water hammer.

2·25. Fluid Mechanics. Hydrostatics. Kinematics. Concept of the control volume. Continuity equation. Momentum theorem. Theorem of momentum of momentum. Dynamics of inviscid fluid. Bernoulli equation. Dimensional analysis. Energy equation. Viscous and turbulent flow. Head losses. Fluid meters. Fluid machinery. Lift. Drag. Boundary layer.

2·252. Fluid Mechanics. One-dimensional compressible flow, with applications to problems associated with the design of turbojets, ramjets, rockets, combustion chambers, supersonic inlets, supersonic wind tunnels, gas turbines, and steam turbines. Unsteady fluid motions, with applications to problems of water hammer, detonation, and the inlet and exhaust ducts of reciprocating machinery. Two-dimensional and three-dimensional flows at subsonic and supersonic speeds.

2·261. Lubrication and Friction. Presented in two parts: (a) Hydrodynamic lubrication covering the Petroff and Sommerfeld equations; criteria for load capacity of bearings; factors for side leakage; and heat balance in a bearing; (b) Boundary lubrication covering the effects of lubricant composition, surface finish and bearing materials on bearing performance.

2·262. Research in Lubrication (A). Opportunity for the student to select a research problem which may be independent of or closely related to the program in progress in the Lubrication Laboratory; the field including lubrication proper, bearing design, surface finish, and fundamental studies of mechanism of friction from both the experimental and theoretical standpoints.

2·263. Lubrication and Friction (A). Derivation of a generalized Reynolds' equation and its application to analysis of sliders, tilting pad bearings, journal bearings, partial bearings, thrust bearings, externally pressurized bearings, dynamic loading; heat balance in bearings; effect of constitution of lubricant, including molecular structure, surface geometry and nature of the bearing surfaces on boundary lubrication; current theories and critical experiments on dry and boundary friction and their relation to wear.

2·28. Fluid Machinery (A). Unified treatment from a fundamental point of view of different types of fluid-handling machinery. Displacement-type pumps, compressors, and motors. Centrifugal and axial pumps. Radial, axial, and mixed-flow water turbines. Steam and gas turbines. Axial and centrifugal fans, blowers, and compressors. Supersonic turbines and compressors. Air and water propellers. Fluid couplings and torque converters. Jet pumps, injectors, and ejectors.

2·31, 2·32. Mechanical Properties of Materials. Structure and interaction of atoms and molecules. Cohesive forces in various types of matter; elasticity. Strength and fracture of metallic and non-metallic materials under various conditions of loading. Mechanical properties of high polymers; rubber elasticity; plasticity, creep, recrystallization, and related phenomena in metals and other crystalline materials. Meaning of the mechanical tests. Points of view for the selection of materials for engineering purposes. Production, chemical and physical properties, testing, and engineering uses of glass, ceramics, cement, plastics, rubber, and textiles.

2·37. Mechanical Behavior of Materials. Lecture and laboratory. Review of certain fundamentals of elastic behavior. Methods of stress and strain measurement, and of mechanical testing. Yield criteria; plastic tension, torsion and bending; hardness. Elementary physics of plasticity and strength; creep, fatigue, notch brittleness. Discussion of ceramics, glass, textiles and high polymers.

2·371. Testing Materials Laboratory. Laboratory methods of making physical tests to determine the properties of the more common engineering materials and a study of their behavior under static and dynamic conditions of stress. Use of true and engineering stress-strain diagrams in tension and torsion. Creep, notch brittle and temperature effects, effect of heat treatment, fatigue, torsion, and elastic stability.

2·40. Heat Engineering. First Law of Thermodynamics and internal energy. Properties of liquids, vapors, gases, gas mixtures, and mixtures of air and water vapor. Second Law of Thermodynamics, the temperature scale and entropy. Applications to closed systems and to fluids in steady flow. Keenan, *Thermodynamics;* Keenan and Keyes, *Steam Tables;* Keenan and Kaye, *Gas Tables.*

2·401. Heat Engineering. For students who have taken thermodynamics or heat engineering but whose preparation is not sufficient to cover 2·40 and 2·42.

2·402. Heat Engineering. Same as 2·40 with, in addition, applications to heat engine cycles and turbine processes. Keenan, *Thermodynamics;* Keenan and Keyes, *Steam Tables;* Keenan and Kaye, *Gas Tables.* (Primarily for selected Officers of the U. S. Navy and Coast Guard.)

2·403. Heat Engineering. Introduction to heat transfer. First law of thermodynamics. Energy. Properties of liquids, vapors, gases, gas mixtures, and mixtures of air and water vapor. Second law of thermodynamics. The temperature scale and entropy. Introduction to the thermodynamics of chemistry. Applications to flow of fluids. Keenan, *Thermodynamics;* Keenan and Keyes, *Steam Tables;* Keenan and Kaye, *Gas Tables.*

2·41. Heat Engineering. Brief study of the fundamental laws and conceptions of engineering thermodynamics; physical properties of gases, saturated and superheated vapors and their application to thermodynamic problems including the use of steam tables and charts; laws governing the flow of gases and vapors and their use in heat engineering; elementary steam turbine theory and practice; theoretical vapor cycles; the reciprocating steam engine; theoretical gas cycles and the internal combustion engine; theory and practice of gas compression; steam boilers, accessories and the elementary principles of combustion. Brief discussion of the principles of refrigeration, heat transmission and humidity problems; also the principal apparatus and machines involved.

2·411. Heat Engineering. For students who have taken thermodynamics or heat engineering but whose preparation is not sufficient to cover 2·403 and 2·421.

Mechanical Engineering Continued

2·42. HEAT ENGINEERING. Steady-state heat transfer through resistances in series and between flowing streams. Reciprocating steam engines and turbines, power-plant cycles, the air standard cycle of the internal combustion engine, an introduction to the thermodynamics of chemistry, heat and power from combustion, gas turbine processes, and a brief discussion of the principles of refrigeration. Keenan, *Thermodynamics;* Keenan and Keyes, *Steam Tables;* Keenan and Kaye, *Gas Tables.*

2·421. HEAT ENGINEERING. Expansion of 2·42 designed for students with elementary preparation in heat transfer and thermodynamics of chemistry.

2·422. HEAT ENGINEERING. Power-plant cycles, introduction to the thermodynamics of chemistry, refrigeration, heat and power from combustion, gas-turbine processes, laboratory exercises in heat engineering. Keenan, *Thermodynamics;* Keenan and Keyes, *Steam Tables;* Keenan and Kaye, *Gas Tables.* (Primarily for selected Officers of the U. S. Navy and Coast Guard.)

2·43. HEAT ENGINEERING. Heat transfer comprising steady-state and unsteady-state conduction, analogies between heat transfer and momentum transfer, convection, correlations of experimental data, radiation, and applications. Mass transfer comprising molecular diffusion in gases, liquids, and solids, eddy diffusion, analogies, correlations of experimental data, and applications. McAdams, *Heat Transmission.*

2·44. DESIGN PROBLEMS IN HEAT ENGINEERING. Applications of principles of thermodynamics, fluid mechanics, heat transfer, and mass transfer to designs, and possible construction of equipment used in heat engineering. Emphasis on creative work.

2·451. ADVANCED ENGINEERING THERMODYNAMICS (A). First and second laws of thermodynamics, their applications to simple systems and to flow processes; partial differential relations for the pure substance; the relation between pressure, volume, and temperature and its development; thermodynamics of chemical reactions; the equilibrium constant; availability.

2·452. ADVANCED ENGINEERING THERMODYNAMICS (A). Continuation of 2·451. Binary mixtures and rectification; the criteria of equilibrium; equilibrium of a pure substance; supersaturated vapor and super-heated liquid; chemical equilibrium; thermodynamics of coupled flows.

2·453. ADVANCED PROJECTS IN THERMODYNAMICS (A). Selected subjects of current interest in thermodynamics, including the relationship between thermodynamics and other sciences such as mechanics of materials, statistical mechanics, kinetic theory, and quantum theory. No formal lectures; assigned reading or experiment arranged on an individual basis in consultation with instructor.

2·46. STATISTICAL MECHANICS. Review of thermodynamics. Quantum mechanical concepts. Atomic and molecular energy levels. Most probably distribution. Calculation of thermodynamic functions. Equilibrium constants. Black body radiation. Elementary considerations of kinetic theory. Mean free path. Transport properties.

2·47. AIRCRAFT PROPULSION. Review of compressible flow. Application to analysis and design of gas turbines, rockets and ramjets. Consideration of limitations on performance imposed by thermodynamics, fluid mechanics, and strength.

2·48. GAS TURBINES. Principles of fluid mechanics, thermodynamics, strength of materials and machine design applied to the synthesis and design of turbomachinery with particular emphasis on the gas turbine. Group design project of a gas turbine for a particular application. Emphasis on the engineering compromises necessary in the development of a successful engine.

2·49. ADVANCED FLUID MECHANICS (A). Statics. Continuity and momentum relations for continuous fluids. Kinematics of fluid motion. Governing equations for motion of non-viscous fluid. Vorticity and circulation. Kelvin's theorem. Helmholtz' theorem. Stream function. Potential flow. Conformal transformation. Theory of lift. Navier-Stokes equation for motion of real fluids and applications. Boundary layer theory. Turbulence. Drag. Applications to fluid machinery, propulsion systems, process industries, and aerodynamics.

2·491. COMPRESSIBLE FLUID MECHANICS (A). One-dimensional compressible flow, with effects of area change, friction, heat transfer, combustion, gas injection. Supersonic diffusers and wind tunnels. Compression shocks. Method of small perturbations for subsonic and supersonic flow. Method of characteristics for supersonic flow. Hodograph methods. Unsteady wave motion in gases. Experimental methods.

2·492. ADVANCED TOPICS IN FLUID MECHANICS (A). Selected subjects of current interest in incompressible, subsonic, transonic, supersonic and hypersonic flow. Friction and heat transfer in the compressible boundary layer. No formal lectures; assigned reading and special problems arranged on an individual basis in consultation with instructor.

2·50. HEAT TRANSFER. Steady and unsteady state conduction; natural and forced convection; heat exchangers with steady and intermittent flow; batch heating processes; solidification; radiation from solid surfaces and gases; errors in pyrometry. Laboratory work as a supplement to lectures.

2·521. ADVANCED HEAT TRANSFER (A). Steady state and transient state conduction problems are solved for various constant and fluctuating boundary conditions. Problems in rectangular, cylindrical and spherical coordinates are considered. Study of thermal stresses resulting from non-uniform temperature distribution. Solution of the differential equations are accomplished by formal mathematics, relaxation method, potential field mapping, method of images, and methods of analogy.

2·522. ADVANCED HEAT TRANSFER (A). Radiation from luminous and non-luminous gases. Review of analogies among heat transfer and friction and mass transfer. Free and forced convection from theoretical and experimental viewpoint. Heat transfer coefficients at high velocities. Heat transfer-friction relationship in heat exchangers. Film and dropwise condensation. Boiling with forced and natural convection.

2·53. HEAT MEASUREMENTS. Selected experiments with laboratory investigation of problems connected with the industrial application of heat such as thermal conductivity, thermal expansion, specific heat, ceramics, etc.

2·56. POWER PLANT ENGINEERING. Discussion of the Steam Power Plant for the generation of electric power together with the production of steam for industrial processes. Emphasis placed on the thermodynamic, economic, and operating problems involved in selecting the prime movers and auxiliary equipment. Lectures supplemented by laboratory work and a trip to a neighboring power station.

2·57. ADVANCED POWER PLANTS (A). Modern power plants, including a study of the design and installation of high pressure boiler, economizers, air preheaters, modern fuel burning furnaces and automatic combustion controls. Study of the various steam cycles and types of auxiliary drive to show their effect on station heat balance. Discussion of deaërators, evaporators, condensers, heater, etc., including turbine and machinery foundations and layouts. Lectures and problems supplemented by trips.

2·601, 2·602. FOOD ENGINEERING. Brief survey of the fundamental principles of thermodynamics with specific application to problems in heat transfer, refrigeration, and air conditioning as they are related to food processing. Discussion of methods, materials, and equipment used in the preparation and handling of foodstuffs including canning, packaging, and bottling equipment Laboratory work as a supplement to lectures.

2·621. REFRIGERATION. Discussion of refrigerating cycles. Refrigeration at more than one level. Operation and ratings of various types of compressors, evaporators, condensers, and automatic controls used in commercial refrigerating systems.

Mechanical Engineering Continued

Heat flow problems in condensers, evaporators, and cooling towers.

2·641. Refrigeration Engineering (A). Study of thermal, physical, and toxic properties of the chief refrigerants. Discussion of the time required to freeze ice and frost formation. Refrigeration at low temperatures. Application of refrigeration to skating rinks, shaft sinking, petroleum, breweries, the manufacture of ice cream, the manufacture of dry ice, and plant design.

2·642. Low Temperature Refrigeration (A). Thermodynamic processes for producing low temperature refrigeration. Problems of heat exchangers, insulation and rectification. Applications of low-level refrigeration to the purification of industrial gases such as oxygen, nitrogen, hydrogen, methane, etc.

2·661. Heating and Ventilation. Thermal balance in the human body in relation to the thermal balance in a surrounding building enclosure. Thermal relationships of the building to climate and weather. Insulation of the building to provide a suitable enclosure. Techniques of heating, heat generation and their control.

2·662. Heating and Ventilation. Continuation of 2·661. Ventilation and its techniques together with discussion of the fundamental problem and techniques of cooling for comfort.

2·663. Air Conditioning. Study and calculation of load, direct and indirect heating systems, heating boilers and water heaters, ventilation and the fundamentals of air conditioning.

2·664. Applied Refrigeration. Application of refrigeration to air conditioning and the storage and transportation of food. Cold storage construction and insulation, load estimates, commercial refrigeration, quick freezing and transportation refrigeration.

2·671. Advanced Air Conditioning (A). Psychrometric and comfort data with application to air conditioning problems. Typical air conditioning equipment and controls will be studied with their application to various types of problems.

2·68. Engineering Laboratory. The general mechanical engineering laboratory for Course II seniors. Focus on principles of engineering measurement: determination of properties; dynamometry; flow metering; similarity; research methods; applications of The First Law. Exercises embodying these elements, providing contacts with representative mechanical engineering apparatus and an introduction to the elements of report writing. Project investigations of some depth pursued by small student groups during the final period of several weeks.

2·681. Engineering Laboratory. Survey of representative mechanical engineering apparatus for students who do not take 2·68. Basic units of study on steam power, fluid dynamic machinery, and positive displacement machinery with supplementary exercises on heat transfer, refrigeration, and miscellaneous equipment.

2·685. Applications of Statistics to Mechanical Engineering. Probability. Frequency distributions of one variable and functions of variables. Confidence limits for a future single observation and for the median of the population based on small samples. Presentation of statistical answers to problems suggested by the students from their other work. Demonstration of the usefulness of statistics in planning experiments, interpreting data, and making predictions from data.

2·693. Refrigeration and Air Conditioning Laboratory. Experimental work involving application and research problems in air conditioning and refrigeration; with equipment including standard condensing units, air washer, heating and cooling coils, constant temperature rooms, and equipment of special design. Facilities available for the use of more than one refrigerant.

2·70. Creative Thinking. Study of the general area of the psychology of thinking and of creative and imaginative thinking in particular. Areas of perception, concept formation, learning and problem solving. Two hours of lecture and one hour of recitation each week. Assignment of many problems to help the student develop the sensitivity, originality, and flexibility essential to creative work in the fields of science and technology.

2·701. Machine Drawing. Study of the development of a typical machine in an engineering drafting room from the design phase to the start of production, through participation in the preparation of detail and assembly drawings of small machines of exemplary design. Introduction to machine design by participation in drafting procedure, analysis of good design practice, accumulation of vocabulary of basic machine elements, and the consideration of problems of production. Development of several complete projects in detailing and design layout, employing professional techniques around proven machines on the current market.

2·711. Product Design. Introductory subject offered in place of 2·701 for a limited number of students who have had considerable previous training in engineering drawing. Seminar discussion of some of the elements of product design with laboratory work on relatively simple case studies. Considerable emphasis on development of the student's perception of space relationships and his ability to express these relationships in two and three dimensions.

2·73. Machine Design. Lectures, drafting-room exercises, and a design project covering the kinematic design of the basic mechanisms. Introduction to dynamics of machine elements. Sloane, *Engineering Kinematics*, and supplementary notes.

2·731. Machine Design. Original design by each student of a simple high performance *machine* demonstrating the applicability of previous fundamental studies in the synthesis of the device. Statement by each student of the required function of a mechanism, its innovation with necessary analyses and integration into a finished design, taking into consideration such things as form, utility, cost and reproducibility. Small groups, with active guidance from staff members professionally competent in design. Corollary lecture material from basic consideration of design criteria for major machine elements, gears, shafts and bearings. Case studies illustrating roles of analytical, experimental, empirical, and intuitive phases of design.

2·732. Machine Design. Demonstration of the analytical approach to machine design by detailed study of a variety of intermittent motion devices such as cams, linkages, and index devices including consideration of kinematics, dynamics, and materials limitations. Study of energy conversion, control and utilization in design including electrical, mechanical, hydraulic and pneumatic examples. Problems of a professional design caliber encouraging ingenuity and developing ability to formulate useful analytical expressions from broad problem statements.

2·734. Creative Engineering. Emphasis on the role of imagination in problem solving, demonstrating at the same time that a delicate balance between analysis, synthesis and evaluation must be established and maintained for creative activity. Work primarily, although not exclusively, in the field of Product Design. Solution of case studies by design of new products or improvement of old ones to provide increased function, higher performance level, lower cost and greater saleability. Combination of laboratory and seminar work. Limited in registration.

2·735. Creative Engineering. Continuation of 2·734 with introduction to and emphasis on new concepts in the field of human engineering or biotechnology. Seminar on the role of the comprehensive designer with laboratory work on case studies covering a broad range of human activity.

2·751. Systems Design (A). Study of many types of physical systems in engineering design. Consideration of static and dynamic characteristics under various operating conditions. Use of free body and block diagrams together with simplifying assumptions to define and understand significant system variables. Selection of components for an integrated system design with the aid of analytical, graphical, and analog techniques. Lectures and problems on mobile and stationary energy converters, industrial processes and

Mechanical Engineering Continued

machines, instrumentation, transmission and storage of energy and information, networks and structures, and miscellaneous types of converters and transducers.

2·78. Hydraulic Machinery and Controls. Theory and design of oil hydraulic machinery and its applications in industry. Discussion of problems in the control and measurement of pressure, flow, speed, position, torque, and power. Consideration of the matching of load to prime power source. Application of basic principles to hydraulic system design problems, use of schematic and block diagrams, introduction to analog computation, and working on selected laboratory projects.

2·782. Automation I. Discussion of the problems associated with the automatic control of machines and processes. Some factors which influence the most effective design of man-machine systems. The engineer's approach to the analysis of feedback control system behavior based upon transient and frequency response techniques. Criteria of stability. The extension of methods to the treatment of systems in which non-linearities occur, when such extension yields usable results. Emphasis on the analogous behavior of a wide variety of physical systems.

2·783. Problems in Automatic Control (A). General theory of automatic control. Applications to advanced problems in the control temperature, pressure, flow, speed and position control. Studies of the dynamics of industrial processes and physical systems. Use of analytic techniques in the design of systems for high dynamic performance. Considerations of some elements widely used in industrial control systems.

2·784. Instruments for Measurement and Control (A). Presentation of basic concepts and principles important to the design and use of instruments for measuring various physical quantities. Analysis of dynamic behavior of instruments as elements in complex control systems. Detailed presentation of typical examples of digital as well as continuous types of instruments and control system components. Discussion of problems connected with signal amplification, remote indication, transmission and storage.

2·79. Elementary Internal Combustion Engines. Fundamentals of the internal combustion engine, including spark-ignition and compression-ignition cycles. Discussion of combustion, friction, cooling, carburetion, and other factors affecting power, efficiency, and general performance. Selection of the most suitable type of engine for various specific applications. Rogowski, *Elements of Internal-Combustion Engines.*

2·791. Internal Combustion Engines. Fundamentals of spark ignition and compression ignition engines, including thermodynamic cycles, combustion, efficiency, capacity and friction. Taylor and Taylor, *The Internal Combustion Engine.*

2·792. Internal Combustion Engines. Continuation of 2·791. Carburetion, cooling, supercharging, performance estimation, engine balance, stresses and materials. Application of engine theory to rational design procedure. Taylor and Taylor, *The Internal Combustion Engine.*

2·7941. Internal Combustion Engine Laboratory. Laboratory exercises supplementing the classroom work of 2·791. Effects of operating and design variables on engine performance and use of instruments with special emphasis on precision of measurements.

2·7942. Internal Combustion Engine Laboratory. Continuation of 2·7941. Laboratory work of a more advanced nature leading to a final experimental project.

2·797. Internal Combustion Engines, Advanced (A). Analytical approach to problems of the Diesel engine, gasoline engine, and other types. Consideration of fluid flow, thermodynamics, combustion and performance included. Preliminary design computations made on particular engine type chosen by student. Taylor and Taylor, *The Internal Combustion Engine*, revised edition, 1948.

2·798. Internal Combustion Engines, Advanced (A). Continuation of first-term subject. Analysis of problems connected with friction, lubrication, fuel injection, supercharging, balance, torsional vibration, detail design of parts. Continuation of design computations begun in first term.

2·80. Automotive Vehicles. Analytical approach to vehicle performance, spring suspension, transmission, brakes, etc. Study of a special problem related to vehicle design by each student.

2·801, 2·802. Special Problems in Internal Combustion Engines (A). Selection of a particular problem by student on which he works independently but under guidance of instructor. Problem may be in field of gas turbines or reciprocating engines or motor vehicles. Work summarized in written report.

2·82. Combustion. (A) Theoretical and experimental treatment of combustion and explosion processes. Thermal and branched-chain explosions. Reaction kinetics. Theory of flame propagation. Flame stabilization. Combustion and detonation waves. Diffusion flames. Ignition by electric sparks and other sources. Problems in engineering combustion processes.

2·83. Research in Combustion (A). Selected analytical or experimental problems in combustion, such as flame propagation, flame instability and stabilization, ignition, limits of inflammability, burning of fuel droplets, diffusion flames, combustion in rockets and engines, etc. Work arranged on an individual basis in consultation with instructor.

2·85. Introduction to Machine Tools. General discussion of the uses, capabilities, and characteristics of the basic machine tools of industry. Practical laboratory exercises in key machining operations of turning, milling, shaping, drilling and tapping, reaming and boring, and cylindrical and surface grinding. Use of automatic and special purpose equipment. Introduction to quality control and the use of inspection and precision measuring apparatus. Surface roughness and nature of finished surfaces. Designing for manufacture; relationship between tolerance and cost. The use of operation sheets and the principles of estimating. Smith, *Advanced Machine Work.*

2·851. Machine Tool Laboratory. Use of basic machine tools, including straight and taper turning, chucking, boring, screw cutting, cylindrical and surface grinding, lay-out work, drilling, reaming, counterboring and tapping, shaping, milling and gear cutting. Use of inspection and precision measuring equipment. Smith, *Advanced Machine Work.*

2·853. Principles of Metal Cutting. Basic mechanics of the cutting process. Influence of physical properties of work and tool materials upon their cutting characteristics. Thermodynamic conditions at the point of a cutting tool. Importance of friction in the cutting process; role of cutting fluids in facilitating the removal of metal. Nature of the surface produced: surface finish, residual stresses and surface damage. Application of principles to special problems in turning, milling, drilling, grinding and polishing. Survey of current technical literature and special topic assignments. Demonstrations of selected current laboratory techniques.

2·855. Theory of Metal Cutting (A). Application of the principles of solid state physics, plasticity and strength of materials to the cutting process. Theory of friction and of cutting points and the chemical and thermal aspects of cutting fluid action. Residual stress, surface damage and the structure of machined surfaces.

2·858. Research in Machine Tools and Metal Cutting (A). Opportunity for the student to work in the Machine Tool or Metal Cutting Laboratories on a research problem in a representative area such as: the mechanics of cutting and chip formation; fundamentals and problems associated with the grinding, milling, turning, drilling, or planing processes; residual stresses produced in machining; vibrations in machine tools; precision measurements and surface finish; time and motion study; machine tool evaluation; preliminary design of a machine tool with special field of application.

2·859. Manufacturing Technology. Historical background and organization of machine tool and mass production manufacturing activities. Characteristics, field of application, and limitations of present manufacturing methods.

Mechanical Engineering Continued

Product design for manufacture. Plant layout and planning. Machine tool construction and performance including frame design and rigidity, power transmission and control, machine tool vibrations, and maintenance and safety considerations. Special tooling problems including holding, guiding, and indexing devices. Product evaluation including gaging and quality control. Problems associated with the human element in manufacturing.

2·86. Machine Tool Fundamentals. Mechanism of chip formation and importance of such items as: tool geometry, physical properties of metal cut, and friction between chip and tool, with regard to tool design and performance. Metallurgical aspects of machining, cutting demonstrations and exercises involving metal cutting dynamometers and thermoelectric apparatus. Application and limitation of current manufacturing processes. Manufacturing economics including selection of equipment. Industrial organization and personnel problems associated with manufacturing.

2·901, 2·902. Principles of Fabric Structure. Discussion of the properties of fibers as related to the properties of yarns and fabrics; properties of yarns as related to fabrics; construction and finishing of fabrics to produce certain desirable characteristics in these materials. Material dealing with principles of woven fabric structure together with the formation of knitted, braided, twisted, and felted materials.

2·903. Elements of Textile Manufacturing. Production and properties of textile raw materials and operations basic to the manufacture of cotton, wool, silk, flax, jute and rayon.

2·904. Principles of Textile Manufacturing. Continuation of 2·903 covering the combination of operations such as blending, carding, combing, drafting, twisting, etc., into processes as for cotton, woolen, worsted, spun and thrown filament, and bast fiber materials; involving mill organization studies and plant inspections.

2·905. Textile Engineering Analysis (A). Analytical approach to problems of textile materials, textile processes and their interaction. *Fiber rheology:* principles of elasticity, viscoelasticity, creep and relaxation, time-temperature effects, static and dynamic testing. *Textile structures:* differential geometry of twisted yarn, translation of fiber properties into yarn structures, role of fiber variability. *Process statistics:* probability theory, mathematical expectation, large number theory, statistical distributions. *Process dynamics:* opening processes, carding mechanisms and dynamics, combing systems, kinematics of winding.

2·906. Textile Engineering Analysis (A). *Fiber rheology:* molecular structure of fibers, bond strength, dependence of mechanical properties on structure, discussion of X-ray, infra-red and electrical measurements. *Textile structure:* cloth geometry, interaction of yarn and fabric structures, mechanical behavior of woven and knitted materials, flow through porous textiles. *Process statistics:* product irregularity, drafting statistics, breakage probabilities. *Process dynamics:* analysis and synthesis of ring spinning mechanisms, balloon dynamics, traveller-ring interaction, spindle vibration, dynamics of weaving.

2·907, 2·908. Textile Microscopy (A). Application of optical and microscopical equipment to technical analysis of textiles. Lectures and laboratory on the types of equipment, their use and the technique of textile microanalysis for fiber, yarn and fabric. Opportunity for intensive research on projects involving quantitative determinations; development of technique; application of photomicrography, polarized light, fluorescence, swelling technique, etc., to textile microscopy. Schwarz, *Textiles and the Microscope; Library References.*

2·911. Textile Research Laboratory (A). Introduction to modern instrumentation used in textile research. Emphasis on engineering and statistical planning of experiments, analysis of test mechanisms, interpretation and presentation of results.

2·912. Textile Research Laboratory (A). Application of the research group method to the solution of textile behavior problems.

2·913, 2·914. Textile Technology Seminar (A). Opportunity for students and staff members to present critical discussions of important problems in fiber technology, textile analysis and textile microscopy together with reviews of the current literature, and the results of researches in these fields at the Institute.

2·93. Experiment Planning and Analysis (A). Designed to acquaint the technologist with the philosophy and methods underlying the design and interpretation of experiments and the presentation of results. Choice of variables, selection of specimens, size and type of experiment, presentation of data in the form of tables, charts, graphs, and equations, statistical analysis of variable data, comparisons of two or more things subject to interactions, correlation, and the interpretation of quality indices.

2·951, 2·952. Industrial Practice. Approximately six months of practical work carried out by the cooperative students in manufacturing, engineering, research, and developments at the plants of the organizations participating in the cooperative program.

2·991, 2·992. Mechanical Engineering Seminar (A). Presentation of special topics in mechanical engineering and related fields intended to develop the student's ability to summarize a topic orally and take an active part in the discussion and criticism of such presentation.

METALLURGY

Subjects 3·00 to 3·99

3·00T. Extractive Metallurgy. Introduction to the processing by which ores and minerals are transformed into metals or semi-finished mineral products. Separation of one phase from another, as of a solid from a liquid, a liquid from a liquid, or of one solid from another; frequently involving preparatory mechanical and chemical changes in the matter under process to make the separations go as desired. Study of the principles of a selected group of processes, and the integration of unit operations into complete industrial processes.

3·01. Metallurgical Engineering I. Extractive metallurgy considered as a series of unit operations, involving physical separations, and unit processes, involving chemical reactions or changes in state. Treatment of the engineering fundamentals of unit processes. Metallurgical stoichiometry and thermo-chemistry. Material and heat balances. Fuels and combustion. Fluid flow and heat transfer. Metallurgical furnaces. Introduction to the physical and chemical bases for phase separation in unit processes.

3·011. Metallurgical Engineering Laboratory I. Laboratory experiments to acquaint the students with apparatus of measurement and to illustrate engineering principles underlying the processes of extractive metallurgy.

3·02. Metallurgical Engineering II. Fundamental study of the unit processes of extractive metallurgy. Stoichiometric and thermodynamic treatment of some simplified unit processes. Consideration of apparatus requirements as to design and operating variables. Gas-solid processes such as drying, roasting, and reduction of metal oxides; simple smelting and blast furnace smelting; converting and distillation processes; refining processes; electro-metallurgical processes; kinetics of unit processes.

Metallurgy Continued

3·021. Metallurgical Engineering Laboratory II. Laboratory exercises to illustrate the significant variables in typical metallurgical processes and to measure thermodynamic quantities in related chemical reactions.

3·03. Metallurgical Engineering III. Study of integrated metallurgical processes. Application of the fundamental treatments of 3·01 and 3·02 to the extractive metallurgy of the more common metals such as iron and copper, and of some less common metals such as titanium and zirconium.

3·10. Metallurgical Plant Visits. One week of metallurgical plant visits to observe the methods and equipment for the production of iron, steel, and non-ferrous metals, as well as metal fabricating processes. Meeting of students and instructor about one week before the opening of the fall term. (Restricted to students who have completed the third year of Course III).

3·11. Engineering Metals. Study of metals and alloys emphasizing the effect of composition and mode of fabrication on their structure, properties, and engineering uses including fundamentals of constitution diagrams and heat treatment. Survey of corrosion and its control; magnetism and magnetic alloys; electrical conductivity and conductors, resistors, and semiconductors. Laboratory work on casting, welding, and working.

3·113. Engineering Metals. Same content as 3·11 omitting laboratory.

3·12. Metal Processing. Theory and practice of metal fabricating processes embracing recent developments in casting, hot and cold forming and joining.

3·13. Foundry Engineering. Theory and modern development of ferrous foundry processes. Sizing, grading and handling of mold materials, flow and solidification of molten metal, heat flow in mold and metal, and gases in metals as related to the production of sound castings. Standard and new methods of molding, melting, alloying, gating, risering, cleaning, cutting, testing and inspection. Comprehensive treatment of casting design.

3·15. Welding Engineering. Detailed treatment of the joining of metals by brazing, and by gas, atomic hydrogen, helioarc, resistance and thermit welding; studies of stress concentration and stress relief, inspection and testing, engineering design and metallurgical aspects of the subject.

3·16. Powder Metallurgy. Introductory survey of the manufacture of metal powders and products. Physical and chemical methods for the production of finely-divided metals. Theory and practice of sintering, emphasizing functions of surface energy and diffusion. Study of flow sheets for the production of typical products including bearings, carbide tools, magnets, and electrical contacts.

3·18. Plastic Working of Metals. Principles of plastic deformation introduced both from the viewpoint of the physical metallurgist and the materials engineer. Principles applied to study of industrial metal forming processes, such as: wire, rod, and tube drawing; deep drawing; extrusion, rolling, and forging; die-less tension forming; shearing and metal cutting; bending. Relation of friction, wear, corrosion, and their control to the fabrication and use of metals.

3·20. Metallurgical Thermodynamics. Thermodynamics emphasizing topics useful in metallurgical operation. Free energies of substances at elevated temperatures and activities of metals in solid and liquid alloys, used in interpreting metallurgical phenomena and in determining the feasibility and limitations of metallurgical processes.

3·21. Principles of Steelmaking (A). Reactions in the manufacture of steel, studied from the viewpoint of physical chemistry. Reduction of ore, reactions of liquid iron and steel with slags and gases and the chemical effects of alloys and deoxidizing agents. Influence of melting and refining methods upon the properties of the finished product.

3·22. Thermodynamics of Metallic Solutions (A). Study of the current literature covering the entropy and energy functions in solid and liquid metallic solutions and their application to phase diagrams.

3·25. Experimental Methods in Metallurgy (A). Intended to acquaint the student with special experimental techniques and methods used in metallurgical research, such as: vacuum melting and casting; attainment of extremely high temperatures; special casting methods such as precision casting; vacuum fusion and special chemical analytical techniques; ceramic and refractory evaluation and application; optical and thermocouple temperature reading; temperature control; etc (Suggested for all new graduate students in the Department of Metallurgy.)

3·31. Physical Metallurgy I. Principles of physical metallurgy, covering such basic subjects as the characteristic properties of metals, solid solutions, intermetallic compounds and aggregates thereof; construction and metallographic interpretation of equilibrium diagrams; plastic deformation and rupture of metals; phenomena of recovery, recrystallization and grain growth; kinetics and mechanism of phase changes in the solid state. Commercial non-ferrous alloys used as a basis of discussion wherever possible.

3·32. Physical Metallurgy II. Continuation of 3·31, using iron, steel and ferrous alloys to illustrate principles of physical metallurgy. Ternary phase diagrams, metastable equilibrium, theory of nucleation and growth applied to phase transformations, martensitic reactions, heat treatment of steel, hardenability, quenching and transformation stresses, surface hardening, properties and uses of iron-base alloys.

3·33. Physical Metallurgy III. Lectures and laboratory conferences on applications of metallography to industrial problems. Examination of microstructures of normal and defective commercial alloys. Critical résumé of the fundamentals of modern physical metallurgy essential to the proper interpretation of the microstructures.

3·34, 3·35. Advanced Physical Metallurgy (A). Advanced treatment of important subjects within the general field of physical metallurgy, including stable and metastable alloy systems, thermodynamics of solid solutions, atomic arrangements in solid solutions, diffusion, nucleation and growth, phase transformations (precipitation, eutectoid decomposition, martensitic reactions, order-disorder transitions), dislocation theory, grain boundary phenomena, recrystallization and grain growth, crystal elasticity and plasticity, anelastic phenomena. Emphasis on the more recent publications covering these topics.

3·38, 3·39. Advanced Physical Metallurgy. Fundamental properties of metals and alloys with particular reference to materials used in torpedo construction. (Primarily for selected officers of the U. S. Navy.)

3·391, 3·392. Properties of Metals. Metallurgical properties of metals and alloys with reference to materials used in ship construction. The making, microstructure, processing, heat treatment, joining and corrosion resistance of non-ferrous and ferrous alloys. (Primarily for selected officers of the U. S. Navy and Coast Guard.)

3·396. Technology of Nuclear Reactor Materials. Description of physical and nuclear requirements of materials which may be used in reactors. Discussion of metallurgical processes and techniques required to handle these materials, followed by detailed study of uranium, beryllium, graphite, etc.. Examination, from a materials viewpoint, of general problems such as heat removal, radiation damage, power generation, and breeding.

3·42. Electrochemistry. Emphasis on fundamental principles of electrochemical theory, with illustrations of their applications in practice. Discussion of electroanalysis, electroplating, electrowinning of metals, primary and secondary cells, electrophoresis, alkalichlorine production, and related processes.

3·43. Corrosion (A). Theories of corrosion; general principles of corrosion control; selection of metals for use at low and high temperatures. Corrosion testing.

3·44. The Behavior of Metals at Elevated Temperatures (A). Study of metal and alloy behavior at temperatures at or above the recrystallization temperature (or equi-cohesive temperature). Correlation of alloy preparation variables with

Metallurgy Continued

the structure and properties of the alloy. Study of the pertinent binary systems prominent in heat resistant alloys. Quantitative evaluation of the present heat resistant alloy field.

3·50. X-ray Metallurgy. Use of X-rays in the study of metals. Radiographic examination of metal parts, X-ray diffraction study of the structure and texture of metals.

3·51. Physics of Metals. Modern theories of the metallic state and their relations to the physical properties of metals.

3·52. Advanced Physics of Metals (A). Various problems of the crystalline metallic state and the dependence of physical properties upon structure. Laboratory work in the form of short research problems. A continuation of 3·51.

3·53. Advanced X-ray Metallurgy (A). Conferences and laboratory work covering all of the important X-ray diffraction techniques used in the study of metallic structures.

3·54. Radiographic Inspection. Theory of the radiographic problem and the application of X-rays and gamma rays to industrial radiographic inspection. Consideration of X-ray and gamma ray sources, the formation of the X-ray image, method of recording the image and a detailed treatment of the problems of contrast, definition, and sensitivity. Questions of industrial specification based on radiographic inspection and the cost of such inspection on an industrial basis. Laboratory experiments to demonstrate the practical techniques for the inspection of weldments, castings and assembled devices.

3·61T. Electric and Magnetic Materials. Relationship of the physical basis of the electric and magnetic properties of metals, semiconductors, and ceramics to the structure of the material. Effects on these properties arising from imperfections, impurities, domains, grain boundaries, and subboundaries.

3·62, 3·63. Special Problems in Metallurgy (A). Minor investigation in one of the special branches of metallurgy. Open only to graduate students properly qualified in the special field.

3·70. Ceramics. Introduction to the more advanced ceramic subjects. Selection of ceramic materials, molding, drying and burning, as well as the physical properties of finished products.

3·701. Ceramics Laboratory. Laboratory work to accompany 3·70T with commercial processes carried out on a small scale.

3·71, 3·72. Ceramics Seminar (A). Selected topics in Ceramics, varying from year to year, presented by the students and staff, each topic being of group interest and followed by group discussion.

3·73. Fundamentals of Ceramic Processes I (A). Principles concerned with raw materials, forming, drying, melting, firing and decorating in the ceramic industry.

3·74. Fundamentals of Ceramic Processes II (A). Application of ceramic principles to the manufacture and testing in the fields of glass, whitewares, refractories, abrasives, heavy clay products, and enamels.

3·75, 3·76. Special Problems in Ceramics (A). Advanced work in this field. Time devoted to lectures, conferences, assigned readings, or laboratory work.

3·77T. Advanced Ceramics Laboratory (A). Fundamentals underlying ceramic processes demonstrated by illustrative experiments.

3·79. Advanced Ceramic Products (A). Treatment of various subjects concerned with the thermal, mechanical, optical, electrical, and magnetic properties of ceramic products, including recent publications on these topics. Effects of composition and microstructure on properties.

3·81. Mineral Engineering I. Introduction to the preparation for further metallurgical treatment or direct use of mineral substances from the unit-process and unit-operation points of view. Subject designed to give an idea of operations and processes employed to utilize solid fuels, ores, and minerals and to extract metals from low grade ores. Limited number of laboratory exercises to illustrate the more important principles and to teach the student useful experimental techniques of general applicability to fields of mineral engineering and metallurgy.

3·82. Mineral Engineering II. Study of unit operations used in the separation of valuable minerals from the worthless material in the ore as mined. Special emphasis placed on the physical principles involved and their importance to sound engineering design. Discussion of principles relating to particle size distribution, surface area determinations, fracture of brittle material, energy distribution during comminution, and the hydrodynamical behavior of solid-liquid systems. Unit operations covering comminution, screening, classification, thickening, filtration, gravity concentration, and magnetic separation.

3·83. Mineral Engineering III. Physical-chemical and surface chemical principles which characterize the flotation and leaching processes. Application of these chemical principles to typical flotation and leaching systems. Physical variables affecting operation and design of continuous flotation and leaching circuits. Laboratory exercises on the important variables in typical mineral engineering problems illustrating small-scale testing of industrial operations. Laboratory work on material covered in this subject and 3·82T.

3·85. Quantitative Mineragraphy. Illustration of the usefulness of microscopical investigations of opaque and non-opaque minerals and other important laboratory techniques in the quantitative appraisal of a specific mineral engineering operation. Preparation for microscopic study of products from an actual operation by use of laboratory techniques such as sizing, heavy liquid separation, isodynamic separation, and briquetting. Microscopic identification of the minerals and evaluation of the degree of liberation of the ore mineral. Laboratory work supplemented by lectures on the elements of optical mineralogy.

3·86. Quantitative Mineragraphy (A). Advanced course in mineragraphy in which the quantitative approach is stressed.

3·87. Ore Testing. Practice in choosing concentration methods for specific ore samples, in developing laboratory testing technique, and in preparing reports.

3·89. Mineral Dressing Design (A). A specific problem in mill design, covering the development of the quantitative flowsheet and the drawing up of specifications for and the general arrangement of, the equipment. Taggart, *Handbook of Mineral Dressing.*

3·90. Advanced Mineral Engineering (A). Informal discussion of topics selected according to the needs of the students. Examples of suitable topics: application of fluid mechanics to gravity concentration, of physical chemistry to flotation, of colloid chemistry to flocculation and thickening, of elasticity and plasticity to comminution.

3·901. Advanced Mineral Dressing Laboratory (A). Study of an ore, a process, or a machine in the field of mineral dressing.

ARCHITECTURE AND PLANNING

SUBJECTS 4·00 TO 4·99

4·00. STRUCTURE OF THE CITY. Lectures, field trips, and reading program to familiarize students with their physical environment; to suggest some of the means for its improvement; and to sharpen observation and the sense of design. Greater Boston as an example of urban structure, with attention to its historical development, its current physical problems, and future possibilities of its industry, commerce, living areas, public institutions, and related services.

4·02. FORM AND DESIGN. Study of visual and structural form in the areas of design where art, science and technology are interdependent. Studio and shop experiments to teach the student the proportion of spaces, scale, shape, volume, structure, texture, line, plane or color. Emphasis on imagination, materials, and techniques directed to enlarge the individual's capacity to create an aesthetic form.

4·04. LIGHT AND COLOR. Physiology and psychology of light and color as employed by the creative artist combined with studio work in the application of this knowledge to the opportunities for visual satisfaction in architectural design.

4·051, 4·052. GRAPHIC PRESENTATION. Lettering, typographical layout, photomontage, collage, charts, diagrams, posters, etc. PHOTOGRAPHY. The study of light as a creative medium; photographic observation of surfaces, textures and structures. Documentation of subjects relevant to students of architecture.

4·06. ADVANCED VISUAL DESIGN (A). Studio projects in areas such as the following: — the visual arts as elements in an architectural setting; visual communication through exhibition design, posters, and architectural use of lettering and signs; visual documentation, or the presentation of environmental situations and ideas by graphic means.

ARCHITECTURAL DESIGN. The sequence of undergraduate subjects in Architectural Design provides cumulative experience with a large number of design problems, ranging over the whole field of architectural practice. In general, each problem is presented as a design situation in a complete context; it requires an evaluation of all pertinent factors of site, climate, purpose and social setting, and provides scope for the application of the student's growing knowledge of materials and building techniques, his skill in arranging space, his sense of relative values, and his artistic sensitivity. This learning by doing is reinforced by class discussions, individual and group criticism, and exhibition and evaluation of completed work. Through a combination of collaborative and individual tasks, the student learns the value of cooperative effort as well as the responsibility for independent creative work. The objective of the sequence, culminating in the thesis, is to inculcate attitudes and methods applicable to any architectural problem. While at all times the need for a broad view of all design considerations is stressed, the several successive terms focus in different ways on major areas of emphasis.

4·11. ARCHITECTURAL DESIGN. Use of small-scale problems of familiar subject-matter to establish the basic concepts of architectural order through harmonious relationships between use and form, building and land, structure and space, materials and appearance. Emphasis on acquisition of skill in the conventional methods of representing architectural form with orthographic, perspective, and freehand drawing and by models.

4·131, 4·132. ARCHITECTURAL DESIGN. A series of projects for simple buildings to develop as rapidly as possible awareness of the principal issues facing the contemporary architectural designer and the range of possibilities available to him for effective satisfaction of the common environmental needs of our culture. Work on separate building units with definitely stated use patterns with ample opportunity for experimental study of appropriate structural systems and search for the uses of building materials most expressive of their physical properties.

4·141, 4·142. ARCHITECTURAL DESIGN. Introduction of problems arising in connection with more complex plan organization, the grouping of buildings, buildings of multistory construction, mass circulation movements, and areas requiring specialized space forms or equipment or having multiple uses. Proposal of solutions in terms of techniques, such as mass production, influencing building construction. Consideration, from time to time, of the thermal problems of buildings, the distribution of daylight and artificial light, and the control of sound in buildings as they influence the design concepts and also in the proportions, materials, and special installations associated with them.

4·151, 4·751. ARCHITECTURAL DESIGN. In the final term of design, emphasis on the setting of architectural work as part of an organized community in projects having to do with built-up areas as well as those on new sites. Study of plans for long-range development giving students increasing experience in the analysis of real-life situations requiring program research. (4·151 not offered 1956–57.)

4·161, 4·162. ARCHITECTURAL DESIGN (A). Concentration of project work on areas of architectural expression which have been most inadequately resolved in contemporary urban life, with the aim of orienting the mature student toward a serious contribution to some of these problems. Exploration of the full implications of the subject under study through organized group-research and seminar activity leading to individual and team solutions. The total work of the group available to each individual as the record of an effort to resolve an important professional issue.

4·17. ARCHITECTURAL DESIGN, SPECIAL PROBLEMS. Supplementary work in architectural design on individual or group basis. Registration subject to prior arrangement for subject-matter and supervision by staff.

4·18. COLLABORATIVE DESIGN. Project work on design problems of such nature as to benefit by collaboration between architects and city planners or between these groups and other disciplines.

4·231. REPRESENTATION. Use of graphic techniques to record or control the environment and to express ideas: freehand drawing, elementary drafting, three-dimensional models, surveying and mapping, diagrams, graphic presentation. Emphasis on the common principles underlying these techniques and their use as tools in analysis. For entering planning students without background in design fields.

4·233. REPRESENTATION. Use of drawing, mapping and representation techniques, as a means both of communication and also of analysis.

4·241. COMMUNITY PLANNING DESIGN. Planning of the physical environment on the scale of the large building group or small community. Problems in site planning, including land use and circulation planning, grouping of buildings, and design of engineering and landscape elements. Programming and design of small communities.

4·261. CITY AND REGIONAL PLANNING (A). Practical application of city and regional planning theory to towns, cities, and regions, including problems of replanning, redevelopment, and urban renewal in existing communities. Individual problems, supplemented by group projects worked out in collaboration. Work in field, library, and studio leading to written, oral, and graphic presentations.

4·262. CITY AND REGIONAL PLANNING (A). Continuation of 4·261.

4·31. STRUCTURAL ANALYSIS. Methods of analysis in design of elementary architectural structures and application of these methods to a problem in architectural design. Consideration of loads in the design of simple and continuous beams, columns and details of assembly. Analysis of a simple roof truss.

4·32. STRUCTURAL ANALYSIS. Continuation of 4·31 including analysis of building types, design of a steel framing and plate girder. Analysis and design of elementary reinforced concrete floor systems, beams, column, and footings. Application to a problem in design.

Architecture and Planning Continued

4·33, 4·34. Structures Seminar. Comparative analytical study concerned with those properties of structural systems and materials which should find a characteristic and clear formal expression in contemporary architecture.

4·41T. Architectural Acoustics. Principles of acoustical designing to achieve good hearing conditions and control of noise in rooms and buildings; design criteria; analysis of sound absorption and transmission; acoustical properties of room shapes, structures, and surface materials; laboratory demonstrations.

4·42. Special Problems in Architectural Acoustics (A). Broad study of functional acoustic design in architecture, based on project work in the fields of impedance and absorption measurement of sound-absorptive materials, full-scale study of sound distribution and diffusion in rooms, and investigation of sound transmission through building structures, conducted in the Acoustics Laboratory.

4·51. Principles of Regional Planning. Principles of regional planning, as evidenced in the study of specific regional planning programs. Emphasis placed upon the interrelationship of various civil engineering and planning problems, and the part which regional considerations play in the planning of civil engineering projects.

4·53. City Planning Theory. Historical background of the modern city planning movement, presented in a series of lectures. Evolution of the modern city and relation of architecture and engineering to problems of city development and civic design, concluding with a discussion of fundamental principles of city and regional planning.

4·54, 4·55. City Planning, Techniques (4·55-A). Advanced problems of city and regional planning, together with modern methods of dealing with them. Collateral reading, written reports, and round table discussions.

4·56. Regional Planning Seminar (A). Critical review of regional, state, and national planning experience in the United States; analysis of principal regional planning problems and investigation into significant current trends in regional planning.

4·57. Form of the City (A). The city and its components as aesthetic elements. Role of plan organization, spatial relations, symbol, silhouette, scale, view, movement, light, color, sound, detail, etc. Field observation, group projects, and seminar discussion.

4·62. Inside Architecture. Seminars on six elements of room design currently accepted, showing the sources and development of each. Evaluation of possibilities, standards, and traditions. An hour of analysis based on pictures, objects and statements by leading architects, designers and critics of the last 100 years, followed by an hour of general discussion. Examination of each element in terms of interior space organization in one seminar; in the next, in terms of products used in rooms.

4·65. History of Architecture. Introduction to architectural history. Emphasis upon the Italian Renaissance period, with study of the Ancient, Medieval and Baroque periods as well. Formal, social and philosophical studies of art and architecture. Lectures, group conferences, essays.

4·66. History of Architecture. Study of art and architecture as expressions of the period since 1750. Lectures, group conferences, essays.

4·70. Urban Sociology. Social characteristics of urban and rural communities and problems which arise in cities in connection with provision of facilities for housing, industry, government, education, recreation, and transportation.

4·71. Planning Legislation and Administration (A). Broad review of public and private legal controls over land development; development of modern planning agencies and their tools: the master plan, official map, capital budget, subdivision control, urban redevelopment and renewal, zoning, and eminent domain; legal problems involved in the attempt to provide elastic administration of legal controls through planning boards and boards of appeal; study of leading cases indicating problems faced by the courts in balancing private property interests against the general welfare of the community as a whole; comparison with planning controls employed in other countries.

4·73. Human Dimensions of Planning (A). Seminar devoted to the study and analysis of some major approaches to planning in terms of human needs and potentialities and our increasing technical resources. Discussion of psychocultural approach, field theory in planning, human communication networks, "feedbacks," human conservation, housing for family living and ethics for planners. Limited to qualified students.

4·751. See 4·151.

4·77. Housing Problems (A). Examination of the meaning and scope of housing problems. Evaluation of the market mechanism for the production of housing followed by an evaluation of still unsolved economic, social technical, design, administrative and legislative problems. Emphasis on the changing and broadening perspective of housing policy in the United States and other countries. Extensive readings.

4·78. Housing Seminar (A). Open to a limited number of students who have taken 4·541 or those students who have the equivalent experience or background. Examination of selected housing problems and research topics with guest speakers for approximately half of the sessions, and after dinner discussions on these occasions. Extensive readings and written reports.

4·81. Land Economics. Economics of the urban land market, the institutional framework within which it operates, and the resulting land use problems and issues of policy. Particular emphasis on the role of the market mechanism and other forces in patterning the structure and growth of land uses in metropolitan areas.

4·82. Land Economics Seminar (A). Study of two or three problems for intensive analysis with critical attention given to techniques for economic base studies of metropolitan and regional areas and to the historical development of the land system and policy in the United States. Preparation of two reports by each student dealing either with an economic base study, a regional land problem or an examination of the implications for land use of a normative theory of urban organization.

4·84. Land-Use Problems in Developing Areas (A). Legal and economic aspects of urbanization in several countries, such as Puerto Rico, South Africa, and India. Examination of the problems of urbanization in developing countries: drastic growth, congestion and slums, inefficient distribution of economic activities. Comparison of the legal, economic and institutional factors of metropolitan development in these countries to the experience of the United States during the nineteenth century and today. Discussion of techniques of general applicability for solving or forestalling some of these problems. Open to students from a number of fields, such as law, economics, and city and regional planning. Registration limited to 15. Preparation of papers by three to five experts on aspects of these problems for discussion with members of the seminar.

4·87. Industrial Location and Regional Development: Principles (A). Theoretical analysis of transport, labor, power and other factors affecting the location of industries. Industrial agglomeration and city formation. Structure of the space-economy and of regions. Input-output and other techniques for projecting urban and regional development.

4·88. Industrial Location and Regional Development: Problems (A). Study of location of specific basic industries such as iron, steel, and aluminum. Analysis of empirical material on industrial concentration and decentralization and on the growth and relative decline of cities and regions of the United States. Key problems and development. Impact of atomic power upon industrial location and metropolitan and world regions.

4·95, 4·96. City Planning Research (A). Selected topics in city and regional planning. Supervised study, with conferences, readings, and reports but without lectures.

4·97. Office Practice. Work in the office of a planning commission. Problems in design or research having a definite relation to the activities of the planning commission concerned with supervision at regular intervals by an instructor.

CHEMISTRY

SUBJECTS 5·00 TO 5·99

INORGANIC CHEMISTRY

UNDERGRADUATE SUBJECTS

5·01. GENERAL CHEMISTRY. Fundamental principles of chemistry: gas laws; mass and energy relationships in chemical changes; writing and the use of chemical equations for quantitative calculations; factors affecting the rate and equilibrium of a chemical reaction; correlation of equilibrium conditions through the mass-action law and the electromotive force of voltaic cells; atomic structure, chemical reactivity of elements, and the Periodic Table; chemistry of certain of the elements of groups 1, 2, and 3 of the Periodic Table. Laboratory work largely quantitative in nature and closely integrated with lectures and recitations. Latimer and Hildebrand, *Reference Book of Inorganic Chemistry;* Hildebrand and Powell, *Principles of Chemistry.*

5·02. GENERAL CHEMISTRY. Application of chemical principles to the correlation of the chemical behavior of the common elements; stability of the various oxidation states; chemistry of the ionic species; quantitative application of the principles of rate and equilibrium to chemical reactions; structural chemistry of crystals and of molecules; acid-base systems; introduction to the chemistry of carbon; nuclear reactions. Laboratory work with emphasis on the important chemical facts of the elements. Use of facts and principles to develop a scheme for the qualitative separation of the elements. Stress on the analysis of unknown mixtures. Same texts as in 5·01.

5·061, 5·062. ADVANCED INORGANIC CHEMISTRY. Physical and chemical properties of the elements and their compounds, presented in a correlative manner. Facts of inorganic chemistry systematized as far as possible with the aid of a comparatively small number of generalizations. Survey of the more important modern theoretical developments in this field, especially the structural aspects of inorganic substances. Discussion of the results of recent experimental investigations, wherever pertinent.

GRADUATE SUBJECTS

5·066. TOPICS IN THEORETICAL INORGANIC CHEMISTRY (A). General treatment of chemical bonding with particular emphasis in application to inorganic chemistry. Introduction to work in new areas of research such as crystal field theory, hydrogen bonding, structure and bonding in metal carbonyls, nitrosyls, organo-derivatives and hydrides, and the structures and mechanisms of reaction of complex ions.

5·071. SPECIAL TOPICS IN INORGANIC CHEMISTRY (A). Selected subjects, varying from year to year, presented by the members of the class and the staff, as well as invited guest speakers, followed by a general discussion by the group. Subjects chosen from current fields of inorganic investigation, and expected to be of sufficiently wide scope to require a literature search in the preparation of the subject for presentation. In successive terms this subject is intended to alternate with 5·912.

5·09. RADIOCHEMISTRY (A). Introduction to nuclear science and chemical aspects of the nuclear energy industry. Chemistry of production, isolation, and identification of radioactive atoms, and techniques of preparation and measurements of radioelements. Applications of radiotracers to chemical problems.

5·091. RADIOCHEMISTRY LABORATORY (A). Laboratory study of special topics including radiochemical analysis, the fission process, and the reactions following nucleogenesis.

ANALYTICAL CHEMISTRY

UNDERGRADUATE SUBJECTS

5·10. QUALITATIVE ANALYSIS. Discussion of theories underlying the reactions of qualitative analysis with particular attention to the law of mass action. Practice in writing chemical equations. Laboratory work, conducted on a semi-micro scale, on a large number of solutions and solids, including alloys, pigments, minerals, slags and miscellaneous commercial products. Preparation for quantitative analysis, correlating and systematizing material relating to general inorganic chemistry. Noyes and Swift, *Qualitative Chemical Analysis;* Latimer and Hildebrand, *Reference Book of Inorganic Chemistry.*

5·11. QUALITATIVE ANALYSIS. Class-room work essentially the same as that in 5·10, with fewer experiments and analyses performed in the laboratory. Noyes and Swift, *Qualitative Chemical Analysis;* Latimer and Hildebrand, *Reference Book of Inorganic Chemistry.*

5·12. QUANTITATIVE ANALYSIS. Discussion of principles of volumetric and gravimetric analysis with detailed attention to the solution of stoichiometric problems. Laboratory work in quantitative analysis by volumetric and gravimetric methods on typical natural and commercial products, and covering acidimetry, the permanganate and iodimetric processes, precipitation methods and gravimetric methods. Emphasis on development of careful laboratory technique. Hamilton and Simpson, *Quantitative Chemical Analysis.*

5·13. QUANTITATIVE ANALYSIS. Includes the topics of 5·12 and continues with a correlative study of analytical chemistry for the identification and determination of the more common constituents as well as some of the rarer elements. Analysis of silicates, minerals, ores and alloys including colorimetric, electrolytic and electrometric methods, and an original study of some special analytical problem. Elements of gas analysis and other technical analyses. Hamilton and Simpson, *Quantitative Chemical Analysis.*

5·15. INSTRUMENTAL ANALYSIS. Theory and application of modern optical and electrical instruments in the solution of chemical problems. Polarography, potentiometry, conductometry, radio frequency conductometry, thermal conductivity of gases; ultra-violet, visible and infra-red spectrophotometry; colorimetry, turbidimetry, nephelometry, fluorimetry, flame photometry, and automatic instruments. Willard, Merritt and Dean, *Instrumental Methods of Analysis.*

5·151. INSTRUMENTAL ANALYSIS LABORATORY. Laboratory coordinated with the topics in 5·15.

GRADUATE SUBJECTS

5·192. ADVANCED ANALYTICAL CHEMISTRY I (A). Separation Methods. Detailed consideration of the theory and application of separation methods by means of distillation and condensation, solvent extraction, precipitation and coprecipitation, chromatography, ion exchange, diffusion and electrodeposition.

5·193. ADVANCED ANALYTICAL CHEMISTRY II (A). Analytical Chemistry of the less familiar elements. Problems encountered in the analysis of technical products. General correlation of analytical methods.

5·194. ADVANCED ANALYTICAL CHEMISTRY III (A). Application of statistical methods to analytical problems with emphasis upon evaluation of validity, control chart methods, analysis of variance, fitting of equations to experimental data and the design of experiments. (Not offered 1956–57.)

5·196. ADVANCED ANALYTICAL CHEMISTRY IV (A). Survey of the methods of quantitative organic analysis with particular emphasis on the determination of functional groups. (Not offered 1956–57.)

ORGANIC CHEMISTRY

UNDERGRADUATE SUBJECTS

5·41. ORGANIC CHEMISTRY I. Introduction to the chemistry of carbon compounds. Survey of the important classes of aliphatic and aromatic compounds with attention to reactions and compounds of current industrial interest.

5·414, 5·416. ORGANIC PREPARATIONS I. Preparation and purification of a series of simple organic compounds by typical reactions illustrating the synthetic techniques of organic chemistry.

Chemistry Continued

5·42. Organic Chemistry II. Continuation of 5·41. Study of organic reactions emphasizing the relation between structure and reactivity.

5.424. Organic Preparations II and Qualitative Organic Analysis. Advanced preparations involving special techniques. Identification and separation of mixtures of organic compounds. Introduction to the literature of organic chemistry.

5·426. Qualitative Organic Analysis. Laboratory practice in the identification and separation of mixtures of organic compounds.

5·43. Organic Chemistry III. Introduction to the theoretical interpretation of reactivity, reaction mechanisms and molecular structure of organic compounds. Application of theories of electronic structure, acids and bases, steric hindrance and stereochemistry with emphasis on recent developments.

5·44. Organic Chemistry IV. Discussion and evaluation of general synthetic methods of organic chemistry with emphasis on the isolation, characterization and synthesis of products of biological significance (antibiotics, peptides, steroids, and alkaloids).

GRADUATE SUBJECTS

5·51. Organic Chemistry: Synthesis, Advanced (A). Survey of organic reactions and the methods by which they are applied to synthetic problems in organic chemistry.

5·54. Advanced Physical Organic Chemistry (A). Mechanism of representative organic reactions in homogeneous liquid systems. Emphasis on kinetic and other physical methods useful in studying organic reactions, and on the types of experimental evidence upon which current theoretical interpretations of reactivity are based.

5·55. Organic Chemistry: Natural Products (A). Discussion of the chemistry and physiological action of natural products. Presentation of methods of isolation; determination of structures and synthesis.

Physical Chemistry

UNDERGRADUATE SUBJECTS

5·60. Physical Chemistry. Physical states of matter; first and second laws of thermodynamics; properties of gases and elementary kinetic theory; properties of solutions; electrolytic conduction. Noyes and Sherrill, *A Course of Study in Chemical Principles.*

5·61. Physical Chemistry I. Composition and physical states of matter; first and second laws of thermodynamics; properties of gases and elementary kinetic theory; properties of solutions; electrolytic conduction.

5·611. Physical Chemistry Laboratory I. Laboratory coordinated with the topics of 5·61.

5·612. Physical Chemistry Laboratory I. Abridgement of 5·611.

5·613. Physical Chemistry Laboratory I. Laboratory coordinated with the topics of 5·61.

5·62. Physical Chemistry II. Continuation of 5·61. Equilibrium of chemical changes; phase equilibrium; rates of chemical reactions; voltaic cells; third law of thermodynamics; systemization of free-energy values.

5·621. Physical Chemistry Laboratory II. Laboratory coordinated with the topics of 5·62.

5·622. Physical Chemistry Laboratory II. Abridgement of 5·621.

5·623. Physical Chemistry Laboratory II. Laboratory coordinated with the topics of 5·62.

5·66. Surface and Colloid Chemistry. The structure of surfaces; surface and interfacial tensions, including solid-fluid interfaces; adsorption, and measurements of surface area; rates of heterogeneous reactions; electrokinetic effects; types of colloids, and methods for preparation and purification; methods for studying size, shape and structure of the colloidal particle; applications to natural and synthetic colloidal systems.

5·67. Introduction to Atomic and Molecular Structure. Use of spectroscopic methods to determine the structure of atoms and molecules; elementary theory of atomic spectra; atomic structure and the Periodic Table; theory of molecular spectra. Technique of chemical spectroscopy; analysis of chemical elements by emission spectra; use of infra-red and Raman spectra in chemical analysis and in determination of the structure of organic compounds; ultraviolet absorption of molecules and their electronic structure. Harrison, Lord and Loofbourow, *Practical Spectroscopy.*

5·68. Kinetics of Chemical Reactions. Introduction to the kinetic theory of gases with special emphasis on the calculation of collision frequencies, and consideration of theoretical and experimental aspects of the kinetics of homogeneous and heterogeneous reactions in gaseous and liquid systems. Frost and Pearson, *Kinetics and Mechanism.*

GRADUATE SUBJECTS

5·71. Chemical Thermodynamics I (A). Fundamental definitions and concepts; first and second laws of thermodynamics with applications to chemical systems, ideal and real gases, ideal and real solutions; partial molar quantities, chemical equilibrium; third law of thermodynamics and applications to chemical systems; free energy calculations. Noyes and Sherrill, *A Course of Study in Chemical Principles.*

5·72, 5·73. Chemical Thermodynamics II and III (A). Development of the general thermodynamic theory from the first and second laws. Application of the theory to homogeneous and heterogeneous systems in which chemical reactions may take place. Gibbs, *Thermodynamics;* mimeographed notes.

5·75. Atomic Structure and Atomic Spectra (A). Introduction to atomic physics and atomic structure: deflection of charged particles in electric and magnetic fields; excitation of spectra; introductory wave mechanics; periodic system of the elements; intensity of spectral lines. Mimeographed notes.

5·76. Molecular Spectra and Molecular Structure (A). Elementary quantum mechanics, rotational, vibrational and electronic spectra of molecules; use of spectra to find dissociation energies, force constants, inter-atomic distances, molecular symmetry and related quantities; other techniques for molecular structure such as dipole moments, magnetic susceptibilities and nuclear magnetic resonance. Pitzer, *Quantum Chemistry.*

5·77. Crystal Structure and the Chemical Bond (A). Application of X-ray, electron and neutron diffraction to the determination of the structures of molecules and crystals. Interpretation of structural results in terms of modern theories of chemical binding.

5·78. Statistical Mechanics (A). Introduction to the principles and methods of statistical mechanics. Time and phase averages. Ensembles and distributions. Classical and quantum statistics. Third law of thermodynamics. Fluctuations. Applications to physical and chemical systems including perfect and real gases, liquids, solids and surfaces.

5·79. Kinetic Theory (A). Fundamental concepts of the kinetic theory of gases. Properties of gases at low densities; transport phenomena in relation to molecular interactions; application of statistical mechanics and kinetic theory to kinetics of chemical reactions. Kennard, *Kinetic Theory of Gases* and other reference texts.

RESEARCH

5·90. Special Problems in Chemistry (A). Directed research and study of special chemical problems. For graduate students only.

5·912. Seminar in Inorganic Chemistry (A). Discussion of recent publications of interest to the inorganic chemist. Scope of these topics more limited than those given in 5·071. Given alternately with 5·071.

5·913, 5·914. Seminar in Organic Chemistry (A). Discussion of current journal publications in organic chemistry by graduate students and staff members.

5·915, 5·916. Seminar in Analytical Chemistry (A). Discussion of topics of current interest in analytical chemistry by graduate students and staff members.

Chemistry Continued

5·931, 5·932. Seminar in Physical Chemistry (A). Discussion of topics of current interest in physical chemistry by staff members and students.

5·941, 5·942. Research Conference in Inorganic Chemistry (A).

5·951, 5·952. Research Conference in Analytical Chemistry (A).

Research (A). Research for any of the advanced degrees in inorganic, analytical, organic or physical chemistry.

ELECTRICAL ENGINEERING

Subjects 6·00 to 6·99

6·00, 6·01. Introductory Circuit Theory. Network topology and topological aspects of duality as means for choosing appropriate sets of network variables on a current or voltage basis. Kirchhoff's laws, volt-ampere relations for the elements, and sources of excitation. Equilibrium equations and methods for their solution, including Thevenin's and Norton's theorems, and other useful devices. Step function and impulse response of simple circuits, and their complex natural frequencies. Sinusoidal steady-state behavior. Impedance as a function of applied and natural frequencies of the circuit and its geometrical interpretation in the complex frequency plane. Resonance phenomena, single and double-tuned circuits, amplitude and frequency scaling, vector diagrams, reciprocal and complementary impedances. Energy storage and dissipation; active and reactive power. Mutual inductive coupling. Polyphase circuits. Usefulness of the duality principle given prominence throughout the discussions, which are concluded with an introductory mention of nonlinear elements, their practical uses and circuit implications. Closely correlated laboratory work accompanying the lectures and recitations. Guillemin, *Introductory Circuit Theory.*

6·001. Introductory Circuit Theory. Classroom part of 6·00.

6·002. Introductory Circuit Theory Laboratory. Experimental aspects of 6·00 taught in the laboratory.

6·011. Introductory Circuit Theory. Classroom part of 6·01.

6·012. Introductory Circuit Theory Laboratory. Experimental aspects of 6·01 taught in the laboratory.

6·02. Electronic Circuits. Introduction to the role of electronic devices in modern technology. Important physical effects underlying electrical characteristics of high-vacuum tubes, gas tubes, and transistors. Various ways of representing an electronic device: nonlinear or piecewise-linear curves, piecewise-linear and linear incremental circuit models. Introduction to methods of analysis of circuit problems involving such curves or models. Coordinated laboratory and classroom work. Study of the following circuits: rectifiers, detectors, basic triode and transistor amplifiers, basic feedback circuits, and elementary oscillators. Much attention given to resistive circuits, and results modified to include effects of capacitance and inductance.

6·021. Electronic Circuits. Classroom part of 6·02.

6·022. Electronic Circuits Laboratory. Experimental aspects of 6·02 taught in the laboratory.

6·03. Fields, Energy, and Forces. Treatment of electromagnetism based on Maxwell's equations and built upon the work in second-year physics, with particular emphasis on the quasi-static behavior of fields and on their macroscopic interaction with materials. Static and quasi-static fields; energy, power flow, and impedance; the field theory of circuit components; forces between bodies in relative motion and the physical bases of electromechanical energy conversion. Coordinated laboratory and classroom work.

6·04. Electrical Energy Conversion. Study of the properties of materials and their interaction with fields to carry out the functions of energy storage, transfer and conversion. Emphasis on the parameters, equivalent circuits and limitations imposed by materials on the devices which utilize primarily the electric and magnetic fields as vehicles. Consideration of the incremental motion electromechanical energy-conversion transducer. Study of energy conversion from the standpoint of interaction at the molecular level; by the use of generalized coordinates and the techniques of theoretical mechanics; and by tracing the energy flow in the fields with the Poynting Vector. Coordinated laboratory work on magnetic devices, transducers, and energy-conversion processes.

6·05. Applied Electronics. Basic principles of application of electronics to perform specific functions in electronic systems. Fourier representation of information to be processed electronically. Amplification, oscillation, and modulation (including rectification and detection). Emphasis on the limitations imposed by nonlinearity, materials, power, dissipation, noise, and inherent residual circuit parameters. Gray, *Applied Electronics, Second Edition*, 1954.

6·051. Applied Electronics. Classroom part of 6·05.

6·052. Applied Electronics Laboratory. Experimental aspects of 6·05 taught in the laboratory.

6·06. Electromechanical Power Modulators. Development of generalized dynamic models of static, translational and rotational electrical devices, using fluid theory, classical dynamics and transformation theory. Use of these models in applications where their characteristics as power modulators are important. Studies of these devices in systems, and the use of elementary feed-back theory to relate individual components to system performance.

6·07. Energy Transmission and Radiation. Characteristics of wave motion, as exhibited both in the formulation of dynamic field equations and in their specific application to elementary transmission and radiation problems in electrical engineering. Connection between dynamic fields and the lumped-circuit notions of voltage, current and impedance; steady-state and transient wave motion in one space dimension; resonance in distributed structures; uniform plane waves; radiation and reception by small antennas.

6·071. Energy Transmission and Radiation. Classroom part of 6·07.

6·072. Energy Transmission and Radiation Laboratory. Laboratory part of 6·07.

6·10. Elementary Electric Circuit Theory. Discussion of the basic principles of linear passive network analysis and synthesis with the primary objective of laying a foundation adequate for subsequent expansion according to the needs of the student's field of specialization. Consideration of the transient behavior of networks in terms of the impulse and step-function response of various simple circuits, making wide use of the principles of superposition, reciprocity, and Thevenin's theorem. Close correlation of the transient and sinusoidal steady-state response through formulating the impedance function in terms of the complex natural frequencies of the network. Stress on energy and power considerations in both the transient as well as in the steady-state discussions of network behavior. Illustration of the theory with numerous practical examples. Guillemin, *Introductory Circuit Theory.*

6·16. Electricity. Fundamental principles of electric and magnetic circuits and application of these principles to the theory of operation of d-c and a-c motors, transformers, and associated devices; types of d-c and a-c distribution systems; computation of loads on wiring systems; design of wiring systems and safe wiring practices; National Electrical

Electrical Engineering Continued

Code; requirements for telephone service; elevators treated as traffic problem in vertical transportation.

6·17. ILLUMINATION. A study of the design of lighting systems for best seeing. Photometric units and measurements, properties of the eye, characteristics of lamps and luminaires, daylight. Moon and Spencer, *Lighting Design.*

6·18. FUNDAMENTALS OF ELECTRICAL ENGINEERING. Fundamental principles of electric and magnetic circuits with applications to theory and performance of components and systems for power, control, and instrumentation. Engineering study of power transmission and industrial utilization of electricity. Laboratory exercises to support principal classroom topics.

6·19. ELECTRONIC INSTRUMENTATION. Study of quasi-linear devices for control and instrumentation. Graphical and incremental methods used to analyze thermionic tubes and semiconductor devices in resistive circuits and circuits with energy storage. Input, output, and gain characteristics as determined by choices of input and output terminals. Instrumentation studies including input transducers, feedback amplifiers, power control devices, power supplies, and output transducers. Laboratory exercises applying classroom techniques.

6·20. ELECTRONIC CONTROL AND MEASUREMENT. Analysis and design principles of electronic systems for control and measurement in engineering, as applied to phototube devices, pH measurement, vacuum-tube voltmeters, high-speed recording instruments, flash-photography apparatus, strain gages, vibration meters, etc. Detailed consideration of: Input and output conversion transducers; grid current and its effect in high-impedance circuits; direct- and resistance-capacitance-coupled amplifiers; differentiating and integrating circuits; amplitude, frequency, phase and pulse modulation for measurement and control; frequency-selective amplifiers; phase- and frequency-sensitive detectors. Emphasis on importance of the non-linear properties of electron tubes and transistors either as limitations or as useful characteristics.

6·202. ELECTRONIC CONTROL AND MEASUREMENT. Analysis and design principles of electronic devices for control and measurement in engineering. Detailed consideration of: voltage-stabilized and current-stabilized-power supplies; switching, multi-vibrator, and timing circuits; power oscillators; induction and dielectric heating principles.

6·204. THERMIONIC ELECTRON DEVICES. Behavior of electrons in vacuum under influence of electric and magnetic fields. Space charge limited flow. Basic theory of electron optical systems, grid-control tubes, and long-transit-time tubes (klystrons, traveling wave tubes, magnetrons). Emphasis on fundamental processes such as interchange of power between electron streams and electromagnetic fields.

6·211. GRAPHICAL TECHNIQUES IN SYSTEMS ENGINEERING PROBLEMS. Numerous problems in the area of the protection of electric systems employing slope-line methods of analysis. Practical solution of traveling wave problems, ferroresonance in power systems, geometry analyses of arc interruption, interruption of capacitive circuits, vacuum switching and lightning protection. Of particular interest to the system planning engineer, system protection engineers, insurance underwriters, and designers of protective equipment. Techniques applicable to numerous fields of engineering science dealing with linear and non-linear systems under impulse, shock, or impact conditions.

6·212. ENERGY CONVERSION COMPONENTS AND SYSTEMS. Discussion of different methods for the generation and distribution of electrical energy. Three-phase system and techniques for solving three-phase problems. Important aspects in the design of rotating machines and transmission lines, as influenced by system operation. Considerations of system stability, relaying and economy.

6·213. FEEDBACK CONTROL PRINCIPLES. Theoretical background for study of the quantitative analysis and synthesis of linear feedback control systems. The use of Laplace transformation techniques for the formulation and manipulation of transfer functions and signal flow diagrams. Frequency response with emphasis on graphical techniques using logarithmic representation of transfer functions, pole-zero configurations in the complex plane, transient behavior, and error coefficients will become principal topics. Introduction to the study of discontinuous and nonlinear systems. Regular laboratory exercises.

6·225. PRODUCTION AND APPLICATION OF ATOMIC RADIATIONS. Engineering survey of the sources of high energy particles and radiation and their application to nuclear science, biology and medicine, sterilization and chemical processing. Consideration of the fundamental electrical processes in certain superior voltage-insulating media, such as high vacuum and compressed gases; principles and engineering features of machine accelerators, including the Van de Graaff electrostatic accelerator, resonance transformer, betatron, microwave linear accelerator and synchrotron; the properties of high energy electrons, X-rays, positive ions, and neutrons; methods of measuring and controlling these forms of ionizing energy; the nature of their interaction with living and non-living matter. Emphasis on the physics and techniques involved in the application of atomic particles in the diagnosis and treatment of disease, the radiographic examination of metal sections, the sterilization of drugs and of tissue for surgical use, the preservation of foods, the production by accelerators of neutrons and isotopes, the polymerization and crosslinking of hydrocarbons. Comparative discussion of radioactive sources of atomic particles and radiation.

6·227. ENGINEERING ELECTRODYNAMICS. Engineering applications of Maxwell's equations with special emphasis on the time-varying case. Paradoxes, ambiguities in usual treatment of induced emf's, skin effect, plane electromagnetic waves, wave guides, antennas. Alternate approach to electrodynamics by way of Ampere, Gauss, and Ritz.

6·231. CIRCUIT AND FIELD ANALOGS AND MODELS. Study of electrical, mechanical, thermal and composite systems or devices through use of electric circuit and electric or magnetic field analogs and models. Exploitation of the principle of duality. General treatment of dimensional analysis with special attention to model theory. Instruction largely through use of problems relating to static or dynamic behavior of instruments, structures or machines, including study of flow, pressure, stress, temperature, and energy distribution.

6·232. ELECTROMECHANICAL CONTROL COMPONENTS. Problems of design and analysis of devices such as various types of servo motors, hysteresis motors, synchros, resolvers, differential transformers, tachometers, accelerometers, vibrometers, torque or force motors, trigger magnets, and relays. Illustrations based on actual apparatus.

6·241. ENGINEERING PROBLEMS. Given by notable practicing engineers to show the whole problem faced by the engineer including the influence of such matters as economic, legal, public relations, manufacturing sales, and servicing considerations as well as technical engineering. Registration officers to be consulted about the field and instructor for any given term.

6·25. MACHINE-AIDED ANALYSIS. Survey of engineering analysis problems wherein machine computation is useful. Summary of modern machine computation techniques available to solve these problems. Study of computing machinery of the analog type. Elementary presentation of numerical analysis and solution of typical engineering problems by numerical methods. Interpretation of arithmetical and logical sequences into digital computer instructions. Comparison of digital and analog computation techniques.

6·26. MOLECULAR ENGINEERING. Engineering advances by the development of materials and the application and control of phenomena. Use of molecular engineering in design of materials and guiding of phenomena by comprehension and utilization of underlying molecular causes. Study of atoms and molecules and their interactions in gases, liquids and solids, leading to the latest tools in electrical engineering such as rectifiers and transistors, ferroelectric and ferromagnetic amplifiers, transducers and memory devices. Primarily for seniors and qualified juniors.

6·281. PRINCIPLES OF WIRE COMMUNICATIONS. Brief discussion of the principal telephone switching systems including the nation-wide toll-switching plan. Transmission characteristics, of long lines with distributed parameters, as a func-

Electrical Engineering Continued

tion of frequency; networks, loading, communications transformers, repeaters, balancing networks, insertion loss, carrier-current systems, distortion and its correction. Economic considerations effecting alternative plans are considered.

6·291. Radar-System Engineering. Emphasis on the engineering design of simple and complex electronic and electromechanical systems. Radar as a vehicle for study. Analysis and synthesis of master-pulse oscillators, cathode-ray-tube sweep generators, high-power pulse modulators, wide-band small-signal amplifiers, antenna-control systems, and r-f transmission and radiation systems. The factors which influence performance of the over-all system and problems resulting from interconnection of subsystems. Reintjes and Coate, *Principles of Radar*, Third Edition.

6·30. Communication and Control Circuit Theory. Continuation of discussions begun in 6·00 and 6·01, with particular emphasis upon problems arising in the communications and electronic control fields. Correlation of the classical differential equation approach to time and frequency domain interrelationships with Fourier and Laplace methods, and the application of these concepts to typical problems in the communications and control art, stressing the design aspects of pertinent circuits. Introductory discussion of network synthesis including conventional filter theory.

6·311. Principles of Communication. Basic requirements for communication. Probability considerations. Signal analysis: convolution and cascaded amplifiers; characteristics of audio and video signals. Amplitude modulation, synchronous detection; suppressed carrier and single-sideband operation; bandwidth requirements. FM and pulse modulation; general relation between signaling rate and bandwidth. Noise, signal-to-noise ratio; effects on AM, FM, PCM; quantization noise; interchange of bandwidth and signal-to-noise ratio.

6·312. Communication System Engineering. Significance of signals, radio frequency, modulation, noise, transmission and detection in communications systems. Investigation of the inter-relationship between the various components of a communication system in the light of the system application and the limitation imposed by the transmission medium and the available components. Investigation of a microwave relay circuit to provide a common theme for the term's work.

6·322. Electromagnetic Waves. Application of electromagnetic theory to communication problems. Uniform plane waves, non-uniform plane waves, and their physical properties. Wave guides of closed and open structures, periodic structures, cavity resonators. Transmitting and receiving properties of antennas. Introduction to theory of propagation.

6·35. Fundamentals of Acoustics. Derivation of the acoustic wave equation and solutions for elementary cases. Radiating systems and radiation patterns. Network theory for electro-mechano-acoustic systems. Sound fields in rooms. Illustrative examples from the field of transducers, such as microphones and loudspeakers. Selected problems and laboratory. Lecture Notes.

6·351. Engineering Acoustics. Presentation of the characteristics of sound waves, acoustical elements, mechano-acoustic circuits, psycho-acoustics; fundamental aspects of room acoustics and noise control. Selected problems and laboratory experiments. (Primarily for Course XIII-A.)

6·36. Engineering Acoustics. Application of acoustic principles to the design of loudspeakers and microphones; to speech communication systems; to noise control; to room and studio design; and to magnetic recording. Psychological aspects of hearing related to acoustical design. Acoustical measurements. Selected problems and laboratory. Beranek, *Acoustic Measurements*.

6·38. Pulse Circuit Analysis. Analysis of wave shaping and pulse generating circuits by means of graphical methods, piecewise linear approximations and single-time-constant approximations. Applications to vacuum tube, transistor and saturable core circuits common to radar, television, pulse communication and electronic computation.

6·521. Electrical Energy Conversion Devices (A). Translation of the principles of energy conversion into physical devices using a synthesis approach. Consideration of the problems of the utilization and limitations of new and existing materials. Discussion of heat transfer and cooling of electrical devices. Model theory. Development of the relationships between the dimensions and material properties of conversion devices and their performance. Exploration of the realization of new energy-conversion devices from non-conventional methods of energy conversion.

6·522. Dynamics of Rotating Machine Systems (A). Rotating electromagnetic energy converters analyzed with the use of matrix, tensor, and model concepts. Application to the study of dynamics of direct-current and alternating-current machines in control systems and electric power systems. Study of the performance and design of electrical apparatus to meet specifications in feedback control systems, power systems, and other fields, taking into account the general physical limitations of the materials.

6·524. Non-Linear Impedances as Power Modulators (A). Theory of amplification and modulation obtained by exploiting non-linear materials and devices; i.e., magnetic and dielectric amplifiers. Methods of representing nonlinearities in analysis including piece-wise linear approximations, analytic function representations and use of analog devices. Effects of hysteresis. Steady-state and transient performance. Applications and design considerations.

6·535. Introduction to Digital Computer Coding and Logic (A). Survey of principles of logical design and of the elements of coding programs for large-scale digital computers, discussed from the user's point of view. Brief description of the logical structure of digital computers operating at M. I. T. and elsewhere. Interpretation of sequences of arithmetical and logical operations into digital computer instructions, with examples chosen from typical engineering, scientific, and business problems and from real-time control applications. Techniques for simplifying and improving the programming and operating of computers by the use of subroutines. Execution on the M. I. T. Whirlwind I computer of examples discussed in class to provide first-hand experience with automatic high-speed machines.

6·538. Electronic Computational Laboratory (A). Study of the basic principles of digital computers by experiments on the following equipment: card punches, sorters, accounting machines, electronic calculator, and the card programmed calculator. Actual programming and operation of a digital computer by the solution of several problems on the Card Programmed Calculator. Type 650 Magnetic Drum Calculator, and the Type 704 Electronic Calculator. Classroom and research studies on scientific computations encountered in the solution of simultaneous algebraic equations, inversion of matrices, solution of ordinary differential equations, etc. Business-data-handling problems in the banking, insurance, public utilities, department stores, and traffic control fields. Use of the Type 650 Magnetic Drum Calculator.

6·54. Pulsed-Data Systems (A). Study of the processes of sampling of continuous data and of smoothing of sampled data. Analysis and design of linear systems employing pulsed data. Investigation of feedback systems employing sampled error data including stability studies of such systems. Transient response of sampled-error data servomechanisms. Study of continuous systems by numerical methods. Study of digital computer operations as data filtering, analysis and synthesis of linear digital computer programs in the frequency domain. Comparison between techniques of numerical analysis and control system design. Design of systems involving digital computers as components. Comparisons between analog and digital computers. Study of optimum linear system design as applied to discrete systems. Comparison of classical "least squares" curve fitting with optimum system design. Survey of methods for handling the approximation problem in discrete systems. Survey of physical characteristics of sampling and holding devices, of analog-to-binary decoders; summary of important considerations involved when these devices are used as components in control systems.

Electrical Engineering Continued

6·55. Linear System Analysis (A). Use of circuit theory with results applicable to any linear dynamic system. Network topology, linear transformations and linear constraint relations, topological versus dynamic independence, energy relations, duality, normal coordinates and normal coordinate transformations. The meaning of passivity and stability. LLFPB impedance and admittance properties relating the frequency and time domain aspects of physical circuit behavior. Fourier methods and their use in analysis and synthesis, including such topics as: convergence and approximation properties of Fourier series, their ability to characterize both aperiodic sampled functions as well as ones that are periodic and continuously defined. Approximation by finite trigonometric polynomials; Cesaro and other methods of summation. The concept of band-limited functions. Fourier and Laplace transforms and a comparison of network analysis by these methods with the classical differential equation solution showing their complete identity. Numerical evaluation methods using impulse-train techniques. Real part sufficiency and related topics. Introduction to network synthesis including conventional filter theory.

6·56. Mathematical Methods in Electrical Engineering (A). Discussion of selected topics from theory of linear transformations, functions of a complex variable, and closely related material forming the basis for analysis of problems in the general field of Electrical Engineering as well as in Communications and Electronic Control. Topics considered are: differentiation, integration and expansion of complex functions into series, including point sets and convergence criteria; multivalued functions and Riemann surfaces; types of singularities, including some physical examples afforded by vector fields; partial fraction expansions; conformal mapping functions with applications (Schwarz-Christoffel formula); complex integration including saddle-point methods; Hurwitz polynomials, stability criteria, positive real functions and relations to synthesis of physical systems; Fourier series as a particular form of the Laurent expansion, mean square properties, approximation properties of its partial sums, transition to Fourier and Laplace transforms, their elementary properties and applications; Hilbert transforms and their fields of applications in electrical problems. Guillemin, *The Mathematics of Circuit Analysis.*

6·561. Network Analysis and Synthesis (A). Methods of network synthesis and their application to the design of networks for prescribed driving-point characteristics. Establishment of necessary and sufficient conditions for the realization of impedance functions. Consideration of the fundamental work of Foster, Cauer, Brune, and Darlington, as well as collaterally significant topics, illustrated with examples. Guillemin, *Communication Networks, Volume II;* Guillemin, *The Mathematics of Circuit Analysis;* Bode, *Network Theory and Feedback Amplifier Design.*

6·562. Network Analysis and Synthesis (A). Extension of the methods discussed in 6·561 to the synthesis of coupling networks for prescribed transfer characteristics, including RC as well as RLC, minimum-phase and nonminimum-phase types, filters and constant-resistance filter groups, and questions regarding the ultimate response characteristics obtainable from linear passive networks. Frequency and time domain aspects of the pertinent approximation problem. Guillemin, *Communication Networks, Volume II;* Guillemin, *The Mathematics of Circuit Analysis;* Bode, *Network Theory and Feedback Amplifier Design.*

6·567. Switching Circuits (A). Treatment of the basic principles governing the interconnection of two-valued switching elements to form networks and systems for automatic control and for the manipulation of binary data. Development and interpretation of switching algebra, and its application to the analysis and synthesis of combinational switching circuits. Realization of algebraic switching functions in terms of networks containing relay contacts. Procedures for minimization of switching networks. Introduction to the design of sequential systems involving relay elements. Selected projects for individual design and laboratory execution.

6·568. Switching Circuits (A). Analysis and synthesis of sequential switching circuits. Development and manipulation of the flow diagram, assignment of secondary (memory) elements, and the reduction of sequential problems to combinational problems. Study of high-speed switching components; realization of combinational and sequential switching circuits by means of electronic and semiconductor elements. Circuits for performing specific functions and their combination into systems in which response is a function of the combination and sequence of discrete input conditions. Individual and group laboratory projects.

6·571. Statistical Theory of Communication (A). Discussion of messages and noise as stationary random processes. Elementary probability theory, statistical characteristics of messages and noise, particularly correlation functions and spectra. Determination of correlation functions by electronic means. Detection of signals in the presence of noise by correlation. Theory of the optimum filter, predictor, compensator, differentiator, and general linear system operator. Synthesis of linear systems by means of normal and orthogonal functions.

6·573. Statistical Theory of Noise and Modulation (A). Introduction to probability and statistics. Derivation of statistical properties of shot noise. Noise in linear systems. Noise figures of amplifiers. Noise through nonlinear devices. Quadratic and linear detectors and mixers. Application of the characteristic function method to more general nonlinear devices. Detection of threshold signals.

6·574. Statistical Theory of Information (A). Quantitative study of communication systems based on the theory of the transmission of information. Definition of a measure of information and study of its properties; the representation of messages; efficient coding; transmission in the presence of random disturbances, channel capacity; equivocation; the fundamental theorem of information theory and the reduction of equivocation by coding. Extension of the theory to continuous channels; signal detection. Application to specific problems of practical interest including problems outside the field of electrical communications.

6·575. Advanced Topics in Information Theory (A). Further work in information theory based on 6·574. Current problems, solved and unsolved, such as: coding; relation between transmission rate, delay, and error probability; noisy channels with feedback; networks of noisy channels. Term paper required.

6·581, 6·582. Transients in Linear Systems (A). Formulation from physical considerations, of differential equations of circuit and field problems in electrical, mechanical, thermal and acoustical systems permitting linear treatment; analogies; mathematical studies of transient disturbances in these systems, using Laplace transformation method to solve ordinary and partial differential equations. Formulation of difference equations of engineering problems and their solution using the Laplace transformation. Provision of requisite background in complex variable theory for use of the method.

6·586. Engineering Applications of Field Theory (A). Engineering solutions of the Laplace, Poisson, diffusion, and wave equations in three-dimensional space. A supplement to familiar electric-circuit theory (one-space dimension), showing what happens when the field spreads into a three-dimensional space. Method of separation-of-variables employed throughout. Practical applications to electrostatic fields, magnetic fields, heat flow, diffusion, acoustic and electromagnetic waves.

6·59. Bioelectric Signals (A). Basic phenomena of the electrophysiology of the nervous system. Electrical activity related to sensory stimuli with emphasis upon the auditory and visual system. Evoked responses at various levels of the nervous system and their relation to ongoing activity. Electronic recording and computing devices in the study of bioelectric signals. Mathematical models for the behavior of sensory systems. Organisms in communication processes and systems.

6·602. Nonlinear and Time-Varying Systems (A). General review of system analysis, with emphasis on nonlinear and time-varying systems. Relative roles of analytic solu-

Electrical Engineering Continued

tion, approximation methods, and machine-computation techniques. Use of sampled-data and numerical-analysis concepts. Response of systems to noise and other random inputs. Use of statistical concepts to formulate the optimum design problem. Optimization of time-varying linear systems. Intentional use of nonlinearities in control-system design. Determination of system characteristics from input-response measurements.

6·605. Advanced Feedback Control Theory (A). Review of servomechanisms fundamentals including Laplace transforms and frequency-response design techniques. Performance indices. Parameter values for minimum integral-square error with specified system configuration. Variational procedure. Compensation design for minimum integral-square error with configuration free. System design in presence of constraints. Systems subject to stochastic inputs. Minimization of rms error. Compensation for minimum rms error with multiple constraints. Intrinsic performance limitations in linear systems. Comparison of analytical and trial-and-error design techniques. Methods for treating problems intractable to analysis. Use of analogue computers. Solution of integral equations by numerical procedures.

6·606. Feedback Control System Engineering (A). Design studies of a wide variety of systems employing feedback control. Special emphasis on the use of feedback control theory to reduce system performance specifications to component performance specifications. Determination of requirements for and the methods of achieving compensation. Study of essential properties of components including data transmitters, amplifiers, motors, and measuring devices. Consideration of nonlinear effects such as saturation, backlash and friction and of the effects of discontinuities such as sampling and quantization.

6·607. Feedback Control Laboratory (A). Supervised investigation of special topics in feedback control system analysis and synthesis, laboratory investigations supported by library research and analytical work utilizing the facilities of the feedback control laboratory. Program and hours to be arranged with interested staff member, subject to approval of professor in charge.

6·608. Process Control (A). Measurement and control theory applied to a wide variety of man-made and natural processes. Organizational patterns of process systems and their functional subdivision into unit processes. Dynamic behavior of single and multi-variable unit processes quantitatively expressed by means of mathematical transforms. Synthesis of continuous, quasi-continuous, discontinuous, and batch processes control systems to achieve predetermined performance characteristics in scientific experiments, the performance of service functions, and the manufacture of goods. (Not offered 1956–57.)

6·621. Microwave Circuits (A). Analysis of electromagnetic wave propagation in uniform cylindrical waveguides with emphasis on those properties which are independent of the shape of the cross section; reduction of wave guide and discontinuity problems to equivalent transmission line and network problems; study of electromagnetic wave propagation along periodic structures; matching elements, cavity resonators and multiple waveguide junctions; fundamentals of microwave network design.

6·622. Antennas (A). General theory of radiation and its application to the analysis of representative types of antennas; emphasis placed on the design of antenna arrays, microwave reflectors, and lenses.

6·623. Principles of Pulse Circuits (A). Brief review of circuit models and approximation methods useful in electronic circuit analysis. Circuits representable by nonlinear resistance and linear energy storage elements (vacuum tube and transistor circuits), circuits with nonlinear energy storage elements (ferromagnetic and ferroelectric devices). Circuit behavior (input and output time functions) related to electronic device behavior (locus of operating point). Phase plane representation of oscillatory circuit behavior. Introduction to synthesis of nonlinear driving point and transfer curves. Examples based on pulse circuits useful in radar, television, high-speed computers, pulse-modulation communication systems and cathode-ray-tube instrumentation.

6·626. Modulation Theory (A). Brief survey of modern systems of modulation culminating in detailed discussion of problems of communication by sinusoidal-carrier modulation. The characteristics of, and the response of filters to, sinusoidal-carrier modulated waves; a detailed discussion of noise and interference characteristics of AM and FM, with emphasis on capture phenomena; and important modulation and demodulation techniques and circuits, with emphasis on receiving circuitry.

6·629. Radar System Engineering (RA). Fundamental principles of pulsed radar; discussion of the radar as a data-gathering device in a fire-control system; analysis of radar-system components with emphasis on those components used in fire-control radars. Current developments in radar. (Restricted to selected officers of the U. S. Air Force, Army, and Navy.)

6·631. Gaseous Discharge Phenomena (A). Experimental investigations of the discharge of electricity in gas-filled devices. Modern oscillographic transient measurements of the electrical and optical characteristics of sparks, arcs, and glow tubes made under pulsed conditions. Observation of the operation of stroboscope tubes, electronic flash lamps, gas-filled photo-electric cells, spark gaps, mercury-pool rectifiers, thyratrons, etc.

6·632. Electronic Instrumentation and Control (A). Principles of analysis and design of electronic instruments for nuclear measurements and nuclear-reactor control, and for other applications involving measurement and use of small currents or of randomly occurring pulses which may be distributed in size. Survey of nuclear particle detectors followed by consideration of pulse amplifiers, scaling circuits, counting-rate devices, coincidence circuits, and pulse-height analyzers.

6·633. Topics in Active-Circuit Theory (A). Selected studies in the field of active-circuit theory. Representation and classification of active circuits; transfer and negative-resistance power gain; limitations upon the use of image-impedance methods; scattering-matrix methods; properties of gain functions; general feedback-amplifier theory; oscillator theory. Discussion of important current literature.

6·635. Transistors (A). Unified presentation ranging from an introduction to the physics of electrical conduction, through discussions of various circuit applications of transistors. Emphasis on physical mechanisms underlying special characteristics and limitations of the transistor as an electronic device, and on the specific manner in which these features influence both small-signal and large-signal circuit performance.

6·637. Beam-Type Microwave Tubes (A). Electron beam as a propagating medium. Llewellyn's equations and the power relations in an electron beam under small-signal excitation. Coupling of electron beams to external microwave circuits. Unified theory of microwave beam-type amplifiers: microwave triode, klystron amplifier, traveling-wave tube. Analysis of the reflex klystron.

6·64. Insulators, Semiconductors and Metals (A). Study of atoms and molecules and their behavior in gases, liquids, and solids from the unifying standpoint of the interaction of matter with electric and magnetic fields (polarization, magnetization and conduction). Short survey of the macroscopic theory; effects of electric and magnetic moments from their initial individual appearance in spectroscopy to their final concerted action in ferroelectrics and ferromagnetics; the laws of motion of electrons and ions from insulators to semiconductors to metals. Interdepartmental subject for graduate students of science and engineering, designed to lead to an understanding of present-day research problems in the field of molecular science and engineering.

6·68. Special Problems in Electrical Engineering (A). Opportunity for individual study, under a staff member, of advanced subjects related to Electrical Engineering not otherwise included in the curriculum. Program to suit individual requirements by the student and staff members interested, subject to approval of the professor in charge.

Electrical Engineering Continued

6·691. Advanced Acoustics (A). Derivation of exact wave equation. Propagation of transients in the atmosphere. Poisson's solution. Stokes' density theorem. Huygens' principle and the method of characteristics. Ray acoustics and Fermat's principle. Energy density and radiation pressure. Ehrenfest theorem. Boundary value problems in acoustics. Normal mode and Greene's function solutions. Effects of viscosity and heat conduction.

6·692. Advanced Engineering Acoustics (A). Advanced applications of acoustics. Engineering procedures for noise control, satisfactory listening environments, and industrial applications of acoustical techniques. Selected problems.

6·695. Special Problems in Acoustics (A). Advanced problems in acoustics, electro-acoustics or vibrations. Opportunity for individual study in the Acoustics Laboratory under a staff member.

6·696. Hearing, Speech and Language (A). Discussion of properties of signals in audio communication systems in the light of characteristics of listeners and speakers. Auditory thresholds, masking, perception of complex acoustic stimuli. Production of natural and synthetic speech. Physical methods of speech analysis. Effects of filtering and clipping. Linguistic units of analysis. Statistical properties of speech signals. Intelligibility criteria for audio communication systems. Integration of experimental data on hearing and speech with recent developments in linguistics and information theory.

6·72. Communications Laboratory (A). Advanced work on a substantial problem or selected group of problems. Opportunity for specialization in communications systems and noise generation and measurement problems. For students with mature independence of attack and investigatory ability.

6·73. Advanced Electrical Circuits and Electronics Laboratory (A). Advanced laboratory problems in Electrical Circuits, Electronics, or Electrical Measurements.

6·74. Advanced Electrical Energy Conversion Laboratory (A). Laid out in accordance with the needs of the individual student, special problems on electrical energy conconvertors and modulators.

6·80. Electrical Circuits and Electronics Laboratory. Laboratory problems in Electrical Circuits, Electronics, or Electrical Measurements.

6·81. Electrical Communications Laboratory. Special undergraduate work in communications problems. Experience in design, construction and testing of communications circuits and simple systems.

6·86. Electrical Energy Conversion Laboratory. For Electrical Engineering students who desire laboratory work in addition to that included in 6·03, 6·04, and 6·06, and other students requiring a special program in energy-conversion laboratory. Arranged to suit the requirements of the individual student.

6·901—6·904. General Electric Industrial Practice. Practical work done by the cooperative students in testing, manufacture, engineering and research in plants of the General Electric Company located in Lynn, Schenectady, Pittsfield, Syracuse, Erie, Bridgeport, and Philadelphia. The output of this company ranges from minute vacuum tubes to heavy power units, and embraces the fields of power, communications, illumination, and electronics.

6·905—6·908. International Business Machines Corporation Industrial Practice. Work done by cooperative students in research, development, design, and associated manufacturing activities in the field of electronic digital computers and data-processing machines, business machines and time equipment.

6·911—6·914. Boston Edison Public Utility Practice. Work done by cooperative students in maintenance of lines and of electric and steam plants, testing and standardizing of equipment, conduct of sales department,engineering and research related to public utility problems.

6·921—6·924. Special Industrial Practice. Assignments to companies outside the regular cooperative program to afford industrial experience to non-citizens. Work of the same standard as required of other cooperative students.

6·931—6·934. Raytheon Industrial Practice. Engineering work performed by cooperative students in research, development, design, and manufacture of electronic equipments, tubes, and components in laboratories and plants located near Boston in Newton, Waltham, Quincy, Lowell, Wayland, and Bedford.

6·941—6·944. Bell Telephone Laboratories Industrial Practice. Work performed by cooperative students in the development of communication apparatus, circuits and equipment for the Bell Telephone System.

6·951—6·954. General Radio Industrial Practice. Work done in the plants of the General Radio Company, Cambridge, in research, engineering, manufacture and testing of high-grade measuring instruments especially adapted to the fields of communications and electronics.

6·961—6·964. Philco Corporation Industrial Practice. Work done by cooperative students in testing, manufacture, engineering and research in the plants of the Philco Corporation in Philadelphia, Pa., which operates an experimental television broadcasting station and specializes in the manufacture of communication and electronic devices.

6·971—6·974. American Gas and Electric Service Corporation Industrial Practice. Work done by cooperative students in the area of system planning, load dispatching, economy computers, relay practices, microwave communication, and high-voltage research. Opportunity to visit many of the steam and hydraulic plants of this organization which is spread out from North Carolina, through Virginia, Ohio, and Indiana. Research and development in 500 kv, 60 cycle transmission as well as in many other phases of public utility practice.

6·981—6·984. Naval Ordnance Laboratory Industrial Practice. Work performed by cooperative students in the field of acoustics, physical optics, terrestrial magnetism, piezoelectricity, explosive phenomena, interior ballistics, electrochemistry, X-ray techniques, mechanical computation, applied statistics, numerical mathematical methods, exterior ballistics, gas dynamics, supersonic aerodynamics, hydrodynamics, plastics research and technology.

6·991—6·994. Airforce Cambridge Research Laboratories Industrial Practice. Work performed by cooperative students in the field of microwave optics, solid state physics, geophysics, communication and radar electronics. Construction, maintenance, testing, analysis and circuit design. Participation in varied problems of organized research directed primarily toward National Defense.

BIOLOGY

Subjects 7·00 to 7·99

7·00. Perspectives in Life Science. Lectures and demonstrations presenting the place of man in the world of living organisms; factors important in man's successful adaptation to his external environment, animate and inanimate; and the processes which make possible the various functions of man's body in health and disease including major concepts of genetics, growth, development, and physiology. Concluding lectures on the growing importance of biophysics and biochemistry in the shaping of modern biological concepts — (biology at the molecular level) and the outlook for theoretical biology.

7·01, 7·02. General Biology I and II. Introduction to the study of plant and animal organisms, including man. *First Term:* Nature of life, physical and chemical structure of protoplasm; form and structure of plants; cells and cell structure; relations and structure of cells, tissues and organs of plants; plant physiology; review of plant kingdom; systems of the animal body (anatomy-physiology). *Second Term:* Review of the animal kingdom, growth and reproduction in plants and animals, heredity, evolution, plant and animal classification, principles of ecology, plant and animal diseases, immunity, viruses, history and perspectives of biology.

Biology Continued

7·011, 7·021. General Biology Laboratory I and II. Laboratory exercises to illustrate the principles in 7·01, 7·02.

7·03. Genetics and Cytology. Lecture and laboratory exercises considering the cell as a structural and functional unit, including an introduction to the principles of cytochemistry. Discussion of the roles of both the nucleus and cytoplasm in cellular processes and in relation to the phenomenon of heredity, variation and mutation in organisms.

7·04. Embryology. Lecture and laboratory exercises concerning the basic concepts and principles of growth and differentiation with emphasis on the experimental method in the development of animals from germ cells to organ systems.

7·05, 7·06. General Biochemistry and Physiology I and II. Contributions of physiology, biochemistry, and biophysics toward an understanding of the structure and functioning of organisms, organs, tissues, and cells. Discussion on cell and tissue components, the chemistry of biological constituents, the physical-chemical basis for the structure and colloidal properties of protoplasm, biophysical and biochemical methods and concepts used in the examination of biological materials, intermediary and general metabolism, also physiological phenomena such as secretion, excretion, permeability, irritability, and contractility.

7·051, 7·061. General Biochemistry and Physiology Laboratory I and II. Laboratory exercises to illustrate the principles discussed in 7·05, 7·06.

7.08. Introduction to Biophysics. Consideration of physical problems which arise from biological systems. Outstanding personalities contributing to biophysical development, past and present. Literature sources of the field. Detailed development of selected examples of biophysical approaches.

7·13. Genetics. Discussion of the facts and theories of heredity and their relation to the present state of biological theory in general.

7·14. Comparative Anatomy. Comparative gross anatomy of vertebrates. Laboratory work consisting of dissection and study of their structure. Classification and general zoölogy of vertebrates.

7·31, 7·32. Biology Seminar (A). Designed to give graduate students experience in critical evaluation of research and in public speaking by presenting oral reports before staff and students.

7·35. Cellular Physiology (A). Lectures and discussions oriented around recent advances in one of the following fields: contractility, transport, coordination (nerve and endocrines), or growth and development. Selection of a different topic each year.

7·351. Cellular Physiology Laboratory (A). Laboratory exercises drawn from the material discussed in 7·35.

7·50. Physical Chemistry of Proteins (A). Considerations of corpuscular proteins including fractionation, physical-chemical characterization, internal structure, surface structure, and modification by physical and chemical agents. Examination of protein interactions such as the corpuscle, fibril transformation and antigen-antibody interactions.

7·51. Physical Chemistry of Proteins Laboratory (A). Laboratory experiments designed to illustrate the principles of 7·50.

7·77, 7·78. Biophysics Seminar (A). Presentation and discussion of reports on current literature in biophysics by participating graduate students.

7·81. Enzymology (A). Quantitative study of enzymes emphasizing their general properties; kinetics of reactions catalyzed by them; conditions which control their activity.

7·811. Enzymology Laboratory (A). Study of the methods of purification of enzymes, determination of their catalytic activity and chemical properties, as well as effects of environmental factors on enzymes.

7·82. Advanced Biochemistry (A). Lectures and laboratory exercises emphasizing current trends in biochemical investigation and illustrating special problems, techniques and approaches of biochemical research; training in the planning and solution of biochemical problems and presentation of results.

7·831. Biochemistry of Microorganisms. General survey course covering the biology, chemistry and physiology of the yeasts, molds, and bacteria. Emphasis placed on modern developments in the field, especially as they contribute to an understanding of general processes in plant and animal life. Historical, taxonomic and morphologic considerations of microbiology given as a background. Laboratory work on various general techniques of microbiology as well as quantitative aspects of the metabolic activities of microorganisms.

7·832. Biochemistry of Microorganisms (A). Emphasis on quantitative aspects of the metabolic activities of microorganisms. Investigation of problems in the general biochemistry of yeasts, molds, and bacteria, by analytical and research methods now in use in various laboratories. Isolation and identification of various metabolic products, metabolic balance sheets, and respiration studies.

7·85, 7·86. Methods in Biophysics I and II (A). Physical and physico-chemical methodology useful for study of biological systems. 7·85: General principles of instrumentation; electrical methods; absorption and emission spectroscopy; microscopy, including use of phase, interference, ultraviolet, polarization and electron microscopes; X-ray diffraction. 7·86: Mathematical procedures, including statistics; use and detection of isotopes and nuclear radiations; biological effects of radiation; physico-chemical methods for studying size and shape of colloidal particles.

7·87. Mathematical Biophysics (A). Selected topics, with emphasis on statistical methods and their application to molecular biology, theories of solutions of electrolytes, transport across membranes, membrane potentials in nerve and muscle, behavior of large molecules in force fields. (Alternate years.)

7·882. Biophysics Laboratory (A). Laboratory coordinated with the topics of 7·86.

7·90. Seminar in Enzymology (A). Designed to acquaint the student with recent advances in the field of enzymology. Special emphasis on enzymes concerned with respiration, phosphorylation, and intermediary metabolism.

7·91, 7·92. Electrical Instrumentation in Biology I and II (A). Principles of electrical instrumentation in the biological sciences including research and industrial biology and certain aspects of medical science, 7·91: principles of electrical measurements and the construction and operation of electrical instruments 7·92: principles of electronics and electronic devices, including amplifiers, oscillographs, photoelectric cells, X-ray tubes, and dosimeters.

7·93. Selected Topics in Biology (A). Class work in various fields of biology not covered by the regular subjects of instruction.

7·941, 7·942. Research Problems (A). Directed research in a field of biological science, but not contributory to graduate thesis.

7·95. Electron Microscopy (A). Principles of electron optics, the electron microscope, interaction of electrons with matter, methods in electron microscopy, applications of electron microscopy.

7·96. Electron Microscopy Laboratory (A). Properties of electron lenses, use of the electron microscope, preparation of specimens, techniques in electron microscopy-selected experiments.

7·97. Tissue Ultrastructure (A). Discussion of the molecular architecture of cell and tissue constituents as revealed by electron microscopy, X-ray diffraction, polarization optics and cytochemical reactions. Study of nerve, muscle, connective tissue and other fibrous structure. (Alternate years.)

7·98. Tissue Ultrastructure (A). Continuation of 7·97, Study of chromosomes, plasma membrane, mitotic mechanisms and cytoplasmic constituents (mitochondria, plastids, particulates). (Alternate years.)

7·99. Molecular Configuration in Biological Systems (A). Consideration of properties conferred on biochemical substances by assumption of specific physical configurations. Optical methods (emphasizing X-ray diffraction) for determining configuration in macromolecular systems. Selected examples of the relationship between molecular order and function in tissues. (Alternate years.)

PHYSICS

Subjects 8·00 to 8·99

8·01. Physics (Mechanics). Fundamental laws of mechanics of particles and rigid bodies. Principles of conservation of mass, energy, momentum and angular momentum. Free use of elementary calculus during second half of subject.

8·012. Physics (College Transfer). Given first term for college transfer students already allowed partial credit for 8·01 and 8·02 on the basis of a previous substantial course in general physics. Not to be taken by any student who must take or repeat 8·01 and 8·02.

8·02. Physics (Mechanics: Heat and Kinetic Theory). Oscillations and waves; hydrodynamics; the equations of state of gases, liquids and solids; elementary kinetic theory.

8·03. Physics (Electricity and Magnetism). Fundamental laws of electricity and magnetism and some of their applications. Electrostatics, direct and alternating currents, magnetic fields, and induced electromotive forces.

8·03S. Physics. Specially arranged for course XIII-A.

8·031. Physics (Electromagnetism). Fundamental laws of electricity and magnetism presented from the standpoint of field theory. Electrostatics, steady currents and their magnetic fields, and time-varying electric and magnetic fields. Designed primarily for students intending to pursue further work in electromagnetism and modern physics. Free use of calculus throughout.

8·034. Physics (College Transfer). Given second term for college transfer students already allowed partial credit for 8·03 and 8·04 on the basis of a previous substantial course in general physics. Not to be taken by any student who must take or repeat 8·03 and 8·04, or 8·031 and 8·041.

8·04. Physics (Optics and Atomic Physics). Propagation, reflection, refraction, interference, and diffraction of electromagnetic radiation. Introduction to the quantum aspect of electromagnetic waves and the wave aspect of particles.

8·041. Physics (Electromagnetism and Electromagnetic Theory of Light). Continuation of 8·031. Electromagnetic waves, electric and magnetic properties of matter. Electromagnetic theory of light and radiation. Quantitative character of 8·031 continued with free use of calculus.

8·05. Physics of Atoms, Molecules and Nuclei I. Survey of the experimental foundation of quantum physics with examples largely from atomic phenomena: optical, X-ray, radiofrequency and infrared spectra; scattering of particles and radiation. Limitations of classical physics; photons, matter waves. Internal structure of atoms, and quantization; vector model, Pauli exclusion principle, and the periodic table of elements.

8·051. Atomic and Nuclear Physics I. Atomic and nuclear phenomena and the interpretation of the experimental facts in terms of quantum physics. For students not majoring in Course VIII.

8·052. Atomic and Nuclear Physics II. Continuation of 8·051, with applications to various topics in modern physics. Topics may vary from year to year.

8·06. Physics of Atoms, Molecules and Nuclei II. Continuation of 8·05. Elementary applications of quantum mechanics to atomic, molecular and nuclear phenomena. Static properties of nuclei, radioactivity, nuclear reactions. Problems of nuclear forces and nuclear models.

8·07. Thermodynamics and Statistical Mechanics. Equations of state of solids, liquids, and gases, and discussion of specific and latent heats. First and second laws of thermodynamics and general thermodynamic formulae with applications to the properties of matter. Elementary statistical mechanics and kinetic theory with applications to the theory of specific heats and black body radiation.

8·08. Electronics. Electron ballistics, mass spectroscopy, introduction to theory of special relativity, principles of high energy accelerators; space charge theory, elements of low pressure gaseous discharges; Fermi-Dirac statistics, thermionic emission, Schottky effect, high field and secondary emission, photoelectric effect in metals, elementary properties of semiconductors.

8·09. Experimental Atomic Physics I. Laboratory experiments on the foundations of modern physics: atomicity of matter and electricity, and special relativity. Typical experiments on Brownian motion, the Millikan oil drop method, charge to mass ratio of high-speed electrons, and Rutherford scattering. Opportunity for detailed technical training in use of machine tools, vacuum practice, glass blowing, and measurements of magnetic fields.

8·10. Experimental Atomic Physics II. Continuation of 8·09: discreteness of atomic and molecular structure and wave-corpuscle dualism. Typical experiments on studies of the ammonia inversion line, the absorption spectrum of sodium, X-ray emission spectra, the diffraction of light, the photoelectric effect, the Zeeman effect, and cosmic ray telescope. Opportunity for detailed training in microwave electronics and pulse counting.

8·11. Experimental Physics. Introduction to experimental research techniques. Assigned laboratory exercises, including setting up and carrying through experiments concerned with fundamental principles in optics, nuclear, atomic, and molecular physics. Designed to bridge the gap between elementary laboratory and research in modern physics.

Acoustics

8·13. Vibration and Sound. Steady-state and transient analysis of vibrating systems: simple and coupled oscillators, strings, membranes; electromechanical coupling and motional impedance; radiation and transmission properties of sound; acoustic impedance, filters and tuned lines; sound waves in rooms.

8·135. Special Problems in Acoustics (A). Advanced problem in acoustics or vibrations with assigned reading and consultation.

8·14. Sound Propagation in Moving Media (A). General discussion of waves in moving inhomogeneous media; geometric vs. wave analysis; elements of the theory of turbulence; generation of sound by turbulent flow; interaction of sound with turbulence; large-amplitude waves and shocks, and interaction of sound with shocks; selected nonlinear wave problems. (Alternate years. Not offered 1956–57.)

Optics and Photography

8·15. Photography. Elementary subject primarily an elective for students not in Course VIII.

8·16. Optics. Fundamental principles of geometrical, physical and physiological optics. Refraction at spherical surfaces, thick lenses, the limitation of rays by apertures, lens aberrations, the resolving power of optical instruments, diffraction, interference, polarization, radiation, light sources, the eye, photometry, color, photoelectricity, the design and construction of optical instruments, stereoscopy, and description of the performance of well-known optical systems such as telescopes, microscopes, photographic objectives, and projection systems.

8·17. Color Measurements. Measurement and specification of color in the objective and subjective sense and the application of such methods to industrial problems. Experiments illustrate the photometric and chromatic properties of the human eye and give experience in the technique of spectrophotometry and colorimetry.

8·18. Special Problems in Optics (A). Experimental work in the optics laboratory with assigned reading and consultation.

8·191. Selected Topics in Physical Optics I (A). The empirical laws of optics, vector-, spinor- and matrix-optics and their relation to wave- and photon-optics.

8·192. Selected Topics in Physical Optics II (A). Selected topics, to change from year to year, in the field of polarization optics dealing with problems of light scattering, diffraction by ultra- and hypersonics, electro-, magneto- and elasto-optical effects.

Physics Continued

Electronics

8·21. Physical Electronics (A). Introduction to the theoretical and experimental aspects of physical electronics, including electron emission from solids (thermionic emission, photoelectric emission, secondary emission and strong-field emission); excitation of electrons in luminescent materials and other solids; excitation and ionization of gases by electrons; and gas discharge phenomena.

8·212. Physical Electronics Laboratory (A). Lectures and laboratory for the development of techniques useful for research in physical electronics and their application to the experimental investigation of important phenomena of physical electronics.

8·231. Electrical Discharges in Gases (A). Fundamental processes of electron emission from cathodes and interaction with gas. Various types of discharges, including ultra-high frequency discharges, the Townsend discharges and breakdown, Geiger-Mueller tubes, the cathode fall, plasma, and anodic parts of glow discharges and arcs.

8·232. Theory of Electrical Discharges in Gases (A). Development of the Boltzmann transport equation and its application to the velocity distribution of electrons in various types of discharges. Calculation of the Townsend coefficients and of breakdown potentials. (Alternate years.)

8·25. Special Problems in Electronics (A). Advanced problem in electronics, with assigned reading and consultation.

X-rays and Crystal Structure

8·27. X-rays and Crystal Physics. X-ray apparatus; production of X-rays, absorption, scattering, refraction, X-ray spectra. Theory and application of the diffraction of X-rays in matter to the determination of the structure of crystals, and the atomic and molecular arrangement in liquids and amorphous solids. General review of the structure of matter as determined by X-ray diffraction analysis.

8·28. X-ray Diffraction (A). Selected topics of advanced nature in the application of X-ray diffraction to problems of solid state physics. The elastic spectrum of crystals from the temperature diffuse scattering of X-rays. Measurement of long range and short range order parameters in binary alloys. Measurement of randomness in structures and cold work distortion in metals by X-ray diffraction. Fourier analysis of imperfect crystals. Extinction effects in perfect crystals.

8·30. Special Problems in Crystal Physics (A). Advanced problem in X-ray diffraction or crystal physics with assigned reading and consultation.

Spectroscopy

8·32. Line Spectra (A). Experimental and theoretical phases of spectroscopy. Production of spectra and spectroscopic analysis. Characteristics of atomic spectra and their interpretation in terms of current theories of atomic structure. (Alternate years.)

8·34. Special Problems in Spectroscopy (A). Experimental work in the Spectroscopy Laboratory, with assigned reading and consultation.

Solid State and Structure of Matter

8·361. Quantum Theory of Matter I (A). Physics of atoms, interatomic forces, and the solid state, treated from the point of view of quantum mechanics, intended for students of metallurgy, chemistry, and other fields, as well as physics. Schrödinger's equation. Atomic structure. Interatomic forces, homopolar and ionic bonds, and molecular structure.

8·362. Quantum Theory of Matter II (A). Continuation of 8·361. Further study of molecular structure. Metallic lattices, energy bands, properties of metals and insulators. Dielectric and magnetic behavior of solids. Properties of semiconductors.

8·363. Selected Topics in Theory of Solids I (A). Discussion of selected topics, changing from year to year, chosen from the theory of energy bands, the theory of molecular structure, the theory of semiconductors, and other subjects.

8·364. Selected Topics in Theory of Solids II (A). Continuation of 8·363.

8·38. Special Problems in Nuclear Magnetism (A). Either experimentation or study in some aspect of magnetic phenomena.

8·411. Statistical Thermodynamics I (A). Principles of thermodynamics. Conditions of equilibrium and stability. The thermodynamic potentials. Derivation of the thermodynamic formulae. Phase transitions of the first and second kind. Nernst's law. Statistical foundations. Ensembles. Canonical and microcanonical distributions. Fluctuations. Elementary quantum statistics, Boltzmann gas, Debye theory of specific heat, entropy constants. (Alternate years. Not offered 1956–57.)

8·412. Statistical Thermodynamics II (A). Fermi-Dirac and Bose-Einstein statistics. The adiabatic method, molecules. Periodic structures, lattice vibrations, electrons in periodic fields. Electric and magnetic properties of matter. Density matrix. Radial distribution function. Irreversible thermodynamics, microscopic reversibility, distribution of fluctuation paths. Transport and relaxation effects. Superfluids. (Alternate years. Not offered 1956–57.)

8·43. Microwave Physics (A). Theory and measurement of atomic, molecular, and crystal energy level differences corresponding to short-wave radio frequencies; rotational energy levels, vibration-rotation interactions, nuclear multipole structure, rotation-induced electronic angular momentum, Stark and Zeeman effect, dia- and para-magnetism, time-dependent perturbations including induced absorption and thermal relaxation processes; properties of angular momentum, tensor interactions and the Racah formalism, and the approximation of perturbations; the interpretation of particular experimental data in terms of the geometry and mass of nuclei, internal fields and charge multipoles; introduction to the experimental parameters defining the limits of experimentation; practical sensitivities and resolution. (Alternate years.)

8·45. Special Problems in Solid State Physics (A). Advanced problems in the physics of the solid state, with assigned reading and consultation.

Nuclear Physics

8·511. Nuclear Physics I (A). Advanced experimental nuclear physics, including description of the properties of nuclei and nuclear transformations, observational methods and instruments and correlation of experimental results with current theory. Charge, mass, radius, nuclear moments, statistics, parity, and selection rules for nuclear transitions. Interaction between particles, binding energy, nuclear models. Radioactive transformations, theory of statistics and fluctuations.

8·512. Nuclear Physics II (A). Continuation of 8·511. Ionization, scattering, and radiative losses for swift charged particles. Properties of neutrons. Origin of gamma rays and their interaction with matter. Transmutation; fission; reactions induced by charged particles, gamma rays, and neutrons; excitation functions. Artificial radioactivity, nuclear spectroscopy.

8·513. Nuclear Physics Laboratory (A). Study of the properties of particles from natural, artificial and fission disintegrations and the corresponding measuring instruments. Use of counters, coincidence amplifiers, ionization chambers, and the cyclotron.

8·52. Advanced Applied Nuclear Physics (A). Advanced applied nuclear physics. Physical problems involved in the use of radioactive and stable isotopic tracers. Industrial and engineering applications. Units, standards, instrumentation, and techniques. Radiation hazard evaluation. Shielding. Safe handling and disposal of radioactive materials. (Alternate years.)

8·531. Nuclear Physics for Engineers I (A). Nuclear phenomena, for advanced students not majoring in physics. Stationary states of nuclei: nuclear charge, radius, mass moments, parity, and statistics. Barrier transmission; radioactive transitions; alpha, beta, and gamma decay. Binding energy, nuclear forces, and nuclear models.

Physics Continued

8·532. Nuclear Physics for Engineers II (A). Continuation of 8·531. Nuclear dynamics: energetics and cross sections for nuclear reactions, scattering, and fission. Passage of charged particles through matter: ionization, scattering, and radiative losses. Interaction of neutrons and gamma rays with matter.

8·541. Advanced Topics in Nuclear Physics (A). Intensive study of selected subjects of contemporary interest in nuclear and high-energy physics, with subject matter related to research in progress at the Institute and treated from the point of view of the experimentalist. Stress on the relation of experiment to the development of current theories.

8·551. Theory of Nuclear Structure I (A). Review of the current theories of the structure of atomic nuclei. Nature of internuclear forces as determined by two-body phenomena. Three- and four-body problems. Nuclear spectroscopy. (Alternate years.)

8·552. Theory of Nuclear Structure II (A). Continuation of 8·551. Interaction of nuclei with light. Beta decay. Shell structure. Theory of nuclear reactions. Alpha decay. (Alternate years.)

8·56. Cosmic Rays and High Energy Phenomena (A). Mesons and their occurrence in cosmic rays and interaction with nuclei and heavy particles, showers, cascades. Artificial production of mesons and their properties. (Alternate years. Not offered 1956–57.)

8·58. Meson Physics (A). Production, properties, interactions of π-mesons. Selection rules and phenomenological description of interactions with nucleons and nuclei, and associated high energy phenomena. Connections with meson field theories. (Alternate years. Not offered 1956–57.)

8·59. Statistical Fluctuations in Physical Processes. Application of statistical theory of fluctuations and errors to experimental physics. Theoretical frequency distributions: binomial, normal, Poisson, interval, and composite distributions. Statistical characterization of data, and tests of significance. Applications of Poisson statistics to the response of nuclear detection instruments, including scaling circuits and counting rate meters. Appraisal of random processes by inefficient statistics using nonparametric tests. (Alternate years. Not offered 1956–57.)

8·60. Special Problems in Nuclear Physics (A). Experimental work on radioactivity, nuclear bombardment, and general nuclear research, with assigned reading and consultation.

Theoretical Physics

8·71. Introduction to Theoretical Physics I (Mechanics) (A, except for Course VIII). Mechanics of particles, planetary motion, rigid bodies, vibrating particles, vibrating strings and membranes, elasticity and hydrodynamics. Use of Lagrange's equations and generalized coordinates, ordinary and partial differential equations, Fourier series, and vector analysis.

8·72. Introduction to Theoretical Physics II (Electromagnetic Theory) (A, except for Course VIII). Electrostatics and magnetostatics. Maxwell's equations, the potentials, Poynting's theorem. Plane waves in empty space, reflection and refraction. Wave guides and resonant cavities. Spherical waves, field of oscillating dipole. Radiation from antennas and antenna arrays, and from atoms and molecules. Interference, diffraction, scattering. Electron theory of dielectric constant, permeability, and polarization.

8·731. Introduction to Quantum Theory I (A). Qualitative discussion of quantum phenomena, relation to classical mechanics, Schroedinger formulation. Motion of free particles, one dimensional problems, transmission through potential barriers, binding, virtual levels using both exact and approximate methods. Central force fields, Zeeman and Stark effects, scattering. Many-body problems, complex atoms, molecules, valence. Interaction with radiation.

8·732. Introduction to Quantum Theory II (A.) Operator formulation of quantum theory. Matrix mechanics. Symmetry and integrals of motion. Generalized angular momenta. Pauli spin theory, composition of angular momenta. Perturbation theory, variational methods, etc. Many-body problems. Applications to nuclear physics including the two- and three-body problems, binding energy of light nuclei, scattering of particles by nuclei, alpha decay.

8·74. Applications of Group Theory to Theoretical Physics (A). Theory of groups and their matrix representations. Application to physical problems drawn from quantum and classical mechanics. Permutation groups and the Dirac Vector Model. Rotation and double groups. Space groups. (Alternate years.)

8·791. Methods of Theoretical Physics I (A). Solution of physical problems systematized by grouping them according to the partial differential equation they satisfy. Boundary conditions and methods of solution peculiar to each equation, including separation of variables, eigenfunctions, Green's function, integral equations, variational and perturbation procedures, integral representations, conformal transformations. Applications to problems in electrostatics, hydrodynamics, acoustics, quantum mechanics, etc. (Alternate years. Not offered 1956–57.)

8·792. Methods of Theoretical Physics II (A). Continuation of 8·791, with emphasis on solutions for vector fields, electromagnetic fields, elasticity, etc. Special emphasis given, in alternate years, to either: (1) Electromagnetic wave theory, including wave guide theory, radiation scattering and propagation of microwaves, etc.; or (2) Relativity, including special relativity, relativistic dynamics with application to particle accelerators, selected topics in general relativity. (Alternate years. Not offered 1956–57.)

8·80. Advanced Mechanics (A). Generalized equations of motion: d'Alembert, Lagrange, Hamilton; transformation theory and the Hamilton-Jacobi equation; perturbation theory; theory of orbits. (Alternate years.)

8·861. Relativistic Quantum Mechanics I (A). Relativistic Dynamics. The Klein-Gordon equation. π-mesic atom and Coulomb scattering of π-mesons. Relativistic Green's functions. The Dirac equation. The hydrogen-atom and scattering of electrons. Quantization of scalar, electromagnetic and spinor fields. (Alternate years. Not offered 1956–57.)

8·862. Relativistic Quantum Mechanics II (A). Spin and statistics. Theory of the scattering matrix. Feynman graphs. Compton effect, Møller scattering and Pair creation. Mass and charge renormalization, vacuum polarization. Radiative corrections to scattering and Lamb shift. Renormalization in Heisenberg representation. (Alternate years. Not offered 1956–57.)

8·90. Special Problems in Theoretical Physics (A). Reading, consultation, and original investigation on a problem in theoretical physics.

CHEMICAL ENGINEERING

Subjects 10·00 to 10·99

10·11. Chemical Engineering. Designed to acquaint the student with the engineering method as applied to chemical problems, by the use of the project and case system.

10·15. Thesis Reports. Preliminary work taken before the S.B. thesis in Chemical Engineering. Written and oral reports on proposed thesis.

10·17. Industrial Chemistry. Techniques of industrial chemical calculation and their application to the chemistry of fuels and combustion. Lewis, Radasch and Lewis, *Industrial Stoichiometry.*

10·18. Industrial Chemistry. Industrial chemical processes studied from the point of view of both the chemical

Chemical Engineering Continued

reactions forming the basis of the process, and the plant necessary for carrying on these reactions. Development of interrelationships of the different industries as to raw materials, sources of energy, and types of apparatus. Extensive problem work.

10·21. Industrial Chemistry. Continuation of 10·18. Industries dealing with amorphous materials, including glass, ceramics, leather, paints, textiles, paper, rubber, etc. Lewis, Broughton and Squires, *Industrial Chemistry of Colloidal and Amorphous Materials.*

10·25. Industrial Chemistry (A). Industrial stoichiometry and the technology of more important chemical industries, with emphasis on applied physical chemistry. Discussion of the interrelationships of the important industries and problem work on the various processes. For graduate students primarily interested in industrial chemistry and particularly for new students from other schools who have had insufficient training in industrial stoichiometry.

10·26. Industrial Chemical Laboratory. A laboratory and design study of the evolution of a chemical process through the successive stages which culminate in the design of the necessary plant, and exemplifying the integration of chemistry and engineering. Effective presentation of conclusions is developed through oral and written reports.

10·27. Chemical Engineering Laboratory. A program of laboratory experiments and reports dealing with fluid flow, heat transfer and other unit operations such as evaporation, absorption, distillation, drying, filtration and combustion.

10·28. Chemical Engineering. Thermal properties of matter and the energy relationships underlying mechanical and chemical processes, including discussion of the first law of thermodynamics as applied to both batch and flow processes, and such operations as combustion, compression and handling of fluids and thermal control of chemical reactions. Development of second law and its elementary applications.

10·29. Chemical Engineering. Quantitative engineering applications of the second law, including heat engines, heat recovery, particularly in chemical operations, thermal level of heat in relation to industrial processes, chemical equilibria and thermodynamic efficiency of chemical processes. Weber, *Thermodynamics for Chemical Engineers.*

10·30. Engineering Equipment. For students in Course X-B. Instruction and practice in testing engineering equipment such as pumps, fans, turbo-blowers, blowing engines, motors, generators, etc., commonly used in chemical engineering operations. Emphasis on determining the operating characteristics of such equipment under plant conditions.

10·31, 10·32. Chemical Engineering. Basic principles underlying the unit operations of chemical industry; material and energy balances, rate laws, and equilibrium considerations. Application of primary unit operations in 10.31 to problems in heat transmission, evaporation, condensation, and filtration. Application of laws of mass transfer in 10.32 to distillation, absorption, extraction, air conditioning, and drying. Walker, Lewis McAdams and Gilliland, *Principles of Chemical Engineering; Flow of Heat Notes,* August 1950.

10·311. Heat Transfer. Fundamentals of conduction, convection, and radiation of heat, with applications to problems arising in practice. (Primarily for selected officers of the U. S. Navy and Coast Guard.)

10·33. Analytical Treatment of Chemical Engineering Processes (A). Mathematical techniques for handling rate problems such as diffusion, heat transfer and chemical reaction which are basic to most chemical engineering operations. Training in setting up ordinary and partial differential equations corresponding to specific physical situations, and in methods available for their solution, including various graphical constructions. Sherwood and Reed, *Applied Mathematics in Chemical Engineering.*

10·36. Process Design. Presentation and discussion of a real process and design problem, the class selecting the best process and specification of optimum equipment sizes and operating conditions. Cost estimates and economic evaluation of the process. Entire term ordinarily devoted to a single process design.

10·37. Chemical Kinetics. Emphasis on reactions of simple order and mechanism with application to processes of industrial importance. Stress on interaction of heat and mass transport with chemical reaction and application to simple design problems.

Engineering Operations

10·40. Chemical Engineering Thermodynamics (A). Properties of homogeneous and heterogeneous systems, physical and chemical equilibria and energy effects, and mechanical manipulation and control of industrial processes. Emphasis on behavior of complex mixtures, correlation of data, and methods of approximation. Weber, *Thermodynamics for Chemical Engineers.*

10·41. Distillation (A). Basic principles of distillation as applied to binary and multi-component mixtures. Problems involve the vapor-liquid equilibria of ideal and non-ideal solutions, batch and continuous simple distillations, steam distillations, vacuum and pressure distillation, and rectification. Special attention is given to the distillation of systems of limited miscibility, azeotropic distillation, extractive distillation, and adsorption distillation. Robinson and Gilliland, *Elements of Fractional Distillation.*

10·45. Distillation and Absorption (A). Distillation, including rectification of binary and complex mixtures. Diffusional processes, with attention to design computations for gas absorption equipment. A combination and condensation of subjects 10·41 and 10·46, using same texts.

10·46. Absorption and Extraction (A). Basic principles of equilibria, mechanism and rate of interaction. Quantitative applications including the absorption of single gases, such as sulfur dioxide, ammonia and hydrochloric acid, and complex mixtures, such as light oil, casing-head gasoline, refinery gases, and the like. Attention to graphical methods. Basic principles of extraction by liquids, solvent recovery by absorption and the leaching of various solids. Sherwood and Pigford, *Absorption and Extraction.*

10·47. Ion Exchange (A). Discussion of preparation and properties of synthetic organic exchangers. Review of industrial applications of the general ion exchange process; equilibrium and rate studies for fixed and moving beds; treatment of ion exchange chromatography.

10·50. Heat Transmission (A). Application of the fundamentals of conduction, radiation and convection of heat to the problems and situations in chemical industry. Emphasis upon the general relationships between fluid dynamics and diffusional processes. Extensive use of graphical methods. Trends of present development. McAdams, *Heat Transmission.*

10·52. Chemical Engineering II (A). Emphasis on basic theories in flow of fluids and mass transfer. Application to problems of advanced character and attention to recent developments. Walker, Lewis, McAdams and Gilliland, *Principles of Chemical Engineering.*

10·53. Chemical Engineering Design (A). Design of a complete plant. Plant size, location and process used based on market analysis and technical and economic evaluation of alternative processes and of sources of raw materials.

10·55. Economic Balance in Chemical Industry (A). Development of original power in the solution of problems in chemical industry. Problems covering a wide range of topics, with quantitative analysis of various factors under the control of the designer, determining the optimum design from the viewpoint of cost and economic return. Emphasis on economic balance applied to unit operations and processes.

Applied Chemistry

10·62. Advanced Thermodynamics (A). Further study of physical and chemical equilibria, particularly in heterogeneous systems. Special emphasis on prediction of thermodynamic properties by theoretical and empirical techniques. Consideration of the effects of surface and force field energies.

Chemical Engineering Continued

10·63. Industrial Chemistry II (A). Chemical industries dealing primarily with amorphous materials, including thermoplastics, textile fibres, cellulose products, leather and rubber. Survey of the general principles of colloidal chemistry followed by analyses of important problems encountered in these industries. Lewis, Broughton and Squires, *Industrial Chemistry of Colloidal and Amorphous Materials.*

10·65. Applied Chemical Kinetics (A). Analysis of problems involved in carrying out chemical reactions in the plant, including study of theories of reaction kinetics and catalysis. Emphasis on the design of reactors involving heterogeneous catalysis.

10·66. Colloid Chemistry (A). Discussion of the colloidal state of matter and of the characteristics and behavior of colloids; description of natural colloids and of the different methods of producing matter in the colloidal state, and consideration of the methods applied in the study of substances in the colloidal state.

10·67. Applied Surface Chemistry (A). Structure and properties of interfaces; functions and uses of surfactants; emulsification, foaming, detergency. Dispersion and flocculation mechanisms and their effects on sedimentation, filtration, suspension-rheology. Flow through porous media. Thermodynamics and kinetics of nucleation and crystal growth. Adhesion and adhesives. Emphasis on application of surface phenomena to chemical process technology.

10·69. High Polymer Technology (A). Broad review of the chemical and engineering aspects of high polymer synthesis and manipulation. Physical methods of characterizing high polymers; basic chemistry and kinetics of polymerization reactions; industrial polymerization processes. Compounding and processing of resins and elastomers; molding, extrusion, and other polymer manipulation techniques.

10·691. Colloid Chemistry of Silicon (A). Survey of the chemical and physical properties and molecular structure of substances containing silicon as their basic constituent. Correlation of theoretical considerations of structure with colloidal properties of scientific and industrial importance. Hauser and le Beau, *Silicic Chemistry.* (Not offered 1956–57.)

FUEL ENGINEERING

10·70. Principles of Combustion (A). Open to students wishing to specialize in the engineering phase of fuel engineering. Emphasis on the application of fundamental principles in combustion reactions, including high output power plants of rocket and jet types. Problems illustrating the quantitative application of principles to fuel utilization. Hottel, Williams and Satterfield, *Thermodynamic Charts for Combustion Processes.*

10·71. Fuel Engineering (A). For students with an adequate background of stoichiometry, physical and organic chemistry and thermodynamics. Application of combustion principles to problems of design and operation of equipment for fuel processing and utilization. Particular emphasis on power generation involving compressible flow systems.

10·74. Furnace Design (A). Principles and calculations of furnace design and construction dealing with rates of heat transfer and with flow of gases in furnaces. Emphasis on radiant heat transmission from gases, surfaces and clouds of particles. Quantitative design and layout of several furnaces, retorts or still-settings.

School of Chemical Engineering Practice

(See also N1–N3 Engineering Practice School at Oak Ridge, page 169)

10·81. School of Chemical Engineering Practice — Bangor Station (A). Conducted in the plants of the Eastern Corporation at South Brewer, Maine, manufacturers of writing papers and sulphite pulp, and of the Penobscot Chemical Fibre Company at Oldtown, Maine, manufacturers of soda and sulphite pulp. Operations include production of chlorine and caustic by electrolysis, of sulfite liquor by absorption, the recovery of soda by leaching, evaporation, smelting and electrical precipitation and many applications of drying.

10·82. School of Chemical Engineering Practice — Parlin Station (A). Conducted in the Cellulose Products plant of Hercules Powder Company in Parlin, New Jersey. The central operations of nitric acid production and nitration of cellulose involve many problems of distillation, catalysis at high pressure, corrosion and disposal of fume and waste.

10·83. School of Chemical Engineering Practice — Buffalo Station (A). Conducted in the Lackawanna Plant of the Bethlehem Steel Company. Blast furnace, open hearth and steel finishing operations, together with by-product coke production, involve a wide variety of work in such fields as combustion, heat transfer, flow of fluids, absorption and distillation.

10·84. School of Chemical Engineering Practice — Bangor Station. Similar to 10·81. Given for seniors during the second period of the academic year.

10·85. School of Chemical Engineering Practice — Parlin Station. Similar to 10·82. Given for seniors during the second period of the academic year.

10·86. School of Chemical Engineering Practice — Buffalo Station. Similar to 10·83. Given for seniors during the second period of the academic year.

General

10·90. Experimental Research Problem (A). Designed to meet the needs of special and graduate students who wish to carry out some minor investigation in a particular field. Subject and hours arranged to fit individual requirements.

10·991, 10·992. Seminar in Chemical Engineering (A). For graduate students engaged on doctorate theses.

GEOLOGY AND GEOPHYSICS

Subjects 12·00 to 12·99

12·00. Earth Science (Geology, Geophysics, Geochemistry). Lectures and demonstrations on the more important aspects of the origin, history, physical behavior and chemical constitution of the earth and the methods of reasoning and investigation by which the major concepts, laws and hypotheses of earth science were formulated. General topics to be discussed: earth origin and methods of determining sequence of events in geologic history; development of continents, oceans and mountains; evolution of plants and animals through geologic time; formation, distribution, and methods for discovery of minerals, rocks, ores, coal, petroleum and natural gas; reshaping of the earth's surface features by water, ice and wind; activities associated with earthquakes, volcanoes and hot springs; and discussion of the kinds of work carried on by earth scientists as geologists, geophysicists and geochemists. Local field trips to collect minerals and study various features of bed rocks and glaciation.

12·001. Astronomy. Survey of the history of astronomy

Geology and Geophysics Continued

and its contributions in philosophy and science to our modern civilization. Emphasis on present theories of the age, origin, and evolution of the Universe. Lectures on the basic physical and chemical principles and the instruments used in modern astrophysics, followed by a study of the planets and their relation to the Universe. Discussion of concepts of stellar magnitudes, spectral classification, stellar energy production, galactic dynamics, Universe expansion, and element origin. Orientation of the Earth to the Universe.

12·011T Mineralogy I. Study of the more common minerals with emphasis on their crystal structure and crystal chemical relationships. Introduction to common rock types. Hurlbut, *Dana's Manual of Mineralogy.*

12·012T. Mineralogy II. Intensive study of minerals with emphasis on determinative methods. Use and occurrence of minerals. Identification and classification of rocks. Hurlbut, *Dana's Manual of Mineralogy.*

12·05. Mineralogical Seminar (A). Presentation and discussion of literature bearing on certain phases of theoretical mineralogy.

12·14. Petrology. Occurrence and origin of igneous and metamorphic rocks, with emphasis on correlation with experimental work. Turner and Verhoogen, *Igneous and Metamorphic Petrology.*

12·15. Petrology Laboratory. Laboratory study with the polarizing microscope of thin sections of igneous, metamorphic, and sedimentary rocks. Rogers and Kerr, *Optical Mineralogy;* Williams, Turner, Gilbert, *Petrography.*

12·161, 12·162. Mineral Deposits and Petrology Seminar (A). Discussion of igneous and metamorphic rocks, mineral deposits, and problems bearing on their genesis.

12·17. Advanced Petrology Laboratory (A). Techniques of petrological research with emphasis on applications of the Universal stage to mineralogical and petrofabric problems. Arranged to suit the requirements of individual students.

12·201. Crystallography. Geometrical fundamentals of crystallography important in the study of mineralogy, metallography, chemistry, and solid-state physics. Symmetry and its restriction in crystals; crystal classes; crystal systems; crystal forms; methods of determining crystal symmetry; space groups; and equipoints. Buerger, *Elementary Crystallography.* (Not offered 1956–57.)

12·202. Crystallography. Introduction to the theory of the structure of crystals, and application of crystal structure concepts to crystallography and mineralogy, including elementary crystal chemistry, structures of the silicates, polymorphism and transformations, disordered structures, solid solution and segregate phase formation, crystal growth and habit, crystal imperfection and lineage structure, and plastic deformation of crystals. (Not offered 1956–57.)

12·231. Optical Crystallography. Discussion of principles of optical crystallography, illustrated in the laboratory by the immersion method of crystal identification. Larsen and Berman, *Microscopic Determination of the Non-opaque Minerals* (U. S. G. S. Bull. 848); Wahlstrom, *Optical Crystallography.*

12·232. Advanced Optical Crystallography (A). Determination of the optical properties of crystals using Universal stage, minimum-deviation, and variable temperature-wavelength methods. Opportunity to undertake optical research problems.

12·27. Crystallographic Research (A). Supervised research on some crystallographic problem.

12·301T. Physical Geology. Objective study of the earth including geological agents and processes. Structural relations of rock masses. Laboratory and field exercises.

12·302. Historical Geology. Development of the surface features of the earth from the time of its origin to the present, including the nature and distribution of lands and seas during the past. Evolution of plants and animals. Principles and methods used in interpreting the geologic record of the past.

12·303T. Geological Surveying. At Nova Scotia Centre for Geological Sciences. Training in surveying methods and in handling instruments commonly used by geologists in the field.

12·304T. Field Investigations and Reports. At Nova Scotia Centre for Geological Sciences. Geological examination of areas selected for either scientific or economic interest. Specific areas assigned to each group of students for survey and preparation of geological sections, maps, and reports.

12·308. Sedimentation and Stratigraphy. Principles and data on which geologic column is based. Regional study of geologic formations and structure. Advanced historical geology.

12·321. Engineering Geology. Geology adapted to the needs of engineers.

12·322. Engineering Geology. Relations of geology to engineering problems, with reviews of actual cases.

12·40. Mineral Deposits. Occurrence and origin of ore deposits. Lindgren, *Mineral Deposits, Fourth Edition.*

12·42. Ore Guides. Application of geological, geophysical, and geochemical data to problems in mineral exploration. Laboratory work on mineral identification, geochemical techniques, and interpretation of air photos and geophysical maps.

12·432. Advanced Mineral Deposits Laboratory (A). Study of specimens or suites of specimens from mineral deposits; metallographic or petrographic work.

12·44T. Petroleum Geology. Nature and origin of petroleum and natural gas. Factors responsible for accumulation of oil and gas illustrated by a study of typical oil fields. Application of geologic principles to location and evaluation of new fields.

12·45. Petroleum Geology Laboratory. Methods of illustration and interpretation of oil field data, in conjunction with principles discussed in 12·44.

12·461, 12·462. Petroleum Geology Seminar (A). Discussion of stratigraphy and structure of principal oil-bearing areas of the world, with special reference to the tectonic setting.

12·51. Paleontology. Study of the past plant and animal life of the earth through comparison of fossils with living plants and animals. Shimer, *Introduction to the Study of Fossils;* Shrock and Twenhofel, *Principles of Invertebrate Paleontology.*

12·52. Advanced Paleontology (A). Laboratory work and assigned reading on fossil invertebrates and index fossils, or on some aspect of stratigraphic paleontology. Shrock and Twenhofel, *Principles of Invertebrate Paleontology;* Shimer and Shrock, *Index Fossils of North America.*

12·581. Sedimentology. Survey of the chief types of sediments and sedimentary rocks, with some consideration of the environmental conditions under which sediments are formed and deposited. Shrock, *Sequence in Layered Rocks.* (Not offered 1956–57.)

12·582. Advanced Sedimentology (A). Laboratory, and microscopic study of the important primary and secondary physical, chemical and structural characteristics of sedimentary rocks using hand specimens, polished specimens and thin sections. Arranged to suit preparation and requirements of individual students. Shrock, *Sequence in Layered Rocks.*

12·583. Sedimentology Seminar (A). Discussion of latest literature on the origin, deposition, classification and significance of sediments and sedimentary rocks.

12·65. Special Problems. For seniors desiring special laboratory or field work on geologic problems.

12·66. Special Problems (A). For graduate students desiring special investigation of some geological subject or special laboratory or field work on geological problems.

12·702. Structural Geology. Primary structural features of igneous and sedimentary rocks and the nature and causes of secondary structural features, joints, fissures, faults, folds and rock cleavage, their manner of formation and their significance.

Geology and Geophysics Continued

12·721, 12·722. Tectonics Seminar (A). Discussion of the structural evolution of typical regions and of the relation of metamorphic and igneous rocks to orogenic belts. Introduction to microtectonics and experimental rock deformation, with discussion of regional structures to which petrofabric methods have been applied. Assigned reading and reports.

12·73. Tectonic Elements. Introduction to geology and geophysics of continental and oceanic structure, and deformation of the earth's crust. Laboratory on regional structural problems.

12·80. Geochemistry. Cosmic abundance of the elements. Geochemical rules and their application to an understanding of the distribution of the elements in the primary minerals and rocks and in the products of weathering. Importance of water in weathering cycle. Redox potentials. Natural radioactivity and enrichment of certain isotopes in minerals.

12·801T, 12·802T. Theoretical Geology I and II. Application of thermodynamics, statistical mechanics, and the mechanics of continuous media to problems of geology. Laws of thermodynamics; introduction to statistical mechanics; equations of state of one component and multi-component systems with special emphasis on silicate systems; elementary elasticity and the thermodynamics of elastic bodies; elementary hydrodynamics and thermodynamics of hydrodynamics with emphasis on motion of fluids through porous media; thermodynamics of irreversible processes; diffusion of material in the presence of a thermal gradient.

12·803T. Theoretical Geology III (A). Continuation of 12·802.

12·804T. Theoretical Geology IV (A). Problems in Theoretical Geology. Topics varying from year to year.

12·81. Spectrochemical Analysis (A). Elementary theory of spectroscopy. Excitation sources, particularly the D-C arc discharge. Qualitative and quantitative analysis with particular emphasis on the analysis of minerals, rocks and soils with the D-C arc. Ahrens, *Spectrochemical Analysis.*

12·831, 12·832. Elements of Geophysics I and II. The earth's magnetic field, and effect of the magnetization of materials near the surface; gravity and its relation to the earth's figure, constitution, and surface irregularities; elastic waves and their uses in seismology in the interpretation of the structure of the earth and near-surface structures of interest in oil and gas exploration; earth heat, radioactivity, and energy considerations in a study of the processes that give rise to vulcanism and mountain building; electrical characteristics of near-surface materials, natural electric fields, and electric and electromagnetic methods of detecting mineral deposits. Chapman, *Earth Magnetism;* Jeffreys, *Earthquakes and Mountains;* Nettleton, *Geophysical Prospecting for Oil.*

12·86. Elements of Seismology. The nature of earthquakes and their effects, and the propagation of seismic waves and their bearing upon the structure of the earth. Seismic instruments and the applications of seismology to prospecting and engineering.

12·87. Introduction to Geophysics. Principles of geophysics, and their application to geophysical exploration.

12·873, 12·874 Advanced Geophysics (A). Mathematical and physical basis of the phenomena studied in earth physics and exploration geophysics, with particular emphasis on the theory of quantitative interpretation of geophysical data. Potential theory as applied to gravity, magnetism, electricity and heat flow. Elasticity and seismic wave propagation; electromagnetic induction and wave propagation.

12·881, 12·882. Geophysics Seminar (A). Selected topics in the physics of the earth: seismology, geomagnetism, geothermal problems, figure of the earth, gravitational problems and geologic age measurement.

12·89. Isotope Geology (A). Measurement and uses of the relative abundance of isotopes in geological materials; methods of measuring geological time, radioactive production of heat, and the quantity of radioactive elements in rocks and minerals, with demonstrations.

12·91. Elements of Mining. Exploration and development of mines. Prospecting procedures and fundamentals of mining practice. Methods of production, management, organization, mining laws, health and safety. Field trips to operating properties.

12·92. Mining Methods and Practice. Mining systems, costs, engineering and administration. Attention concentrated on adaptability and operation of representative methods of mining as applied to either open-pit or underground mining of metals and non-metallics. Opportunity for mine inspection trips.

12·94. Mineral Economics. World mineral resources their economic importance and industrial potential. Effects of distribution, control, monopolies, cartels, and tariffs on availability of mineral raw materials. Current mineral problems, national and international.

12·95. Valuation of Mineral Property (A). Methods of examination and principles of valuation to equip the student with the theory of valuation and its practical application to representative types of mineral and oil property. Emphasis on sampling, sampling calculations, estimation of ore, costs, selling prices, profit spread, the interest rate, depletion, and taxation. Parks, *Examination and Valuation of Mineral Property.*

12·96. Mineral Economics Seminar (A). Detailed study or report on a particular mineral, area, or condition developing in the mineral field.

12·97. Mineral Valuation Seminar (A). Optional study; engineering report on valuation of a mineral or oil property, or detailed investigation of some phase of the problem, e.g., taxation.

NAVAL ARCHITECTURE AND MARINE ENGINEERING

Subjects 13·00 to 13·99

13·01. Naval Architecture I. Statics of naval architecture: buoyancy and stability of ships in intact, damaged and partially waterborne conditions, hydrostatic aspects of strength calculations; international regulations on freeboard, tonnage, subdivision and stability; problems in the launching of ships. Laboratory work consisting of applications of principles of stability and free surface.

13·012. Naval Architecture. Combination of material in 13·01 and 13·02, including laboratory exercises. (Primarily for selected officers of the U. S. Navy and Coast Guard.)

13·02. Naval Architecture II. Dynamics of naval architecture: resistance, propulsion, oscillation and steering of ships and design of propellers and rudders. Laboratory work consisting of towing tests of ship models in the towing tank and tests of model size propellers in the propeller tunnel.

13·03. Principles of Ship Design (A). Principles and procedures involved in the preparation of the preliminary design of ships. Manning, *The Theory and Technique of Ship Design.*

13·031. Preliminary Design of Ships (A). Preparation of the preliminary design of a ship selected by the student to fulfill the Department's requirement of a comprehensive design problem for the Engineering Degree. Manning, *The Theory and Technique of Ship Design.*

13·04. Advanced Ship Design (A). Seminars dealing with problems in naval architecture and ship design more advanced than those given in the undergraduate course. Special attention to historical development, basic design of various types, structural design, stability in the damaged condition, subdivision, powering, analysis of performance, economics of design, general arrangement, cargo handling, launching, heating, ventilation, air conditioning, hull piping systems, etc. Discussion of naval and merchant vessels.

13·05T. Advanced Hydromechanics of Ship Design (A). Advanced work in the fields of ship resistance, propulsion, seakeeping, excited oscillations, directional stability, automatic control, and allied topics. Discussion of model

Naval Architecture and Marine Engineering Continued

research techniques and recent research and progress in ship hydrodynamics.

13·06. Special Problems in Naval Architecture and Marine Engineering (A). Special reading, study, design, and investigation under supervision of a specially qualified member of the Faculty. Topics in Naval Architecture or Marine Engineering individually arranged to suit the interests of the student. Only for students with background in the field of Naval Architecture and Marine Engineering.

13·12. Warship General Arrangements (R). Principles involved in the general arrangements of warships and in the design and installation of hull systems, fittings, and auxiliary machinery. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·13. Warship Structure, Theory I (RA). Stresses in a warship and the design of the hull structure. Hovgaard, *Structural Design of Warships.* (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·14. Warship Structure, Theory II (RA). Continuation of 13·13, including problems peculiar to submarines. Lectures and seminars. Hovgaard, *Structural Design of Warships; Technical papers and reports.* (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·15. Warship Basic Design I (RA). Principles and procedures to be followed in the preparation of the preliminary design of warships. Manning, *The Theory and Technique of Ship Design.* (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·16. Warship Basic Design II (RA). Fundamental considerations involved in the selection and provision of the military features of warships. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·17. History of Warships (R). Presented in the form of a seminar, supplemented by lectures by members of the Faculty and other authorities. Designed to give a perspective view of the characteristics of warships, including the interrelationships of such characteri stics and the Naval policies of the several powers, particularly the United States. Emphasis on warship developments of World War II and possible developments of the future. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·20. Elementary Ship Design. Comprises fairing warship lines, construction of a half-model and indoctrination lectures by the staff. (Primarily for Course XIII-A.)

13·21. Warship Form Design (R). Work in the drawing room which includes calculations for and drawing of displacement and other curves, cross curves of stability, curves of statical stability, and floodable length curves for a warship from preliminary design data. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·22. Warship General Design (R). Analyses of general arrangement problems and the preparation of general arrangement plans. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·24. Warship Structure, Design I (RA). Determination of requirements for longitudinal strength of a warship, the preparation of a structural design for a midship section and arrangement of shell and deck plating and framing. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·241. Warship Structure, Design I (RA). Abridgement of 13·24 including only the preparation of a structural design for a midship section. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·25. Warship Structure, Design II (RA). Continuation of 13·24, including the preparation of structural designs for a transverse bulkhead, stem and bow framing, stern framing with stern post and propeller struts and a transverse strength analysis. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·26. Preliminary Design of Warships (RA). Work in the drawing room which includes the preparation of the necessary plans and calculations for the preliminary design of a warship. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·40. Elementary Ship Design and Construction I. Familiarization with naval architecture and marine engineering terms and ship types. Introduction to ship design: ship's form; lines drawing; basic hydrostatic characteristics; integrating rules; regulatory bodies and tonnage rules. Introduction to ship construction: ship structure; shipyard layout, organization and tools.

13·41. Elementary Ship Design and Construction II. Elements of main propulsion machinery: steam and diesel. Propeller geometry, weight and inertia calculations. Marine fuels. Auxiliary shipboard gear: deck machinery; steering gear; lifeboats; ground tackle; cargo handling gear. Hull piping systems. Introduction to ship launching and post launching activities: outfitting and trials.

13·42. Hull Form Design. Displacement and metacenter calculation; curves of form; calculations of stability; cross curves and curves of statical stability; floodable length calculation.

13·43. Ship Structural Drawing. The design of a ship's structure in compliance with the requirements of the American Bureau of Shipping Rules; thereafter checking the adequacy of the structure by the balancing of the ship on a wave to determine the bending moment, and calculating the moment of inertia of the mid-section of the ship to establish the maximum stress in compression and tension.

13·45. Ship Structures. Study of the general and local stresses in ships, both longitudinal and transverse, including some consideration of dynamic loads. Discussion of shipbuilding materials, structural sections, continuous beam and elastic stability theories with application to ship structure. Lectures on riveting and welding, culminating in the factors involved in the design of the midship section longitudinally continuous material; examination of bulkheads and framing from the theoretical aspects in conjunction with A. B. S. Rules requirements.

13·46. Ship Design. Lectures on the basic principles of ship design and the methods of preparing the preliminary design of a ship. Drawing room work consisting of the preliminary design of a merchant ship, including the determination of principal dimensions and external form, internal arrangements to satisfy subdivision, cargo stowage and accommodation requirements, the design of the salient structural features, and the machinery and shafting arrangement.

13·52. Marine Engineering I. Basic considerations, common calculations and performance of boilers, steam turbines, steam reciprocating engines, surface condensers, evaporators; steam conditions and cycles. Diesel engines, cycles, supercharging, scavenging, auxiliary plant, Diesel Electric drive. Effect of direct drive of propeller on Diesel.

13·53. Marine Engineering II. Heat balance, steam cycles, auxiliary requirements. Characteristics of pumps and centrifugal fans; multi-stage steam turbine steam path, its efficiency and performance; reduction gears. Steam piping system and friction losses. Properties of machinery for ship propulsion and auxiliary machinery. Electrical equipment, particularly electric motors, generators, and distributing systems; ventilation equipment and pumps.

13·54. Marine Engineering Dynamics. Dynamical problems of Marine Engineering. Elementary vibration theory, the balance of rotating and reciprocating machinery. Torsional vibration of reciprocating machinery, vibration of turbines, vibration of ships.

13·56. Marine Engineering Economics (A). Economic aspects of marine engineering; comparison of fuels, and the various types of steam and Diesel propelling machinery for different types of ships and trade routes; the economical operation of propelling machinery and auxiliaries at sea and in port; heat balances; boilers, main engines, auxiliaries and auxiliary systems; turbo-electric and Diesel-electric drives; gas turbine developments.

13·61. Marine Engineering Design III. Design projects including dynamic forces and stresses on selected marine machinery parts and provisional design of same.

Naval Architecture and Marine Engineering Continued

13·62. Marine Engineering Design IV. Heat transfer principles, application to marine heat transfer equipment condensers, lubricating oil cooler, boiler equipment. Special design projects, propeller-blade-hub construction.

13·71. Ship Propulsion I (A). Design of important components of ship propulsion plants, with emphasis on current trends and selection of units to meet requirements of various types of ships. Lectures, seminars, and outside reading. (Students to attend selected lectures in 13·75.)

13·711T. Ship Machinery Design I (A). Lectures and seminars on the design of important components of ship propulsion plants. Students to attend selected lectures in 13·75 and prepare one or more seminar papers based on outside reading in an area of interest.

13·72. Ship Propulsion II (A). Continuation of 13·71. (Students to attend selected lectures in 13·76.)

13·721T. Ship Machinery Design II (A). Lectures and seminars on the design of important components of ship propulsion plants. Students to attend selected lectures in 13·76 and prepare one or more seminar papers based on outside reading in an area of interest.

13·73. Mechanical Vibration (A). The free and forced vibration of systems of a single degree of freedom; complex variable and vector representation; Fourier Series; harmonic analysis by tabular and mechanical methods; systems of several degrees of freedom; torsional systems; the balance of rotating machinery and reciprocating engines; the elements of torsional vibration problems in reciprocating engines.

13·74. Mechanical Vibration (A). Advanced theory of the torsional vibration of reciprocating engines, including uniform distributions, forced vibration, calculation of amplitude, branched systems, etc. The transverse vibration of uniform and irregular beams and the application to the vibration of turbines and other rotating machinery; Rayleigh's, Stodola's and other methods; separation of normal modes of vibration; vibration isolation; La Grange's theorem; nonlinear systems; self-sustained oscillation.

13·75. Warship Propulsion I (RA). Critical interpretation leading to useful application of the formal and theoretical content of Naval Engineering to foster discrimination in practice. Selection of machinery units supported by related design studies and calculations. Lectures, outside reading, critiques. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·76. Warship Propulsion II (RA). Continuation of 13·75 with emphasis on the propulsion plant as a whole and its arrangement. Supported by studies and calculations. Selection and arrangement of machinery with emphasis on student exploration. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·791. Marine Propellers (A). Theories of propeller action. Propeller testing procedure. Methods of presenting propeller test data. Application of theories and test data to propeller selection. Maneuvering and towing performance. Cavitation criteria. Theoretical and mathematical development and application of modern airfoil theory to design. Strength of propeller blades.

13·90. Warship Electrical Engineering (RA). Review of basic electrical engineering including single-phase and polyphase electric circuits, magnetic circuits and transformers, and electric machines. Critical examination of these electrical engineering principles as applied to the generation and distribution of electric energy in warships; study of system design; selection of machinery and equipment; the application of new developments in electrical engineering practice to warship electrical systems. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·91. Warship Electrical Engineering, Advanced (RA). Critical examination of the principles of electrical engineering as applied to the generation and distribution of electric energy in warships on an advanced level; study of system design; selection of machinery and equipment in view of more recent developments in electrical engineering practice. Lectures, seminars, and outside reading. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·911. Warship Electrical System Design (RA). Design study of the generation and distribution system of a particular warship, including load analysis, distribution system layout, and selection of generating equipment. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

ECONOMICS AND SOCIAL SCIENCE

Subjects 14·00 to 14·99

General Economics and Theory

14·01. Economic Principles I. Introduction to fundamental economic concepts, such as production, money, banking, labor, business organization, government fiscal policy, with primary emphasis upon the level and fluctuations in national income and employment. Stress on current economic problems.

14·02. Economic Principles II. Continuation of 14·01 with emphasis on the composition and pricing of output of particular industries, supply and demand analysis, competition and monopoly, and international trade. Stress on current economic problems.

14·03. Prices and Production. Basic theory of the equilibrium of the firm and the industry under conditions of competition, monopoly, and monopolistic competition; the consumption equilibrium of the household; factor markets and the distribution of income; introduction to the concept of general equilibrium.

14·04. Industrial Organization and Public Policy. Case studies of the economic organization of particular American industries, with evaluations of their efficiency and technological progressiveness; anti-trust laws and other regulations of business.

14·09. Economic Problems Seminar. A seminar, especially designed to complete a three-term Humanities combination in economics and taking up selected problems of business and public policy, chosen because of their current interest or continuing significance for engineers and scientists. Reading and discussion of problems selected by the instructor and calling for the further development and application of the analytical techniques of 14·01 and 14·02; selection of other problems by the students for individual investigation. (Sections limited to fifteen students.)

14·101. Mathematics for Economists. Introduction to mathematical methods, with emphasis on topics useful in economics, Analytic geometry, differential calculus, problems in maxima and minima. Allen, *Mathematical Analysis for Economists.*

14·102. Mathematics for Economists. Continuation of 14·101. Functions of several variables, integral calculus, Taylor series, elementary determinants and matrices. Allen, *Mathematical Analysis for Economists.*

Economics and Social Science Continued

14·114. Economics and Finance: Principles and Policies I. Introductory discussion of the determination of national income and its fluctuations; the composition and pricing of output; financial institutions and the functioning of money and capital markets; fiscal and other stabilization policies; industrial economics, with special attention to price policy and the relations of government and business; and international economics. (Restricted to Sloan Fellows.)

14·115. Economics and Finance: Principles and Policies II. Continuation of 14·114. (Restricted to Sloan Fellows.)

14·116. Economics and Finance: Principles and Policies III (A). Continuation of 14·115. (Restricted to Sloan Fellows.)

14·117. Economics and Industrial Management. Introduction to measurement and determination; interpretation of national income and national product; economic fluctuations and effectiveness of stabilization policies, especially monetary and fiscal. (Restricted to graduate students in Course XV.)

14·121, 14·122. Economic Analysis (A). Interdependent growth of theory and fact, general theory of equilibrium under competition and monopoly. Findings revalued under conditions which more closely approach reality.

14·132. Schools of Economic Thought (A). Economic ideas developed by different groups of economists in recent times.

14·151. Mathematical Approach to Economics (A). Use of mathematical methods in all fields of economics.

14·161. Economic History (A). Analysis of development of world economy and major national economies in terms of theory of economic growth, 1750–1873.

14·162. Economic History (A). Analysis of development of world economy and major national economies in terms of theory of economic growth, 1873 to present.

14·171. Theory of Economic Growth (A). Analysis of the interaction of economic variables in the long-run growth process. Theoretical models of the relationships among population and resource patterns, capital formation, monetization of the economy and growth of markets, technological change, sectoral patterns of investment, foreign trade, and the like.

14·172. Research Seminar in Economic Development (A). Conceptual and empirical problems of conducting both library and field research on economic development. Discussion of formulation of relevant research topics, problems of quantification and measurement, interpretation of results, etc. Case materials from literature and from research in progress.

14·174. Non-Economic Factors in Economic Growth (A). Review of the role played in economic growth by the social, political, and psychological factors that lie at the boundary of formal economics and of the extent to which the social sciences are able to treat these factors systematically. Family structure and mores, legal systems, the role of rationalism and scientific thought, nationalism, the structure and goals of political parties, individual motivations and social status systems, communications patterns, consumer tastes, etc., with emphasis on empirical materials.

14·191, 14·192. Economics Seminar (A). Special social problems or economic problems of particular industries. (Open to graduate students only.)

14·195, 14·196. Reading Seminar in Economics (A). Reading and discussion of special topics in Economics. Open to advanced graduate students by arrangement with individual members of the staff.

Industrial Economics

14·20. Building Economics. Social, political, industrial, and economic factors affecting the location, construction, financing, and marketing of buildings — with emphasis on low-cost housing.

14·21. Economics of Invention. Discussion of the process of research, invention and innovation in relation to economic development in the United States and other countries. (Not offered 1956–57.)

14·271. Problems in Industrial Economics (A). Small and large enterprises in the American economy; market structures; degrees of monopoly and competition; requisites of public policy.

14·272. Government Regulation of Industry (A). Follows 14·271. Development of anti-trust policy, generally and in specific cases. "Public utility" price fixing, government ownership as alternative.

14·281. Economics of Entrepreneurship and Innovation (A). Analysis of the function of entrepreneurship in economic development with particular emphasis on the process of technological change and innovation.

14·282. Economics of Innovation Seminar (A). Case studies of innovation drawn from different industries. Special attention is given to the problem of forecasting the rate of industrial development based on the analytical techniques developed in 14·281.

14·291, 14·292. Industrial Economics Seminar (A). Readings, discussions, reports on such topics as industrial price policies, government regulation of industry, competitive practices and other phases of industrial economics.

Statistics

14·30 Elementary Statistics. Theory and application of probability and statistics to engineering and administrative problems. Elements of statistical inference.

14·32. Statistical Quality Control. Application of statistical methods to industrial problems including sampling inspection, quality control charts, engineering tolerances, and design of experiments. Text: Duncan, *Quality Control and Industrial Statistics.*

14·33. Elementary Statistics. Introduction to statistical methods. Frequency distributions, moments, elements of probability, probability distributions, elements of sampling, confidence limits, regression and correlation of two variables.

14·371. Statistical Theory. Elementary but mathematical viewpoint. Random variables, elements of probability, mathematical expectation, generating functions, probability distributions, sampling theory, elements of the theories of estimation and testing hypotheses.

14·372. Statistical Theory. Correlation and regression, the problem of moments, limit theorems, stochastic processes, sequential analysis, introduction to game and decision theory.

14·381. Statistical Method. Elements of probability, sampling, statistical inference, and the design and analysis of experiments, with emphasis on industrial applications and their interpretation, rather than on manipulation.

14·382. Economic Statistics (A). Study of selected statistical techniques which have been found useful in recent economic work, especially the regression analysis of economic time series.

14·391. Research Seminar in Economics (A). Individual or team participation in a single substantial project involving empirical or theoretical research with required report. Discussion of technical and statistical problems, as they arise. Varying topics each year.

National Income and Finance

14·40. Money and Income. Introduction to the study of factors affecting the level of national income and relationships of financial institutions to these factors. Survey of the financial organization of society: the money-banking system, credit institutions, capital markets, fiscal policy, international financial relations.

14·43. Public Finance. Effects of government revenue and expenditure programs on the level and distribution of economic activity; intergovernmental fiscal problems; relationship of fiscal to other economic policies.

14·451. National Income (A). Economic problems involved in maintaining national income and employment.

Economics and Social Science Continued

14·461. Monetary and Banking Problems (A). Commercial and central banking in relation to price levels and employment. Analysis of such problems as bank asset management, Federal Reserve organization and policy, interest rates, money markets, the Treasury and the banking system, proposals for monetary reform with some historical background.

14·472. Fiscal Policy (A). Analysis of alternative tax, expenditure, and debt policies with particular reference to the federal government; relation of various fiscal policies and procedures to economic stability and progress; relation of fiscal to monetary policy.

14·481. Business Cycles (A). Statistical, historical, and theoretical examination of determinants of income, production and employment. Modern methods of analysis, forecasting, and control.

International Economics and Relations

14·51. International Relations. Analysis of basic factors in world politics: the influence of geography, demography, economic resources, nationalism upon national power and foreign relations. Power politics and the balance of power system. The formation and conduct of foreign policy. The United Nations and regional arrangements. The search for national and collective security.

14·52. Principles and Problems of American Diplomacy. Study of the underlying assumptions, basic principles and major objectives of American foreign policy. Analytical examination of some of the leading issues confronting American diplomacy today, including changing patterns of alignment, programs of economic and technical assistance, and domestic problems of policy making.

14·521. Strategic and Political Geography. Geography as a basis of national economy. Natural environment of national development and policy. Geography of natural resources, including raw materials and sources of energy; their bearing on economic development and national security. Theories of utilization of land, sea, and air space. Global patterns and critical areas in politics and strategy.

14·53. Seminar in International Politics. Selected problems of international politics designed to complete a three-term sequence in international relations. Problems varying from year to year with special emphasis on problems involving the nations of Asia and the Pacific area.

14·531. Asian Politics and United States Foreign Policy (A). Study of the processes of social change and the problems of political stability in modern Asia, and an examination of American policy interests in the area. Consideration of alternative courses of policy action open to the United States in strengthening the development of representative institution.

14.533. Social Science and U. S. Foreign Policy (A) Examination of the contributions which modern research in the social sciences can make to the formulation and solution of problems faced by the United States in the modern world. Emphasis on problems on which the Center for International Studies is currently conducting active research. Review by project directors from the Center and others of their work in the fields of international communications, economic and political development, and United States-Communist Bloc Relations.

14·54. International Trade. Theory of international trade and finance, and application to current problems, such as exchange restrictions, economic development, and foreign aid.

14·571. Major Problems in United States Foreign Policy. Analysis of some of the principal economic, political and military problems facing the United States in its present-day foreign relations. Special emphasis upon the question of national security, relations with the Soviet Union, the Eastern European and German problems, Far Eastern crisis, and the United Nations.

14·581, 14·582. International Economics (A). The foreign exchange market, foreign trade and commercial policy, with emphasis on the relation of the items in the current account to national income: international finance and the achievement and maintenance of equilibrium in the balance of payments as a whole: current problems of international economics.

Industrial Relations

14·61. Industrial Relations. Structure and functioning of management and unions in the handling of industrial relations. Union policies and problems to which they may give rise. Reconciliation of union and management policies. Intended for students who do not plan to take 14·63 and 14·64.

14·63. Labor Relations. An introductory analysis, made through use of an integrated social science approach, of the institutions which have developed in response to the "human resource problems" of a highly industrialized economy. The course surveys the growth, structure, and objectives of management and organized labor groups and then examines the framework and issues of collective bargaining as parts of a dynamic accommodation process between organizations that have economic, political, and social characteristics.

14·64. Labor Economics and Public Policy. Particular applications of the analytical tools developed in prerequisite subjects to two aspects of the industrial relations scene: (1) the economics of collective bargaining, with special emphasis on the problems presented by wage determination at firm, industry, and economy levels; and (2) the development within a free society of public policy on the rights and obligations of employers, unions, and workers.

14·671. Problems in Labor Economics (A). Development of the labor movement, and detailed analysis of collective bargaining and union policies on wages, hours of work, entrance to the trade, hiring, layoffs and transfers, make-work and restriction of output, technological change, union-management cooperation, and industry-wide agreements. Major emphasis on the economic aspects and effects of these policies.

14·672. Public Policy on Labor Relations (A). Study of major trends in labor legislation, with emphasis on the legality of union activities, protection of the right to organize and bargain collectively, regulation of wages and hours, governmental machinery for the adjustment of labor disputes, and various types of social insurance. Particular attention given to the broad economic and social questions raised by these trends.

14·673. Labor-Management Relations and Public Policy (A). Brief survey of the background of labor law, followed by analysis of the nature of the collective bargaining process, its major issues and points of contention, and selected problems in public policy. (Restricted to Sloan Fellows.)

14·681, 14·682. Seminar in Personnel Administration (A). Research in the theory and practice of case study as dynamic learning. Experimentation with the "Incident Process" of case analysis, as a variant of the orthodox case method stressing the need for control mechanisms in case discussion. One or two demonstrations, followed by delegation of responsibility to group members for finding, preparing and presenting case material and leading discussion on these cases. Other teaching objectives: learning to distinguish between facts and opinions, summarizing key facts, formulating issues, making and testing practical decisions, and generalizing from and about case situations. Reports by group members after each session for use as the basis for joint evaluation of group performance.

14·691. Research Seminar in Industrial Relations. (A). Discussion of important areas for research in industrial relations, frameworks for research, research techniques, and methodological problems. Centered mainly on the thesis research of advanced graduate students.

14·692. Research Seminar in Industrial Relations (A). Continuation of 14·691.

14·693. Collective Bargaining and Union-Management Cooperation (A). Intensive discussion of collective

Economics and Social Science Continued

bargaining problems in particular industries and introduction to plans for union-management cooperation in solving production problems and reducing costs.

14·694. Seminar in Union-Management Cooperation (A). Seminar involving active participation in the work being done at a number of firms which are beginning or have developed union-management cooperation programs.

Psychology

14·70. Introductory Psychology. Facts, principles, and theories of learning, memory, thinking, emotion, personality, communication, and intelligence. Application to everyday life and to man-machine systems.

14·72. Union-Management Relations. Specific problems in union-management-worker relations, and the development of programs to secure greater worker participation through union-management cooperation plans.

14·73. Organization and Communication in Groups. This subject will deal with the problems in organization and communication in groups which have specific tasks to perform. Two-person situations, small informal groups, and larger organizations such as businesses, industrial firms, military units, etc., will be studied. The approach will be made from the point of view of social psychology.

14·75. Experimental Psychology. Problems of method and procedure in the scientific study of living organisms. Analysis of and participation in psychological research.

14·762. Human Relations and Labor Relations. An introductory subject including the following topics: (1) the basic principles of human relations; (2) the place and functions of personnel administration, with emphasis on actual case situations: (3) the development of the American labor movement, significant union policies and practices, and basic issues raised by the present strength of unions. (Restricted to Sloan Fellows.)

14·765. Quantitative Methods in Psychology Seminar. Provision for obtaining a working knowledge of the statistical and mathematical techniques used in quantitative psychology. Major areas covered in 14·765 and 14·766: statistical analysis in psychology, linear metric methods (factor analysis); time series analysis; information theory in psychology; psychological measurement, including psychophysical methods, scaling methods, multidimensional scaling; attitude measurement; mathematical models for psychological processes. Determination of topics to be covered through mutual agreement of instructor and students. Varying content from year to year so that graduate students may take the subject for credit in successive years.

14·766. Quantitative Methods in Psychology Seminar. Continuation of 14·765. Varying content from year to year so that graduate students may take the subject for credit in successive years.

14·77. Psychology of Communication. Survey of phonetics, acoustic, perceptual, statistical, developmental, behavioral, and social studies of the psychology of language and communication. Particular emphasis is placed upon the effects of verbal habits upon perception, learning, and thinking.

14·771. Interpersonal Relations Seminar. Attempt to improve the student's understanding in working with other people. Leadership and communication in a small group, interpersonal cooperation and competition, group creativity and productivity. Investigation through lectures, demonstrations and exercises, but primarily by analysis of the changes that take place in the seminar group.

14·772. Industrial Sociology Seminar (A). Topical approach to problems of industrial and social organization including such topics as authority and power in organizations, cultural and social obstacles to and consequences of industrialization, morale and productivity in organizations, sociology of occupations and professions, social aspects of science and technology, role and personality in organizations.

14·774. Social Psychology Seminar (A). Selected problems in social psychology; their origins and theoretical development; the methods and findings associated with them.

14·775. Analysis of Behavior Seminar (A). Intensive survey of selected topics in the field of experimental psychology. Major areas in 14·775 and 14·776: learning and memory, including verbal and motor learning, conditioning, learning theory, animal learning; sensation and perception, including psychological and psychophysiological studies of discrimination in vision, hearing and other senses; motivation, including reflexes, tropisms, drives, social motives, and abnormal behavior; and thinking, including abstraction, generalization, concept formation, problem solving, and verbal behavior. Determination of topics to be covered through mutual agreement of instructor and students. Varying content from year to year so that graduate students may take the subject for credit in successive years. (Not offered 1956–57).

14·776. Analysis of Behavior Seminar (A). Continuation of 14·775. Varying content from year to year so that graduate students may take the subject for credit in successive years. (Not offered 1956–57.)

14·784. Psychological Theory Seminar (A). Designed to cover at an advanced level, modern theories of learning and behavior derived from accounts of clinical experience and experimental work. (Not offered 1956–57.)

14·79. Psychology of Learning and Motivation. Systematic treatment of the acquisition, maintenance, and activation of behavior patterns. Application of principles of behavior developed in experimental psychology to problems of human motivation in the individual.

14·791, 14·792. Reading Seminar in Social Science (A). Reading and discussion of special topics in the fields of social science. Open to advanced graduate students by arrangement with individual members of the staff.

Sociology, Anthropology, and Government

14·81. Personality and Social Structure. Analysis of social institutions, and structure and function in community life, and their influence upon personality formation and development. The role of culture in shaping social norms and individual behavior. Social change and social mobility. The influence of individual persons on social phenomena. Use of American and non-Western data. Some field research.

14·90. Government, Politics and Technology. Introduction to the principles and problems of political science with emphasis on their relation to changing levels of technology. Basic concepts and assumptions of politics and technology and their interrelationships. Effect of technological change upon political participation and behavior in preindustrial and industrialized countries. Current problems concerning policy formation and international politics.

14·91. The American Political System. Emphasis on the political environment in which much of the technical student's work will be carried on with special attention to the role and problems of government in modern society, the interrelationship of political parties, public opinion and the pursuit of individual interests. Examination of these forces against the background of government in the United States.

14·92. Comparative Political and Economic Systems. Comparative study of the organization and use of political power in contemporary foreign political systems with emphasis on the British and European Parliamentary governments, the Soviet structure, the roles and policies of political parties abroad, and the problems arising out of the changing relations of government to private enterprise.

14·93. Seminar: Issues in Contemporary American Politics. Investigation of selected problems connected with political parties, elections, and pressure politics, and with the formation and implementation of public policy in such possible fields as problems of federalism (federal centralization, regional development, states rights), government and education, impact of national security problems on the Constitution and governmental institutions.

14·941. Government and Public Administration. Organization, powers and duties of state and local administrations; general survey of public administration — national, state and local — including the relationship of administrative agencies to the legislative and judicial branches; budget and

Economics and Social Science Continued

personnel systems; how administrators handle their problems. (Not offered 1956–57.)

14·95. Politics, Society, and Policy Making. Examination of case material drawn largely from studies of decision-making conducted in the Center for International Studies with a view to seeing what types of persons are likely to take action and in what ways under a variety of conditions. Cases involving conflicts of parties, pressure groups and governmental policy makers.

14·951. Behavioral Factors in International Politics (A). Analysis of the psychological, cultural, and personal factors affecting policy determination, leadership procedures, and action patterns in national and international politics. (Not offered 1956–57.)

14·953. Mass Media and Communication Systems. Examination of the pattern of communication in societies at different stages of development. Comparison of networks of oral communication with systems based on mass media. The role of opinion leaders, informal communication networks, literacy, the press, radio, film, and international communications.

14·954. Methods of Communication Research (A). Survey analysis, content analysis, with some study of the institutional structure of communications and of communication flows. For students needing to secure or evaluate data about public opinion and attitude formation under the impact of communication.

14·956. Public Opinion and Propaganda. History and development of public opinion as a factor in public policy: relationship of public opinion and specialized opinion; relationship of public opinion and private attitudes; organization of political parties and pressure groups; techniques used by them; conditions of effective and ineffective communications.

14·957. Research Seminar in International Communication (A). Cooperative examination of the research topics of students specializing in this field.

14·96. Influences on Policy Decisions. Review of factors shaping such decisions as those examined in 14·95. Emphasis on systematic analysis of such elements as communication flows, the values, motivations and personality traits of political activists, and the structure of power among them.

14·97. Political Science Seminar. Seminar for students in political science program with members of the faculty to explore various aspects of selected problems in political science. Coordination of thinking from the varying points of view of political science and development of ability to deal with issues of decision-making. (Not offered 1956–57.)

GRADUATE SUBJECTS IN INDUSTRIAL MANAGEMENT UNDERGRADUATE SUBJECTS IN BUSINESS AND ENGINEERING ADMINISTRATION

Subjects 15·00 to 15·99

15·01. Industrial Management I. Study of general analytical principles relevant to management of private, profit-seeking business enterprises. Principles and techniques presented in terms of logical development, as well as of application to particular problems. Emphasis on reconciliation of long-range policies and short-run adaptations to circumstance. Demand and cost analysis, selling and price policies, and the nature of investment decisions.

15·02. Industrial Management II. Introduction to business and economic statistics, covering frequency distributions, moments, tests of significance, statistical inference, simple linear regression and correlation, analysis of time series and index numbers. Discussion of applications of statistical methods in industry, with particular reference to decision making.

15·11. Introduction to Industrial Management. (Designed as an elective for all courses except XIV and XV.) Basic consideration of fundamental principles and practices of industrial management. Brief coverage of administration, finance, marketing, production, and personnel. Development of relationship of scientist and engineer to functions of industry and operations of management. Analysis of effect of scientific and engineering viewpoints and decisions applied to industry with particular emphasis on use of science and engineering by industrial management. Designed for students interested in industrial operations but with no previous training in these areas.

15·17. Historical Studies in Innovation (A). Examination of process of innovation in industry with attention to nature of environment in which innovation takes place, personality of innovator, areas of resistance and means of accommodation to new ideas or new instruments. Influence of innovations upon technological development, administrative policy, and social arrangements. Case histories such as introduction of continuous aim firing in the U. S. Navy, introduction of Bessemer Converter, and introduction of electric motor.

15·18. Accounting and Production. A basic study of two important aspects of business management activity planned for students who have had substantial experience in industry: (1) basic methods and problems in maintaining financial and cost control records within a business and in the use of recorded data for policy determination and review of performance; (2) the organization of manufacturing processes, with emphasis directed toward distinguishing fundamental principles from current practice. (Restricted to Sloan Fellows.)

15·183. Structure of American Law and Industrial Change (A). First half: study of fundamental legal principles as an element of the environment within which management of industrial enterprises is carried out; Second half: historical study of the industrial process.

15·185. Management Problems (A). Study of problems in production control, and marketing policy. Work at an advanced level to serve the needs of students who have had a substantial amount of general business experience.

15·201. Problems in American Political Economy. Examination of political and social problems attending development of federal regulation of American economy, 1865 to 1938. Emphasis on function of politics in reconciling conflicting demands of various social groups and on discrepancies between real and felt economic needs of these groups. Restricted to School of Industrial Management graduate students; others admitted only by permission of the instructor.

15·30. Personnel Administration. Personnel administration as a staff function to assist line executives. On the basis of case material, fundamental requirements for personnel work discussed as to principles that build and problems that test constructive personnel policies. Selection, placement, and follow-up of employees; basic problem of worker's attitude toward authority; the plant as a social system; man-power problems; recruitment, training and upgrading; management-union relationships; establishment and maintenance of satisfactory working conditions; job analysis and grading; employee evaluation; interviewing as a tool of management; wage administration; employee counseling.

Industrial Management and Business and Engineering Administration Continued

15·312. Labor Management Relations. Similar to 14·61. Restricted to School of Industrial Management graduate students; others admitted only by permission of the instructor.

15·352. Measurements of Human Behavior (A). Basic principles involved in psychological measurement and various measurement techniques useful in the industrial situation. Nature and problems of measurement in general: the underlying theory and the experimental and analytical procedure involved in particular testing and scaling methods; the kinds of situations where each is appropriate; the kinds of conclusions that can and cannot be legitimately drawn from scores derived from a given method; and the characteristics of the various indices used in evaluating the effectiveness of measuring devices in given situations.

15·371. Social Psychology. Opportunity for the student to become familiar with the methods, subject matter, and findings of social psychology, with opportunity to look into literature in the field and to raise questions about his reading. Detailed examination of a few subjects within social psychology which are particularly relevant to the problems of industrial management, with class discussions and reading on such subjects as: motivation, learning and behavior change, leadership. Restricted to School of Industrial Management graduate students; others admitted only by permission of the instructor.

15·372. Laboratory in Industrial Behavior (A). General demonstration, discussion, and analysis of learning, social perception, problem solving, and organized group activities. Student participation and assistance in demonstrations and in the analysis of the data. Readings and weekly reports. (Restricted to Sloan Fellows.)

15·41. Finance. Principles of financial organization and management; directed primarily toward analysis of demand for and costs of funds to the firm and problems of internal financial control. Types of corporate securities, financial institutions, and tax aspects.

15·412. Finance. Similar to 15·41. Restricted to School of Industrial Management graduate students; others admitted only by permission of the instructor.

15·42. Investments. Investment objectives; nature of alternative means to attain these objectives; estate planning; portfolio planning; industry and security analysis; security and commodity markets; State and Federal laws bearing on taxes and security transactions.

15·46. Financial Administration of Industry (A). Practical problems of internal financial management. Analysis of specific problems confronting business managers in manufacturing, mercantile, and public utility fields. Use of case method, with other readings also required. Emphasis on current financial operations; financial problems relating to taxation, consumer purchasing power and availability of investment funds. Oral and written reports.

15·50. Accounting. Introduction to the use of accounting as a tool of applied economics with emphasis on its employment by management. Concepts and methods pertinent to the accumulation, organization, and interpretation of data useful in evaluating and controlling the performance of the individual business enterprise.

15·501. Accounting. Similar to 15·50. Restricted to School of Industrial Management graduate students; others admitted only by permission of the instructor.

15·502. Industrial Accounting. Study of cost flows and cost behavior in industrial firms. Systems for recording and interpreting cost data. Elements of cost planning and control. Cost analysis for decision-making. Restricted to School of Industrial Management graduate students; others admitted only with permission of the instructor.

15·51. Industrial Accounting. Characteristics and use of various cost accounting systems. Analysis of the behavior of costs. Use of data in evaluating alternative courses of action, planning business programs, control of current operations. Case material from a variety of industrial situations supplemented by accounting exercises and selected readings.

15·511. Economics of the Firm. Intensive study of economic analysis of the individual business firm, leading to practical application in terms of business policies and problems. Designed to bring out the formal analytical assumptions and techniques that underlie following subjects in the major functional areas of management. Restricted to School of Industrial Management graduate students; others admitted only with permission of instructor.

15·52. Business and National Income Accounting. Fundamentals of the methods and principles of business accounting and of the development of national income statistics from private accounting data. Emphasis on the problems of asset valuation and income determination, the contrast between private and social concepts of income, familiarity with the structure and interrelation among national income accounts, and the analysis of data for the solution of problems in business and economics.

15·531. Problems in Accounting Control (A). Design and use of semi-variable overhead expense budgets and standard cost systems for income measurement, determination of product costs for pricing, and planning and control of costs. Survey of selected other topics such as operations budgets, capital budgeting, breakeven analysis, distribution cost analysis, LIFO, and responsibilities of controller to stockholders. Exercises, case material, and reports to develop facility in organizing and interpreting data.

15·542. Management Information Systems (A). Study of the structure and related techniques of an information system required for managing an enterprise. Nature and development of information systems and formulation of improved system. Emphasis on development and use of both digital computers and less sophisticated techniques, and relationship to firm management. Lectures, library research, problem formulation and solution, computer facility visits, and case studies of existing information systems.

15·591. Quantitative Analysis of Industrial Problems (A). Exploration of possibilities for extending the areas of quantitative evaluation in industry by wider application of methods successfully used in scientific analysis. Measurement procedures employed in industry and cases illustrating the current work of operations research groups reviewed by faculty members and visiting lecturers. Admission by consent of instructor in charge.

15·61. Business Law. Elementary study of some legal problems involved in the operation of a business enterprise; formation, performance and discharge of contracts, and remedies for breach, the Statute of Frauds; agency and employment relationships and liability of principal and agent in contract and tort; provision of the Uniform Negotiable Instruments Act; use of checks, notes and other negotiable instruments, rights and duties of parties in various banking transactions; organization of corporations, duties and responsibilities of management, rights and remedies of stockholders and creditors; consideration of some legal aspects of corporate finance.

15·65. Labor Law. Fundamental legal principles underlying formation and operation of labor unions, limitations upon right to strike and right of boycott, and control of union and employer activities through administrative governmental agencies.

15·66. Fundamental Legal Principles (A). Survey of the fundamental principles of American law. Development of insights into capabilities and limitations of legal system, considered as an element of the environment within which management of industrial enterprises is carried out. Emphasis on understanding how system works and changes, the underlying ethical and political ideas which give it direction, and the major policy issues exemplified in it. Seminar discussion of legal cases and selected essays. Admission limited to School of Industrial Management graduate students; others admitted only by permission of the instructor.

15·71. Production Management. Treatment of some principal methods of analysis and their application to important problems of production management, including analysis of work methods, economic quantity planning, production programming, statistical control, and equipment purchase

Industrial Management and Business and Engineering Administration Continued

analysis. Emphasis on the decision-making process in production management.

15·712. Production Management. Similar to 15·71. Restricted to School of Industrial Management graduate students; others admitted only by permission of the instructor.

15·72T. Industrial Standardization. Review and analysis of history and theoretical background of standardization movement in industry. Study of existing practices and techniques exemplified by actual industrial situations. Extensive consideration of practical problems of initiation, organization, and development of industrial standardization programs, including managerial evaluation and support. Determination of responsibility, authority, and opportunity of standards engineer in operating organization. Evaluation of present and potential worth as tool of management and relation to other phases of administration. Development of underlying philosophy of standardization as aid to industrial improvement and progress.

15·73. Management Laboratory. Work Simplification. Techniques of motion study in simplification and standardization of manual work. Process charts, micro-motion and principles of motion economy, proper work-place layout, labor-saving tools and equipment, assembly jigs, etc. Motion picture films of industrial operations; labor relations involved in introduction of work simplification; problems of employee training; and bearing of motion economy upon morale.

15·74. Advanced Management Laboratory. Advanced techniques in work simplification and motion study, with especial emphasis upon managerial procedures followed in introducing and demonstrating analytical techniques to administrators, executives, and to employees; organization and operation of work simplification training programs, co-ordination with suggestion systems, and maintenance of progress schedules and records of waste elimination.

15·741. Advanced Management Laboratory (A). Industrial improvement as a management philosophy. Critical analysis and appraisal of various improvement techniques as currently applied in industry. Re-evaluation of these techniques in the light of specific management situations originating at the moment as a result of the participation of a team of local industrial executives who meet regularly with the group.

15·75. Manufacturing Analysis. Continuation of 15·71. Devoted largely to field applications of methods of analysis developed in 15·71. Emphasis upon developing actual data required for operational use of decision-making models.

15·751. Manufacturing Analysis (A). The subject matter of 15·75 at advanced graduate level.

15·781. Manufacturing Control Seminar (A). Study of procedures and techniques for controlling manufacturing operations conducted from standpoint of top management. Laboratory work in cooperating firms. Emphasis upon development of control philosophy and administrative policy.

15·792. Manufacturing Policy Seminar (A). Seminar in selected topics of broad manufacturing policy, such as long-term planning, unit-plant determination, international operations, diversification, decentralization, and defense production. (Not offered 1956–57.)

15·81. Marketing. Introduction to managerial problems in marketing operations. Study of consumer demand behavior and development of techniques for its analysis. Retail institutions with particular attention to the dynamics of their adaptation to the changing consumer market. Nature of industrial demand; wholesale structures of the consumer and industrial markets; selection of channels of distribution and development of sales programs. Product analysis: product policy and brand policy; manufacturers' strategies in the face of various common competitive situations: Government regulation of marketing.

15·812. Marketing. Intensive coverage of the subject matter of 15·81, with some flexibility to allow for special interests of the group. Instruction on a seminar basis. Particular emphasis on oral reports and analyses by individual class members. Restricted to School of Industrial Management graduate students; others admitted only by permission of the instructor.

15·82. Sales Promotion: Strategy and Methods. A second subject in marketing following 15·81. Overall strategy involved in use of various sales promotional methods to secure user and trade acceptance in selling industrial and consumer products and services. Advertising and use of salesmen as tools in accomplishing a desired promotional task. Advertising methods, including choice of themes, selection of media, copy and layout technique, methods of testing effectiveness and organization for efficient operation of the activity. Treatment of management of the sales force including selection, training, supervision and control of salesmen. Administrative control of sales operations through marketing research and planning, and role of price policy as it affects promotional problems.

15·821. Marketing Policy and Administration (A). A follow-up subject to 15·812. Major emphasis on managerial problems in devising and putting into effect efficient combinations of selling methods. Applications and methods of sales forecasting. Consideration of consumer and industrial products in study of the use of advertising, salesmen, exhibits, pricing policies, sampling and other methods of promoting sales. Seminar-type class. Written assignments consisting of both individual and group effort in developing marketing plans to meet particular problem situations.

15·83. Marketing Research. Basic principles and techniques in marketing research. Original field study by class, each student making a substantial number of field interviews. Training in marketing research methods including planning of the investigation, development of a questionnaire, collection and interpretation of data, techniques of analysis and presentation, and the preparation of written reports.

15·86. Product Planning and Development (A). The product mix as a major element in marketing strategy. Diversification policy. Sources of ideas for new or improved products and methods for screening such ideas in light of potential market demand, costs, prices, and suitability to company's production and marketing facilities; organizational relationships and methods used to insure coordination between production, research, marketing, financial and other company departments affected by production planning and development. Problems on transferring new products from development stage to regular production, package design, testing market acceptability, and planning introductory sales campaigns.

15·90. Organization. Examination of basis for useful theories of organizational behavior. Requirements for successful design and control of industrial organizations and their components. Study of selected problem areas: decision-making, communication, measurement of organizational effectiveness, etc. Commencement of two-semester field study of prospects, policies, and operations of a specific industrial firm.

15·91T. Administrative Policy. Continuation of 15·90. Examination of overall problems of business enterprise from viewpoint of top administrator. How need for policy decision arises and how administrator proceeds. Impact of decisions on organization, enterprise and its environment. Continuance of field studies started in 15·90.

15·92T. Organization (A). The subject matter of 15·90 at advanced graduate level.

15·93T. Administrative Policy (A). The subject matter of 15·91T at advanced graduate level.

15·942. Administrative Policy Seminar (A). Analysis and evaluation of specific current major problems confronting top management. Emphasis on group discussion of current issues and investigation of underlying reasons for behavior of top management under circumstances involved. (Offered both terms but restricted to Sloan Fellows in fall term.)

15·951, 15·952. Special Studies in Management (A). For graduate students who desire to do advanced work or to carry out some special investigation of a management problem not specifically covered elsewhere and not qualifying as a thesis. Readings, conferences, laboratory and field work, and reports.

Industrial Management and Business and Engineering Administration Continued

15·96. Administrative Theory and Practice (A). Consideration of initial problems confronting the business administrator whose responsibilities call for determination as well as execution of policy, and incorporate supervision over major functions of business. Formulation of method of approach to administrative problems. Outline of techniques of negotiation, mediation and group deliberation. Examination of relationships of the business administrator to subordinates, investors, vendors and customers, associates, community, government and public. Review of underlying principles leading to continuity of administrative tenure. Evening conferences with business administrators and industrialists.

15·971. Seminar in Research Management. An evening seminar dealing primarily with human relations aspects of managing research laboratories. Case discussions, guest speakers, readings and reports. Participation by research supervisors from local laboratories. Generally restricted to graduate students who have been employed in research or development laboratories. Permission of instructors required.

15·972. Management of Research and Development. Organizational and economic aspects of managing research laboratories. Lectures, readings, discussions, field studies, reports. For graduate students with little or no previous experience in research management.

15·98, 15·99. Seminar in Administration (A). Study of fundamental economic, financial, organizational and administrative relationships analyzed and discussed by experienced leaders in business, labor and public administration. Examination of managerial philosophies and practices in the field and in seminar discussions. (Restricted to Sloan Fellows only.)

AERONAUTICAL ENGINEERING

Subjects 16·00 to 16·99

16·00. Aeromechanics. Dynamics, with applications to aeronautical problems. Kinematics of a point, particle dynamics. Kinematics of plane motion, moment of inertia, general plane motion. Work and energy, impulse and momentum, relative motion.

16·01. Aeromechanics. Dimensional analysis, variable mass problems, dynamics of groups of particles. General motion of rigid bodies, ellipsoid of inertia, geometric and mass symmetries, Euler's dynamical equations, gyroscope equations. Linear systems, free and forced oscillations, classical and operational methods of analysis.

16·02. Aerodynamics. Applications of the principles of particle dynamics and thermodynamics to study of real and perfect fluids, with particular reference to aeronautical problems. One-dimensional flow of perfect gases; fundamental equations of three-dimensional fluid motion; applications of incompressible-flow theory to airfoils and wings, including complex variable techniques; effects of viscosity.

16·03T. Principles of Aerodynamics. Navier-Stokes equations, laminar boundary layer equations, transition, turbulent boundary layers, effect of compressibility. Two-dimensional airfoils in incompressible flow. Lifting line and surface theories for straight and swept wings. Influence of compressibility on subsonic flight. One dimensional compressible flow, shock, combustion and condensation waves. Slender bodies in compressible flow, Ackeret theory for supersonic airfoils.

16·04. Aerodynamics — Viscous Fluids (A). Navier-Stokes equations, laminar boundary layer theory, single and multiple force systems, Reynolds number, Blasius solution, Pohlhausen solution, outer and inner solutions, separation. Turbulent boundary layer theory, Schlichting theory of damped and undamped oscillations, transition, Prandtl momentum mixing length, Karman law of similitude, logarithmic velocity distribution, Taylor vorticity mixing length, turbulent friction drag and layer thickness under pressure gradients, effects of surface roughness and heat transfer.

16·051. Aerodynamics of Compressible Fluids I (A). Thermodynamics and one-dimensional aerodynamics of compressible flows. DeLaval nozzles. Shock waves. Equations of motion of a compressible fluid. The Prandtl-Glauert approximation; subsonic and supersonic airfoil theory. Hodograph transformation. Transonic similarity laws and general features of transonic flow.

16·052. Aerodynamics of Compressible Fluids II (A). General solutions of the Prandtl-Glauert equation. Non-lifting and lifting flow past bodies of revolution and very low aspect ratio configurations. Supersonic wing theory. Source superposition method and conical flow method. Boundary layer concept and some properties of compressible boundary layers.

16·061, 16·062. Steady and Unsteady Potential Flows (A). One of a series of discussions of advanced topics in aerodynamics. Equations of motion of an inviscid fluid. Range of application of various approximate equations. Steady and oscillating airfoils and wings in subsonic flows. Transonic flow past two-dimensional airfoils and past fixed and oscillating slender configurations. Supersonic wing theories. Reverse flow theorems. (Not offered 1956–57.)

16·063. Viscous Flows (A). One of a series of discussions of advanced topics in aerodynamics. Some special solutions of the Navier Stokes equations and their behavior as viscosity vanishes. One-dimensional and linearized models of boundary-layer-like behavior. Special boundary layer problems in three dimensions, with suction and with time variation. Critical review of the present knowledge of turbulent flows. Isotropic turbulence theory, its physical significance and field of application. Other models illustrating the physics of turbulence. Recent experimental results and techniques in turbulence research.

16·064. Thermal Effects (A). One of a series of discussions of advanced topics in aerodynamics. Nature of aerodynamic heatings. Modes of heat transfer. Physical properties of fluids. Equations of motion of viscous heat conducting compressible fluids. Exact solutions. Boundary layers. Analytical and numerical solutions. Comparison with experiment and discussion. Turbulent boundary layers. Effect of radiation. Stability and effect of variation of transition point on average heat transfer coefficients. Shock wave boundary layer interaction and other special problems.

16·065. Waves, Shocks, and Combustion (A). One of a series of discussions of advanced topics in aerodynamics. Hyperbolic equations. Riemann waves. Interaction of simple waves. Oblique shocks. Reflections and refractions. Shock Tubes. Hydrodynamic analogy. Curved shocks. Diffraction of acoustic waves. Spherical and cylindrical strong shocks. Growth and structure of a shock in a real fluid. Explosions and combustion. Special topics. (Not offered 1956–57.)

16·066. Hypersonics and Superaerodynamics (A). One of a series of discussions of advanced topics in aerodynamics. Nature of the hypersonic problem. Discussion of equations and physical phenomena. Range of validity of continuum theory. Kinetic theory of gases. Application of distribution functions and free path concept to transport phenomena and the equations of fluid flow. Effects of molecular structure. Condensation. Superaerodynamics and slip flow. Special problems. (Not offered 1956–57.)

16·10. Applied Aerodynamics. Application of aerodynamic theory to airplane design and aircraft propellers.

16·105. Applied Aerodynamics (A). Further studies of airplane performance, including the survey of effects of variations of propeller, type of power plant, Mach number — both at trans- and supersonic velocities.

Aeronautical Engineering Continued

16·13. Airplane Stability and Control. General theory of longitudinal and lateral stability, controllability and maneuverability of airplanes.

16·15. Advanced Stability and Control of Aircraft (A). Various features of stabilityand control of aircraft are studied, including airplane motion with free controls; rotary derivatives; airplane frequency response to control motion; controls and control forces; etc.

16·18. Guided Missiles (A). Introduction to the problems of the flight of guided missiles, their components, flight path control and guidance.

16·20. Aircraft Structures. Fundamental theory and methods for static strength analysis and design of airplane components. Elasticity relations and practical two-dimensional plasticity. Properties and failure modes of ductile materials, including combined stresses, fatigue, and elevated temperature effects. Solid sections, simple shells, and stiffened-skin structures under shear, bending, torsion, and compression; both elastic and plastic effects. Niles and Newell, *Airplane Structures*, Vol. I, and notes.

16·21. Aircraft Structures. Introduction to energy methods in structural analysis. Statically indeterminate trusses, continuous beams, and beam columns. Aircraft shell structure; load distribution in multicell and tapered stiffened shells, analysis of ribs and fuselage rings, general stability problems. Introduction to digital machine computation techniques. Niles and Newell, *Airplane Structures*, Vols. I and II, and notes.

16·22. Aircraft Structural Theory (A). Advanced topics in aircraft structural theory. Theory of elasticity applied to the stress and stability analyses of plates and shells including variational methods. Approximate solutions including finite difference techniques and relaxation methods. Plastic effects in stress and stability analyses. Thermal effects.

16·23. Aircraft Structural Design. Structural features of various methods of fabrication and application to design of airplane components. Extrusions, castings, forgings, integrally stiffened designs, sandwich structures, brittle materials. Methods of optimum design for selection of materials and structural types.

16·25. Advanced Aircraft Structures (A). Varying content from year to year as new methods for analysis of all-metal aircraft become available for examination. Emphasis on investigation and development of methods involving stability criteria or applications of elastic theory, and on probable effects on structural analysis methods to be expected from new trends in design.

16·30. Principles of Automatic Control. Analysis of automatic control systems, including analytical, graphical, and analog methods. Formulation of control system performance equations leading to solutions for transient and steady state inputs. Non-dimensionalized treatment of first and second order differential equations with applications to more involved automatic control loops.

16·302. Aeronautical Systems. Application and extension of the basic techniques for control system analysis, such as root locus, frequency response and computer utilization to feedback control systems of prime importance in the aircraft and missiles field. Case studies of power boost and control systems, radar and fire control systems, guidance systems, etc.

16·31, 16·32. Principles of Instrumentation and Control (A). Development of generalized concepts, methods and notation for the quantitative description of static and dynamic performance of measurement and control systems by means of diagrams, mathematical forms and plots of various types. Use of dimensional analysis and theory of deviations for reduction of data to dimensionless variables and graphs. Study of coherent pattern for associating solutions with the forms that commonly occur in engineering practice. Numerical and graphical methods for evaluating transient stability of feedback systems. Theory and practice of pulse method testing. Practical examples ranging from simple measuring instruments to complex control systems with parallel open and closed chain components. Stress on limitations imposed by uncertainties and interference effects on static and dynamic performances.

16·33. Instrumentation and Control Laboratory (A). To be taken simultaneously with 16·31. Laboratory exercises on instruments and control systems designed to provide experimental familiarity with the principles set forth in 16·31. Static and dynamic performance tests on various instruments are followed by exercises involving control systems.

16·35. Special Problems in Instrumentation and Control (A). Problems of interest to qualified individual students in consultation with the instructor.

16·36. Dynamic Measurements (A). Measurement of the physical quantities encountered in engineering practice with emphasis on rapidly varying quantities. General principles of dynamic measurement, supplemented by detailed studies of systems used for the measurement of mechanical vibrations, pressure, strain, temperature and flow.

16·37. Random Processes in Automatic Control (A). Discussion of statistical foundations of control systems analysis, including concepts of stationary and non-stationary random processes. Analysis of output response of variable coefficient linear systems to random inputs. Perturbation methods in error studies for non-linear systems. Emphasis on use of simulator methods.

16·38. Control Systems Components (A). Study of physical components utilized in instrumentation and control systems from the point of view of the effect of their separate performance characteristics on the control system problem. Specification of components to meet particular control system requirements. Consideration of electrical, mechanical, pneumatic, and hydraulic components with emphasis on non-ideal effects.

16·39. Vector Kinematics and Gyroscopic Instrument Theory (A). Generalized theory of accelerations and velocities of bodies in spaces which are moving with respect to inertial space. Specialized application of this general theory and of Newtonian mechanics to development of the theory of gyroscopic instruments. Development of the treatment from the standpoint of the engineer, using both the methods of vector analysis and those of conventional coordinate components. Application of the results of the generalized theory to the analysis of gyroscopic devices used in airborne and marine craft.

16·40. Automatic Control Equipment for Aircraft (A). Discussion of errors and uncertainties associated with the components included in airplane automatic control equipment. Particular emphasis on dynamic errors. Several analytical techniques demonstrated, including graphical, operational and simulator methods. Analysis of gyroscopic and other flight instruments necessary for automatic control. Discussion of various aircraft computer units and comparison of merits of displacement, integral and derivative control. Dynamics of control elements, including servo lag and cable effects, considered. Analysis of complete aircraft system for longitudinal and lateral performance.

16·41. Fire Control Principles (RA). Discussion of static and dynamic behavior of instrument elements from the standpoint of functional performance. Particular emphasis on the theory of systems that can be described by means of first- and second-order differential equations with constant coefficients. Emphasis on the simplifications in analysis possible by use of non-dimensional variables and application of the principles of dimensional analysis to a wide variety of problems. Vector analysis methods used to set up the general requirements of the problems for both airborne and anti-aircraft fire control. (Restricted to selected officers of the U. S. Air Force, Army and Navy.)

16·42. Fire Control Systems (RA). Continuation of the study of fire control instruments started in 16·41. Applications of the theory of gyroscopic instruments to the analysis of fire control gyroscopic equipment. Development, as necessary, of the theory of other components used in fire control systems. Consideration of the dynamic characteristics of fire

Aeronautical Engineering Continued

control systems, including solution time and smoothing action. Study of design factors controlling dynamic performance with reference to possible methods for realizing satisfactory performance in actual systems. (Restricted to selected officers of the U. S. Air Force, Army and Navy.)

16·43. Fire Control Instrument Laboratory (RA). Laboratory work to demonstrate experimentally the principles developed in the lectures of 16·41 and taken concurrently with it. Experiments illustrating general static and dynamic performance of instrument systems following first- and second-order differential equations. Various experiments on the characteristics of fire control instrument components, including gyroscopic elements, data transmission systems, and integrating units. (Restricted to selected officers of the U. S. Air Force, Army and Navy.)

16·44. Advanced Fire Control Instruments Laboratory (RA). Continuation of 16·43. Experiments carried out on service fire control equipment and special demonstration units to study the static and dynamic performance characteristics of typical airborne and antiaircraft equipments. Particular attention given to the problems of solution time, smoothing and tracking. (Restricted to selected officers of the U. S. Air Force, Army, and Navy.)

16·45. Advanced Fire Control Systems (RA). Problems of current interest in fire control systems. (Restricted to selected officers of the U. S. Air Force, Army, and Navy.)

16·46. Advanced Fire Control Systems (RA). Problems of current interest and study of projected developments in fire control. (Restricted to selected officers of the U. S. Air Force, Army, and Navy.)

16·472. Rockets, Guided Missiles and Projectiles (RA). Review of one dimensional gas dynamics and of rocket propulsion; exterior ballistics of rockets; interceptor missile trajectories; ballistic missile trajectories; multiple step ballistic missiles; terminal ballistics; design considerations for guided missile and rockets. (Restricted to selected officers of the U. S. Air Force, Army, and Navy.)

16·48. Structural Problems in Weapons (RA). Principles of static and dynamic stress analysis of aircraft structures. Theory of shock loading. Effect of structural response on the fire control system. Fundamentals of gun and gun mounting structural analysis. (Restricted to selected officers of the U. S. Air Force, Army, and Navy.)

16·49. Special Problems in Fire Control (RA). Problems of interest to qualified students in consultation with the instructor. (Restricted to selected officers of the U. S. Air Force, Army, and Navy.)

16·50. Rotating Wing Aircraft (A). Discussion of problems of performance evaluation, control and stability, vibration and design, as applied to rotating wing aircraft.

16·51. Advanced Rotating Wing Aircraft (A). Discussion of specific design problems encountered in helicopters, convertiplanes and other vertical take-off aircraft, including automatic control and stabilization, methods of blade analysis, dynamics of the rigid and flexible blade and other current topics.

16·53. Aircraft Propulsion. Review of mechanics of compressible fluids. Applications to analysis and design of gas turbines, rockets and ram jets. Consideration of the limits on performance imposed by thermodynamics, fluid mechanics and strength.

16·56. Jet Propulsion Engines (A). Analysis and preliminary design computations for a turbo-jet power plant for a specific purpose.

16·60. Advanced Aeronautical Problems (A). Individual advanced work by properly qualified graduate students. Problems selected in consultation with the instructor.

16·61. Aeronautics Seminar (A). Weekly two-hour seminar given by the staff and the graduate students to discuss current aeronautical problems.

16·63. Aerodynamic Laboratory. Study of methods and equipment used for research in aerodynamics.

16·65. Aeronautical Engineering Laboratory. Series of lectures and experiments to illustrate the principles and practices of experimental aeronautics in the fields of aerodynamics, structures and automatic control systems.

16·70. Aircraft Detail Design. Aircraft drafting room practice and the preparation of airplane assembly, subassembly, and detail part drawings. Lectures and drafting room exercises covering air frame detail design, landing gear and landing gear control system mechanisms, fuel systems, airplane graphics, and the preparation of a weight estimate and balance diagram for a complete airplane.

16·71, 16·72. Aeronautical Engineering. Design of an airplane including layout, weight, balance, and performance estimates, structural design and preliminary stress analysis, stability and control analysis including the design of a simple automatic control system. Particular emphasis is placed on individual initiative and independent application of fundamental principles of design and on the presentation of a final report.

16·74. Advanced Airplane Design (A). Preliminary design of high performance aircraft, including structural design and aerolastic effects, aerodynamic evaluation, automatic control and stability analyses. Considerable latitude in choice of type of aircraft to be developed; use of design mainly as a means of illustrating advanced design problems encountered with high-speed piloted and pilotless aircraft.

16·76. Orbital Vehicles. Introductory engineering considerations connected with the design of rocket-propelled vehicles. Mechanics of long-range trajectories and satellite orbits, environmental conditions which exist in the upper atmosphere and beyond, aeroelastic, aerodynamic, propulsive, structural guidance and control aspects.

16·81. General Aeronautics. Characteristics of aircraft, engines, and propellers for non-aeronautical students.

16·82. Introductory Aeronautical Engineering. Introduction to aircraft, their components and general principles of flight.

16·8[illegible]·852. Industrial Practice. Approximately six months of practical work carried out by the cooperative students in manufacturing, engineering, research, and developments at the plants of the organizations participating in the cooperative program.

16·91. Aeroelasticity (A). Dynamics of elastic structures; air forces under unsteady conditions; flutter.

16·92. Advanced Aeroelasticity (A). Advanced aspects of aeroelasticity: corrections for finite span and compressibility in flutter calculations; study of wing divergence and aileron reversal.

16·93. Aeroelasticity Laboratory (A). Experimental study of problems in structural dynamics and aeroelasticity.

16·94. Dynamics of Aircraft Structures (A). Application of vibration theory to the determination of the vibration characteristics of the aircraft structure. Determination of the dynamic stresses produced during the transient response of the aircraft structure to rapidly applied forces. Discussion of current structural dynamics problems.

BUILDING ENGINEERING AND CONSTRUCTION

Subjects 17·00 to 17·99

17·40. Job Management. Studies in the field of contracting activities including owner-architect-engineer-contractor relationships; contract types and relations, including sub-contracting; job planning and organization, supervision, superintendence, job records, labor relations and safety procedures. *Departmental Notes.*

17·401. Advanced Job Management (A). Development of the organization of large projects with particular reference to the initial economic survey, time schedules, job organization, and the integration of construction procedures. Particular emphasis on the character of contract instruments, legal requirements for job insurance and the expedition of materials to accomplish speed and quality. *Departmental Notes.*

17·402. Construction Management Seminar (A). Continuation of 17·401 in seminar form. Diagnosis of failures and their causes; integration of the electrical, mechanical and sanitary services into building construction; analysis of architectural concepts in the light of existing construction procedures; study of professional relations in the conduct of contracting as a profession. Extensive contributions by the students. Field trips to illustrate difficult situations. Participation of contractors, architects and engineers from a variety of projects. Field surveys, library research papers and a term paper.

17·41. Building Management (A). Especially designed to train graduate students in the field of property management. Study of the elements of first cost, expansion, maintenance, rentals, repairs and modernization as applied to commercial and industrial buildings. Work consists of lectures, field surveys, assigned readings and reports. *Departmental Notes.*

17·43. Building Construction. Abridged study of building construction, estimating and job management. Procedure in planning construction operation, sequence of construction, quantity take-off and estimating, visits to building projects currently under construction. Designed to provide civil engineers with essentials of building construction procedure. Staley, *Semi-Fireproof Construction.*

17·44. Specifications (A). Development of theory and practice of writing specifications for large buildings. Special emphasis on the utilization of principles of structural design, construction, construction management and materials in specifications. Simplification of technical requirements for greater efficiency and clarity. Discussion of all major trade subdivisions and choice of materials for proper coordination and performance in the completed structure. Development of engineering judgment in technical choice and in anticipation of difficulties.

17·45. Construction Problems. Continuation of previous courses in Building Construction. Specifications, details, and construction procedure for an actual job in progress, or for an approved project in the field. Discussion of original and alternate specifications and methods from those used or proposed in the actual project.

17·53T. Wood Design and Graphical Analysis. Study of the applications of the string polygon in determining bending moments, moments of inertia, and elastic curves. Use of space and force diagrams in the analysis of trusses. Design of wood beams, columns, trussed girders, connections, spaced columns, trusses, glued laminated structures, plywood girders and stressed skin panels. Scofield — O'Brien, *Modern Timber Engineering.*

17·531. Advanced Reinforced Concrete Design (A). Analysis and design of retaining walls, continuous footings, flat slabs with irregular spans, beams subject to torsion, rigid frame bents and hipped plate roofs. Calculation of elastic and plastic deformations.

17·532. Advanced Reinforced Concrete Design (A). Stresses due to shrinkage and creep, ultimate strength theories, design of prestressed members, design of shells.

17·54T. Concrete Design. Structural design of reinforced concrete building frames, including development of the theory of design, design of solid and ribbed slabs, beam and girder framing, two-way slabs, flat slabs, columns, footings, and retaining walls. Dunham, *Theory and Practice of Reinforced Concrete.*

17·542. Advanced Structural Steel Design (A). Design of rigid and semi-rigid riveted and welded connections; design of members subject to torsion. Limit design; design of members with variable moment of inertia; design of rigid frame bents.

17·73. Materials — Wood, Plastics, Fabrics. Mechanical and physical properties of wood in relation to growth, structure and other characteristics which influence its use in construction and engineering. Strength, moisture content, preservative treatment, wood products, identification, and selection of species for various uses. Fundamental properties and uses of plastics, and basic characteristics of coatings and fabrics used in construction. *Wood Handbook;* Dietz, *Construction Materials;* A.S.T.M., *Selected Standards for Students in Engineering.*

17·74. Materials — Masonry and Metals. Portions of 17·71 and 17·72 most essential for architectural students, with particular reference to masonry materials, concrete, and metals. Study of factors affecting the durability of masonry structures. Principles underlying metals, alloys, corrosion and welding of metals. About two-thirds of subject devoted to masonry materials, and the balance to metals. Laboratory work testing brick and mortar; concrete and concrete beams; ferrous and non-ferrous metals; wood, plastics, and laminates; and thermal conductivity of walls. Murray, *Masonry Materials; Laboratory Manual;* Williams & Homerberg, *Principles of Metallography.*

17·741. Engineering Properties of Plastics. Engineering attributes of plastics studied, with principal emphasis upon mechanical and structural properties. Work includes an introductory review of the chemistry of plastics to familiarize the student with the various types; the various strength properties; other properties important from an engineering standpoint such as dimensional stability and durability; and methods of manufacture and fabrication, insofar as these modify and influence the engineering properties. *Departmental Notes.*

17·742. Engineering Laminates (A). Consideration of the general theory of composite materials, followed by discussion of specific laminates such as plastics reinforced with paper, textiles, glass fibers, and various types of mats; sandwiches of soft cores and hard faces; plywood and laminated timber; laminated glass, rubber duplex metals, and cements and adhesives employed in making up composite materials. Dietz, *Engineering Laminates.*

17·76. Research in Organic Structural Materials (A). Opportunity for laboratory investigation amplifying the work done in subjects 17·741 and 17·742.

17·771. Cementitious Materials. Continuation and more advanced study of the cementitious materials covered in 17·72. Critical studies of the composition of cements, effect of composition on the use of the cement and upon the durability of the products. Special emphasis on the composition and physical properties of mortars, stuccoes and plasters, and effect of these properties on masonry construction. Murray, *Masonry Materials; Concrete Manual.*

17·772. Concrete (A). Advanced study of portland cement concrete with particular attention to the effect of type and composition of cement, type and size of aggregate on such properties as soundness, volume stability, and durability. Advanced study of selected topics as concrete mix design, air entrainment, admixes, bleeding, and creep. No required text but frequent assignments from current literature on concrete.

17·78. Research in Cementitious Materials (A). Opportunity for laboratory investigation amplifying the work done in subjects 17·771 and 17·772.

METEOROLOGY

SUBJECTS 19·00 TO 19·99

19.00. GENERAL METEOROLOGY. Introductory subject presenting a general treatment of the observational facts, mechanics, thermodynamics, and physics of the atmosphere. Applications of meteorological knowledge to weather forecasting, business, industry, transportation, etc. Laboratory exercises in the use of the weather map.

19·001. GENERAL METEOROLOGY. Same as 19·00 without the laboratory exercises.

19·003. ELEMENTARY METEOROLOGY I. Introduction to the study of weather. Consideration of the characteristics which define the three-dimensional structure of the atmosphere, its average state, and departures from the average state. Qualitative treatment of the physics and physical processes of the atmosphere, including radiation, optics, atmospheric electricity, cloud physics, and the upper atmosphere. Brief treatment of principles of weather analysis and forecasting. Open to students who desire only one term of elective study in meteorology.

19·01. DESCRIPTIVE METEOROLOGY I. Simplified treatment, with a minimum of mathematics, of composition and structure of the atmosphere; elementary thermodynamics and the heat balance of the atmosphere; the circulation principle (geostrophic, gradient, and frictional wind); formation and characteristic forms of atmospheric condensation phenomena. Willett, *Descriptive Meteorology.*

19·02. DESCRIPTIVE METEOROLOGY II. Continuation of 19·01, covering the general circulation of the earth's atmosphere; the secondary circulations, both tropical and extratropical, including the role of air masses and fronts; the tertiary (local) circulations, including drainage winds, local convection, whirlwinds, showers, thunderstorms, land and sea breeze, large scale turbulence eddies, föhn winds, etc. Willett, *Descriptive Meteorology.*

19·14. LONG RANGE WEATHER FORECASTING (A). Principal methods of long range weather forecasting. Detailed treatment of the present Weather Bureau five-day forecasting and verification techniques. Laboratory exercises in application of the five-day prognostic technique. Selected reading of special reports and articles.

19·21. METEOROLOGICAL OBSERVATIONS. Observation, recording and coding of weather data; use and maintenance of station instruments; teletype circuit operation and procedure.

19·22. METEOROLOGICAL INSTRUMENTS (A). Principles and techniques of meteorological instrumentation. Lectures and laboratory exercises in static and dynamic responses of pressure, temperature, humidity and wind instruments. Laboratory and field exercises with surface and upper air instruments. Reduction of observed data to forms suitable for synoptic and dynamic studies.

19·23. MICROMETEOROLOGICAL INSTRUMENTATION (A). Instruments, techniques and procedures for micrometeorological measurements.

19·30. GENERAL CLIMATOLOGY. Distribution of radiation temperature, pressure and wind, hydrometeors and air masses and fronts at the surface of the earth and aloft and of the physical factors determining this distribution. Climatic zones and types. Description of the climate of each continent and of the oceans in terms of dynamics of the atmosphere, of air mass types and frontal activity. Haurwitz and Austin, *Climatology.*

19·32. MICROCLIMATOLOGY. Study of physical properties which determine the structure of the lowest layer of the atmosphere.

19·33. APPLIED CLIMATOLOGY (A). Study of modern climatological methods applied to problems of business, industry, agriculture, aviation, the military, and public health. Extensive use of principles and techniques of synoptic and dynamic meteorology, physical climatology and statistics in the development of the climatological method. Lectures on techniques and case method of demonstration. Opportunity to select weather problems for solution and presentation for class discussion and criticism.

19·44. SYNOPTIC METEOROLOGY I. Meteorological elements and their conservatism; practical rules and formulae for extrapolating the movement and development of surface and upper air pressure systems; hydrometeors, clouds and colloidal stability; stability and instability and their relation to weather phenomena. Structure of pressure systems and their synoptic application. Petterssen, *Weather Analysis and Forecasting.*

19·45. SYNOPTIC METEOROLOGY II (A). Analysis of methods and results of investigations of cyclonic and anticyclonic behavior. Synthesis of this information into models and theories of pressure change. Review of recent research in synoptic meteorology. Interrelationships between surface and upper-air changes and their application to the forecast problem.

19·46. NUMERICAL WEATHER PREDICTION (A). History of the problem and early attempts at its solution; analysis of the hydrodynamical equations; finite difference methods with error control; application to barotropic and simple baroclinic models of atmospheric flow.

19·50. INTRODUCTORY METEOROLOGY LABORATORY. Explanation of international weather symbols and airways teletype code; decoding and plotting of daily weather reports; identification of cloud types; elementary principles of weather map analysis.

19·51. SYNOPTIC LABORATORY I. Analysis of weather maps. Application of practical rules for extrapolating the movement and development of pressure systems. Practice forecasting for selected stations.

19·52. SYNOPTIC LABORATORY II. Analysis of weather maps and practice weather forecasting for selected stations, together with practice in special airways forecasting, utilizing the teletype line sequences.

19·53. SYNOPTIC LABORATORY III (A). Continuation of 19·52. Advanced methods of analysis and forecasting with special emphasis on the use of aerological diagrams, cross sections, upper air charts, etc.

19·601. INTRODUCTION TO THEORETICAL METEOROLOGY. Simplified treatment of atmospheric statics, dynamics and thermodynamics designed to provide the theoretical background for synoptic meteorology and to prepare the student for more advanced subjects in dynamic meteorology.

19·62. DYNAMIC METEOROLOGY I. Hydrodynamic equations of motion. Streamlines and trajectories, circulation and vorticity, theory of atmospheric turbulence, its effects on the vertical distribution of wind and other meteorological elements. Energy transformations in the atmosphere. Survey of the wave theory of cyclones. Haurwitz, *Dynamic Meteorology.*

19·64. DYNAMIC METEOROLOGY II (A). Large scale atmospheric motions. Examination of recent theories of the general circulation. Research in the application of fluid mechanics to meteorology and oceanography. Lamb, *Hydrodynamics.*

19·65. DYNAMIC METEOROLOGY III (A). Analysis of certain types of atmospheric flow. Study of theory of turbulence and diffusion in the lower layer of the atmosphere with special emphasis on non-isotropic turbulence.

19·70. ELEMENTARY PHYSICS OF THE ATMOSPHERE. Treatment of atmospheric radiation, the ozone layer and the upper atmosphere, atmospheric electricity, atmospheric optics, propagation of sound in the atmosphere, and icing of aircraft.

19·71. RADAR METEOROLOGY (A). Elementary principles of radar and the techniques of storm detection. Analysis of the radar echo from precipitation. Discussion of the potentialities of radar for the examination and measurement of precipitation processes. Brief discussion of radar propagation anomalies. Lectures and laboratory work with operating radar systems.

19·72. PHYSICAL METEOROLOGY (A). More detailed study of radiation theory as applied to the atmospheric heat balance; structure and composition of the stratosphere with

Meteorology Continued

special reference to the ozone layer. Theory of the visual range; physical theory of atmospheric condensation and precipitation processes.

19·83. Oceanography. Principles and methods of physical and dynamical oceanography, and the current systems of the oceans with special emphasis on their meteorological significance. Sverdrup, *Oceanography for Meteorologists.*

19·91. Meteorological Seminar I (A). Weekly reviews and discussions by staff members and students, of recent meteorological contributions published in current periodicals, and of original research.

19·911, 19·912. Meteorological Seminar I, II (A). Same as 19·91.

19·94. Special Problems in Meteorology. Reading, consultation, and original investigation on meteorological problems.

19·95. Special Problems in Meteorology (A). Reading, consultation and original investigation on meteorological problems of more advanced nature than those in 19·94.

. FOOD TECHNOLOGY

Subjects 20·00 to 20·99

20·00. Man's Food. Survey of the natural and cultivated sources of food for mankind from the viewpoint of production, transportation, processing, packaging and consumption. History of the foods of mankind through the ages; natural food resources; nutritional requirements of man; effects of geography on dietary patterns; food habits and fads; environment, soils and agriculture; plant and animal breeding; harvest, storage and distribution of food; international movement of food; food economics; agricultural economics; federal regulation of agriculture; food industry of the U. S.; food laws and regulations; science and engineering in food technology; population and the world food problem.

20·001. Food Production. Study of food production for processing purposes including the following aspects: agronomic and horticultural crops, live stock and poultry, foods from salt and fresh water, agricultural economics, environmental relationships with soil and water, genetics, nutrition, insect and disease control, and applications of chemical and engineering principles.

20·01, 20·02. Chemistry and Technology of Food Supplies I, II. Chemical composition, production, consumption, statistics, and methods of treatment of food materials. General commercial methods of production and handling of raw foods, such as milk, eggs, meats, cereals and other vegetable food supplies, and their preparation for commercial distribution or for later manufacturing processes. Fundamental principles involved in physical processes such as refrigeration, dehydration, and salting, and the microbiology and chemistry of the processes. Laboratory work including numerous exercises involving the chemical analysis of various foods and food products. Prescott and Proctor, *Food Technology;* Woodman, *Food Analysis.*

20·11. Technology of Food Products. Methods of food preservation and manufacture. Semi-plant scale operations in dehydration. Production of fruit juices and concentrates, canning processes, and quick-freezing of various foods. Cruess, *Commercial Fruit and Vegetable Products;* Tanner, *The Microbiology of Foods.*

20·12. Technology of Food Products. A continuation of 20·11 with reference to the products and technological processes of the meat-packing industry, fisheries, dairy products, and special technical procedures involving heat penetration, sterilization, and packaging. Tressler and Evers, *The Freezing Preservation of Fruits, Fruit Juices and Vegetables.*

20·13, 20·14T. Chemical Engineering Food Applications. Fundamental principles of chemical engineering operations, with emphasis upon application in the food industry. Flow of heat and flow of fluids, extraction, evaporation, distillation, drying, filtration, etc. Laboratory work on various food engineering problems by groups of students. General discussions, supplemented by extensive problem work. Perry, *Chemical Engineers' Handbook.*

20·21. Flavor Evaluation (A). Study of the senses of taste and smell and their interrelationship with other senses. The concept of flavor and its estimation by the senses. Natural and synthetic flavors, their preparation, composition and use in food products. Flavor changes in food products. Introduction to organoleptic technics.

20·22. Food Acceptance (A). Study of the factors influencing the acceptance of foods by individuals and by large groups. Consumer acceptance testing. Sensory difference testing. Development and maintenance of specifications and standards for food acceptance. Analysis of variables and attributes for the control of food products.

20·32. Chemistry of Nutrition. The needs of man and animals for calories, carbohydrates, fats, proteins, amino acids, minerals, and vitamins, and discussion of their metabolic interrelationships.

20·322. Chemistry of Nutrition Laboratory. Analysis for nutrients of representative foods by chemical, colorimetric, fluorometric, and microbiological techniques.

20·34. Applied Nutrition (A). Nutrient requirements of man and animals; laboratory and clinical methods for determining requirements and nutritional status; techniques for measuring adequacy of dietaries; genetic and environmental factors influencing nutrient content of foods; food habits; population feeding programs; school lunches; communal feeding, etc.; international nutrition problems.

20·36. Advanced Nutrition (A). Digestion of food and metabolism of nutrients, including: occurrence of nutrients in plant and animal products; stability of essential nutrients during plant growth, harvesting, storage, manufacture, and preparation for serving; influence of diet on intestinal synthesis of vitamins; synergistic action of nutrients; absorbability of nutrients from alimentary tract; endocrines and nutrition; dynamics of body constituents; isotopic and radioactive techniques; measurement of food proteins; amino acid analysis; methods of research with animals.

20·38. Nutritional Evaluation of Food Processes (A). Consideration of losses or gains in nutritional values of foods and food products during transit, treatment and storage. Discussion of the effects of the following operations: harvesting, transportation, refrigeration, freezing, concentrating, dehydration, bleaching, refining, blanching, canning, pickling, salting, brewing, fermenting, baking, steaming, boiling, frying, roasting, and toasting. Procedures for minimizing these losses in vitamins, minerals, amino acids and other nutrients are suggested.

20·41. Bacteriology. Biology, physiology, biochemistry and biophysics of bacteria. Pure culture studies, identification of unknown bacteria, effects of physical and chemical agents on bacteria, food intoxication and infection, anaerobiosis, water and milk bacteriology. Frobisher, *Fundamentals of Bacteriology.*

Food Technology Continued

20·42. Industrial Microbiology. Fundamental studies involving industrially important fermentations. Cultural and production methods, biochemistry. Applications of microbiology in the food, brewing, leather and textile industries. Ethanol, yeast, vinegar, butanol and acetone, organic acids, antibiotics. Prescott and Dunn, *Industrial Microbiology.*

20·43, 20·44. Advanced Industrial Microbiology (A). Selected problems in the use of yeasts, bacteria and molds for the production of substances of industrial or potential value. Emphasis on the study of the most recent cultural and production methods and the biochemistry of the fermentations or the changes concerned. Biochemical activities of the acetic acid bacteria; preparation of organic acids, alcohols, alcoholic beverages, yeast, butanediol, antibiotics, enzyme products, lipids, sterols, and other substances; saccharification of starches and cellulosic materials; microbiological determination of amino acids, vitamins; and relation of certain biological agents to the textile, timber and leather industries. Prescott and Dunn, *Industrial Microbiology;* Smith, *Industrial Mycology;* Bern-Hauer, *Gärungschemisches Praktikum.*

20·46. Bacteriology of Foods (A). Quantitative study of the handling and storage of foods and their bacterial deterioration. Food storage in atmospheres of inert gases, food fumigation, recent advancs in food packaging, and relation of bacteria thereto.

20·47, 20·48. Biochemical Engineering. Applications of biochemical engineering in the modern fermentation and antibiotic industries. Lectures, discussions, and laboratory studies on production, recovery, and analytical methods, including such topics as construction materials, control instruments, aeration, ion exchange, chromatography, ultrasonics, Warburg technique, and pilot plant investigation.

20·51, 20·52. Advanced Food Technology (A). Technical problems in special food industries, involving the use of dehydration, sterilization, homogenization equipment, and special applications of physics, chemistry, and biology in food technology. Mrak and Stewart, *Recent Advances in Food Research.*

20·53. Food Applications of Ionizing Radiations (A). Introduction to theory and application of ionizing radiations to the sterilization of foods and pharmaceuticals. Effects of radiations on bacteria, molds, insects, enzymes, foods and their constituents.

20·531. Food Applications of Ionizing Radiations Laboratory (A). Laboratory exercises and problems on the fundamental as well as applied aspects of the utilization of ionizing radiations for the sterilization of food and pharmaceuticals by ionizing radiations.

20·55. Technology of Lipids (A). Study of the chemistry, isolation and identification of fats, oils, fatty acids and related compounds. Industrial preparation of fats and oils and their utilization in the food industry. Importance of lipids in the economy of life processes.

20·61, 20·62. Food Technology Seminar (A). Presentation of recent advances in food technology and research and analysis of the fundamental principles involved.

20·71, 20·72. Research Problems (A). Special research techniques in food technology.

20·83, 20·84. Selected Topics in Food Technology (A). Surveys and investigations arranged by individual conference.

20·91, 20·92. Food Industry Seminar (A). Seminar, with guest speakers, relating to industrial aspects of food technology and related professional topics.

AIR SCIENCE

Subjects AS11 to AS99

AS11, AS12. Air Science. Introduction to AFROTC, Introduction to aviation, fundamentals of global geography, international tensions, security organizations, and instruments of national military security; drill.

AS21, AS22. Air Science. Careers in the USAF, moral responsibilities of Air Force leaders, introduction to aerial warfare, targets, weapons, aircraft, bases, operations and leadership laboratory.

AS31, AS32. Advanced Air Science. Air Force commander and staff, communicating and instructing in the Air Force, military justice system, air navigation, weather, Air Force base functions and leadership laboratory.

AS41, AS42. Advanced Air Science. Career guidance, leadership and management seminar, military aviation and evolution of warfare, military aspects of world political geography, briefing for commissioned service and leadership laboratory.

GRAPHICS

Subjects D1 to D99

D11. Engineering Drawing. Fundamentals of representation by projection. Freehand sketching, isometric, perspective, and orthographic projection. Conic sections and graphical calculus. Dimensioning, conventions and working drawings. An individual project.

D111. Graphics Laboratory I. Exercises, problems and experiments in graphical representation — real and abstract, perspective and shade and shadows. Emphasis on line sensitivity, introduction to design and form. Work in pencil, pen, charcoal, crayon and brush.

D12. Descriptive Geometry. Analysis of three dimensional space relations on a two dimensional surface. Analysis of problems involving points, lines, planes and surfaces into fundamental components and development of methods of attack. Development of capacity to think in space terms.

D121. Graphics Laboratory II. Continuation of representational techniques in pencil and pen. Further development of the basic elements of design and form. Introduction to color and texture. Work in water color, air brush, and camera.

D13. Graphical Processes. Methods of graphical solution of physical problems. Graphical arithmetic and algebra. Conic constructions, projective geometry, coordinate systems, graphical calculus, scales, nomograms, empirical curves, and periodic curves. An individual project.

D14. Elementary Nomography. Introduction to graphical solution of equations through alignment diagrams based on plane geometry.

D31. Nomography. Nomographic methods for solving equations in three or more variables and their application to scientific data. Plane geometry foundation and concurrent presentation of advanced determinant theory with adequate algebraic background. Central projection in nomographic technique, interpretation in terms of general projective transformation, corresponding determinant operator, and graphical

Graphics Continued

and analytical methods. Errors of Lo-Ho. Discussion of classical and modern necessary and sufficient conditions for nomographic form as presented by Duporcq, Gronwall, Kellogg, Thomas, and others. Quasi-alignment diagrams and applications of the principle of duality to alignment diagrams based upon empirical data. Project problem. Douglass and Adams, *Elements of Nomography; Mimeographed Notes.*

D32. Advanced Graphics. Projective geometry, construction of conics, projective transformations. Applications to streamline shapes such as aircraft. Wrapped surfaces. Duality transformations, with application to network charts and alignment diagrams. Theory of graphs and tables. Transformation of curvilinear network charts into rectilinear networks. Graphical calculus, including general methods for solution of ordinary non-linear differential equations; harmonic analysis. Emphasis on graphical techniques applied to empirical data. Opportunity for the student to pursue projects connected with his own field of engineering.

ENGLISH

Subjects E1 to E99

E11. English Composition. Principles of effective written communication. Particular attention to logical organization of papers and to precise and coherent expression of facts and opinions. Numerous papers required.

E25. English Composition. Students who in the collective judgment of members of the Department of Humanities have failed at the end of H22 to meet certain standards of expression and therefore have received a deficiency in composition required to take this subject. It may be prescribed at any time for juniors and seniors whose use of English in their professional courses is unsatisfactory. Instruction carried on in frequent group meetings and in individual conferences, at hours to be determined by the instructor. No credit given for this subject.

E27. Creative Writing. Consideration of materials and techniques of fiction, poetry, and drama through detailed study of models and practical application in writing. Considerable reading in novels, short stories, dramas, and poems. Limited to juniors and seniors showing evidence of creative ability and sincere interest in writing. Minimum manuscript requirement 1,000 words a week. Each student encouraged to practice the type best suited to his taste and experience. Permission of instructor required for enrollment. (Not offered 1956–57.)

E28. Creative Writing. Continuation of E27. (Not offered 1956–57.)

E31. Introduction to Literature. The attempt by class discussion of common reading to suggest the possible meanings of pieces of literature, to form some sense of taste, and to formulate criteria for critical judgment. Reading of stories, novels, plays, and poems largely from European and American literature of the past century.

E32. Literary Theory. Examination of a few works of literature in various genres and from several periods for their possible, aesthetic, social, and philosophic meanings.

E35. Reports. Preparation and presentation of business and engineering reports. Practice in investigation of subjects, arrangement of material and its presentation in report form. Subjects covered range from simple memoranda and business letters to longer, more comprehensive reports.

E36. Seminar in Technical Writing. Application of the principles and practices of good technical reporting to individual writing situations. Comparison of requirements for professional and non-professional reader levels. Exercises in the preparation of research papers, journal articles, and abstracts — as well as the standard types of technical reports. Selection of topics from the student's professional courses or experience.

E37. Public Speaking. Designed to afford knowledge of principles of expression and argumentation in business discourse and everyday life. Use of the voice; practice in vocal elements of quality, pitch, force and time, for securing better authority, resonance, and confidence. Practice in specific speech situations: extemporaneous, impromptu, and read speech; business meeting, sales talk, and after-dinner speech.

E38. Public Speaking. Continuation of E37. May be taken separately with permission of instructor. Study of parliamentary procedure. Duties of the chairman and master of ceremonies. The logical development of subject matter Voice recording and analysis. Designed through practice and criticism to assist the engineer in his professional work and to give confidence in himself.

E40. Epic Tradition in Literature. Reading of such authors as Homer, Vergil, Lucretius, Job and Milton. Emphasis on ways in which lyric, drama and the modern novel are related to the epic view of man. (Not offered 1956–57.)

E42. Non-Western Literature. Examination of available non-western literature, some primitive songs and stories, including early Chinese and Vedic hymns, parts of the Hindu epics of *Mahabharata* and *Ramayana*, Confucian and Buddhist writings, Chinese and Japanese verse and prose, Hindu drama, and Persian epic, lyric, and philosophic verse. Some emphasis on the attitudes of Eastern peoples and their taste in the arts revealed through their painting and sculpture.

E43. English Drama before Ibsen. Selected readings and discussion of major playwrights from its classical and medieval beginnings in the modern period, including Marlowe, Shakespeare, Webster, Jonson, Congreve, Wycherly, Sheridan, Goldsmith, and others. Special emphasis on the history of the development of the western stage and related problems of production. Close reading and interpretation of the texts.

E44. The Nature of Poetry. Aims to stimulate understanding and appreciation of essentials of poetry. Selected works of poets from Chaucer to contemporary Americans discussed in terms of the variety of influences — social, psychological, literary, technical — shaping them. Lectures, readings, and informal discussions by poets in the vicinity.

E45. Shakespeare. Reading and discussion of Shakespeare's major plays and sonnets.

E46. Modern Drama since Ibsen. Selected reading and discussion of the major European and American playwrights of the modern period, including Ibsen, Wilde, Chekov, Shaw, Gorky, Yeats, Pirandello, O'Neill, Rice, Hellman, Miller, and others. Special emphasis on the techniques of production and history of the modern theatre. Close reading of the texts.

E47. Nineteenth-Century American Literature. Reading and discussion of fiction and poetry by such writers as Poe, Hawthorne, Emerson, Melville, Whitman, Twain, Dickinson, James, Crane, and Dreiser.

E48. Twentieth-Century American Literature. Reading and discussion of such authors of fiction as Anderson, Fitzgerald, Caldwell, Wolfe, Faulkner, Steinbeck, Welty, and Hemingway; and of such poets as Eliot, Jeffers, Robinson, Frost, MacLeish, Moore, Cummings, and Stevens.

E49. Russia and the West in Modern Russian Literature. Focus on the superfluous or isolated man in Russian literature. Readings from such writers as Pushkin, Gogol, Aksakov, Turgenev, Dostoevsky, Tolstoi, Leskov, Chekhov, Bunin, Gorky, Blok, Olyesha, Pasternak. All works in translation.

E50. The Bible. Close reading of seminal texts from Old Testament and New Testament as literary documents illustrating specific kinds of religious experience. Philosophical implications and historical repercussions of such basic problems as faith, creation, perfection, time, etc.

English Continued

E51. Modern Novel. Reading and discussion of selected novels by such authors as Mann, Joyce, Proust and Kafka.

E52. Comic Sensibility. Close reading and discussion of selected comic writings from classical times to the present by such authors as Apuleius, Shakespeare, Jonson, Molière, Swift, Sterne, Chekhov, Shaw, and Potter. Emphasis on the special nature of the comic response to events.

E57. Special Readings. Subjects offered to selected groups by visiting professors and to advanced students who may require a special program.

E58. Special Readings. Continuation of E57.

HISTORY

Subjects H1 to H99

H1. Philosophy and Scientific Methodology. The nature of science and scientific inquiry; the nature of philosophy and its problems. The language problem in science and philosophy; the subject matter of logic; the nature and role of induction and deduction, "facts," hypotheses, laws; experimental methods, prediction, and operational definition. Science as a description of experience; scientific law as explanation; critical evaluation of scientific results. Discussion of various key concepts from the physical and biological sciences from the points of view of their role in science and the light they shed on philosophical problems.

H2. American Character and Institutions. Role of technological innovation in shaping social institutions and influencing the formation of American character. Consideration of impact of technology on social organization, social changes, group solidarity, status and mobility, urbanization, family, and personality formation.

H11, H12. Foundations of Western Civilization.* Study of the individual in his relationship to society and of the moral and intellectual problems involved in this relationship. First term: focus on two societies in the pre-modern period which have contributed significantly to contemporary civilization and are remote enough in time and place to provide contrasts to contemporary social organization and behavior. Selection of materials in approximately equal parts from history, literature and philosophy. Emphasis on written expression throuh themes and on oral communication through class discussion. Second term: focus on two societies in the early modern period.

H21, H22. Humanities. Two options are provided, as follows:

A. The United States: Men and Issues. Consideration, with continuing attention to contemporary relevance, of various problems and forces involved in the formation and perpetuation of the Union. Examination of these problems through the use of source materials, literature and biography, to illuminate the institutional and intellectual conditions under which they arose and were solved. Second term: focus on problems of industrialism and world politics.

B. Modern Western Ideas and Values.* Analysis of selected intellectual, ethical and aesthetic developments since the beginning of the Age of Reason. Readings in great books covering such fields as religion, philosophy, science, and political economy, and in literary classics epitomizing relevant ideas. Second term: focus on the period since the late nineteenth century.

H31. American Social and Intellectual History. Topical study of development of institutions and ideas in America. Special study of one topic by each student, participation in the discussion of a dozen others. Topics varying from year to year with the interests of students and instructor.

H32. Political Process in Industrial America. Study of selected topics from the history of the United States since the Civil War. Emphasis on the changing demands made on the federal government, the ways in which the political and legislative processes have resolved conflicts among these demands, and the ways in which the institutions and theories of government have been adjusted to changing situations.

H34. Religious Thought and American Society. Study of the interaction of scientific, economic and social change with American religious thought. Examination of religious ideas through the works of the novelist, philosopher and pamphleteer as well as the theologian.

H35. Europe — The Expansion of Europe. Case studies in modern imperialism. Topics including the British in India, the French in North Africa, and the South African complex. Readings from relevant literary sources. Emphasis on history; coverage of other appropriate disciplines. Focus of student's independent study on a specific nationalistic brand of imperialism.

H36. Modern Europe — War, Society and the State. Analytical study of the major problems confronting Western Europeans before and after World War I. Special consideration of the causes and effects of that war.

H38. The Russian Revolution and the Soviet Union. Nature and meaning of the Soviet challenge to America. Use of literary, historical, and intellectual materials in the study of the origins and course of the revolution. Political, social, and economic structure of the USSR and its relationship to recent and contemporary Soviet foreign policy.

H51. American Economic Development. Examination of the transformation of the American economy from an agrarian to an industrial one with emphasis on the interdependence of such factors as natural resources, capital accumulation, technological change, institutional structures, the laboring force, the professions and the role of the entrepreneur.

H52T. Business Leadership in the American Economy. Historical study of the function of business leadership in the growth of American economy. Social and economic backgrounds of the American businessman. Professionalization of management; comparison of technical and general training as preparation for management. Factors in decision-making; economic, technological, institutional. Case studies of business leadership in the growth of various industries; such as railroads, textiles, oil, iron and steel, automobiles.

H55. History of Engineering. History of the techniques and achievements in engineering from ancient times to about 1800. The goals, methods, and status of the engineer in Babylonia, Egypt, Greece, Rome, the Arabic world, the Middle Ages, and the Renaissance set against the background of the political, social, and economic conditions of the times. Study of the development of engineering as an integral part of the life of cultures different from our own to give perspective and background for studying and evaluating the position and contributions of the engineer in modern times. Extensive use of lantern slides.

H56. History of Engineering. Study of the development of modern engineering from 1830 to about 1930. Presentation of engineering advance as an important factor among the economic and social changes which center around the Industrial Revolution. Concentration on those key aspects of greatest importance for future engineering development and for economic and social change — coal, steel, textiles, machinery, transportation, electric power, etc. Lantern slides.

H58. Art and Industrial Civilization. Perceptual and conceptual analysis of painting, sculpture, architecture and product design, especially in the period since 1750. Focus on both the nature of the visual arts and the ideas they reflect.

H63. American Foreign Policy in Action. Study of selected topics in the development of American foreign policy in the pre-industrial period, the period of growth to a major industrial power, emergence as a world power, and, finally, in a bi-polar world.

* For suitably prepared students special sections of these subjects are offered in French by the Department of Modern Languages.

History Continued

H65. Problems in Economic Development. Comparative study of economic growth and decline. Materials drawn mainly from contemporary situations in underdeveloped and advanced societies, including some problems of the American economy and of Fourth Point Policy. Introduction of historical data where necessary, as background and for purposes of comparison.

H71. Basic Ideas of Western Politics and Ethics, 500 B.C.–1500 A.D. Survey of development of fundamental ideas and institutions of Western Civilization. Discovery of generalized thinking — science — in the search for truth, ideas of predictability and fitness — law and justice — in the search for political stability, ideas of personality and soul in search for a meaningful life. Rise and collapse of scientific progress and political power in the Roman era, new start by early Christians with new attitude toward persons, work, and the universe, rise of communities and experimentation in new social order in Middle Ages, and such resulting western traditions as division of political and spiritual power and legacy of continuing technological and social changes in a self-transforming civilization.

H72. The Rise of Modern Political and Social Science, 1500–1914. Continuation of approach of H71. Background of ideas represented by Renaissance, Reformation, and Age of Reason, with concentration on new basic patterns of scientific and social thought that emerged. Study of conceptions of mechanism, organism, and society and their application to political and social problems. Attempts to apply reason to society studied in ideas of Machiavelli, Hobbes, Locke, Hume, Adam Smith, Madison, Robespierre and Kant. Changes in conservative position traced in Burke, Hegel, Nietzsche, Cecil Rhodes, Spengler, and Pareto. Evolution of liberalism traced in Bentham, J. S. Mill, Herbert Spencer, and Lloyd George.

H73. Science and Philosophy from the Greeks to Copernicus. Study of the course of civilization around the growth of scientific ideas, from the Pre-Socratics to Copernicus, including the birth of scientific thought with accompanying philosophical ideas, idealistic reorganization, medieval view from its origins to its breakup with Copernicus and the age of discoveries. Particular emphasis upon the vital link between scientific, philosophical, and social ideas.

H74. Science and Philosophy from Galileo to the Present. Continuation of H73 to modern times including the foundation of modern natural philosophy, the Age of Reason, the foundation of modern physics, chemistry and biology, centered around such figures as Lavoisier, Faraday, and Darwin, and the conflict of nineteenth century ideas, arising from these developments.

H75T. Philosophic Problems and Systems. Consideration of such problems as man, nature, causality, knowledge and value; and reading and analysis of selected systematic works in philosophy.

H76T. Philosophic Problems and Systems. Continuation of H75T.

H77. Classical Philosophy. Systematic reading and critical discussion of selected works of Plato and Aristotle with consideration of important later thought until St. Augustine. Focus on certain basic issues (time, consciousness, freedom, purposiveness, choice in ethics and aesthetics, deity) still central in modern philosophy. (Not offered 1956–57.)

H81. Contemporary Ideas on Political and Economic Development. Continues emphasis of H71 and H72. Topics include "hard-boiled" schools of thought: Sorel, Pareto, Vaihiger; Pragmatists and Institutionalists: John Dewey, William James, Veblen, the "pragmatic revolt." Problems of the "Welfare State": Herbert Hoover, J. M. Keynes, war and "total mobilization," economic planning, and the problem of freedom. Responses to crisis: Fascism, Communism, Democratic Socialism, Catholic views of reform, current philosophies of hope and despair, and perspectives beyond 1950.

H82. Nationalism and National Development. Studies the interplay of political ideas and social institutions in the case of nationalism in the present era. Ideas of nationality surveyed and contrasted with the verifiable realities of peoples and countries. Effect of urbanization and industrialization on nationalism studied, as well as effect of nationalism on further political and economic development. Leaders and decisions studied against background of broad trends and particular movements. Forces making for national sovereignty surveyed and contrasted with trends toward federal government, economic unions, or international organization. (Not offered 1956–57.)

H83. Philosophy of Science. Studies the interconnection between the chief philosophical ideas that still stand up from the past, and the scientific philosophy arising from twentieth century physics. Includes Kant, Schopenhauer, Hegel, Marx, Darwin, Kierkegaard as the Unscientific Postscriptor, Russell, Bridgman, Einstein, Planck, Bohr, and Carnap.

H84. Topics in the History of Science. Topics to be arranged in accordance with the interests of students, and to be given, when possible, in cooperation with members of the School of Science.

H85. History and Historians. Study, in the works of selected historians, European or American according to the students' interests and previous work in the field, of the nature of historical knowledge; method, purpose and meaning of history; and typical epistemological, ethical and aesthetic problems arising in the writing of history.

H91. Special Topics in History. Provides for the periodic presentation by members of the staff of topics in history not included in other course offerings and for individual reading by qualified students.

H92. Special Topics in History. Continuation of H91.

H93. Philosophy and Literature Seminar. (Not offered 1956–57.)

H94. Philosophy and Literature Seminar. (Not offered 1956–57.)

H95. American Industrial Society Seminar. (Not offered 1956–57.)

H96. American Industrial Society Seminar. (Not offered 1956–57.)

MODERN LANGUAGES

Subjects L1 to L99

SUBJECTS are offered in German, French and Russian. Pronunciation, speaking ability and understanding the spoken language are the objectives of the first two semesters of French and German together with acquisition of the minimum essentials for a reading or speaking knowledge. The first term of Russian emphasizes vocabulary and structure of the technical language. The second semester of Russian has the development of speaking ability as its primary aim.

The intermediate level is principally concerned with the development of a broad reading vocabulary. The reading texts include some scientific matter, but also introduce fiction, drama, and historical or descriptive works of a nature to open up to the student the genius, institutions and social organization of the country involved.

Advanced subjects in modern French and German literature and thought are conducted entirely in French and German respectively. Elective subjects in Spoken French and German are also offered.

Special subjects in scientific German, French, and Russian, *open to graduate students only*, are offered in addition to the above. As opposed to the more general objective of the undergraduate subjects, these have a narrowly limited purpose;

Modern Languages Continued

namely, to prepare each student to read technical and scientific material in his own field.

Two elective seminar subjects offered by the Department treat language in general, the problems it raises and, wherever possible, their solution.

In choosing language subjects students should assume that one year of secondary school study will be considered as roughly equivalent to one Institute term. Credit towards graduation will not be given for repeating work offered for admission; so that, for instance, a man with two or more years of high school German may not take either semester of Elementary German for credit.

Special sections of **H11, H12, H21** and **H22** (see page 162) are offered, with reading and lectures in French for graduates of American high and secondary schools with three or more years of unusually good achievement in French. The purpose of these sections is to allow interested students to use and improve their knowledge of French while simultaneously satisfying the Humanities requirements.

L11, L12. Elementary German. Necessary foundation in German language for conversational and literary purposes. Training in pronunciation, elementary grammar, acquisition of useful vocabulary, reading of varied matter. Texts (subject to modification): L11, L12, Goedsche, Flygt, and Spann, *A Modern Course in German*, Blauth and Roderbourg, *Erzähl mir was!*

L13. Intermediate German. Training in reading and understanding ordinary narrative prose. Examination of more mature literature with regard to content and interpretation. Texts (subject to modification): Foltin, *Aus Nah und Fern.*

L14. Intermediate German. Reading, translation, and discussion of representative German works. Emphasis on the transition from classical tradition of German idealism to the modern point of view. Study of German modes of expression, German thought and life as seen through German eyes. Some discussion in German.

L15. German Literature 1919–33. The course will give a thumbnail sketch of German literature from the ushering in of the Weimar Republic to the Burning of the Books. The student will acquaint himself with selected writings of authors who enjoy a European reputation, and others who occupy a niche as innovators or recorders of social trends (Mann, Kafka, Fallada, Frank, Toller, Kaiser, Brecht and others). Conducted in German. Prerequisite: ability to understand spoken and written German easily.

L16. Literature of Postwar Germany. Study of the evolution of German opinion and life since 1945 as seen in the current works of German writers; books and periodicals consulted. Conducted in German. Prerequisite: ability to understand spoken and written German easily.

L17. Scientific German. Intensive preparation for graduate language requirement in German. No previous study of German required. Group meetings for discussion of ways to facilitate comprehension of grammatical and syntactical difficulties. Section meetings by Courses for reading material in the field of the student. (Open to graduate students only.)

L20. Great Books and Authors in German Literature. Reading and discussion of outstanding works in the drama, poetry and prose fiction of German literature. Period 1750–1900. One play of each of the following: Goethe, Schiller, Grillparzer and Hauptmann. Selections from the poetry of Goethe, Schiller, Heine and Rilke. Selections from Goethe's *Dichtung und Wahrheit* and *Die italienische Reise;* Heine, *Die Harzreise.* One novel each by Gottfried Keller and Conrad Ferdinand Meyer. Emphasis on the comparative nature of literature. Some discussion in German. Prerequisite: ability to understand spoken and written German easily. (Not offered 1956–57.)

L21, L22. Spoken German. Two-term sequence for students with three years of high-school German, or the equivalent, but with little or no experience in using the spoken language. Recently developed techniques used to convert reading knowledge into ability to comprehend the spoken language. Full use made of mechanical devices for improving intonation and pronunciation. Emphasis upon development of the basic vocabulary of words and phrases used in everyday conversation.

L31. English for Foreign Students. Designed for students for whom English is a foreign language. First essentials of pronunciation and grammar, with attempt to improve understanding of and expression in American English, particularly the spoken language. A reading knowledge of English is assumed.

L51, L52. Elementary French. Necessary foundation for French language and literature, or for scientific studies. Training in pronunciation, elementary grammar, acquisition of useful vocabulary and reading of varied matter, part of which deals with French institutions and the history of France, practice in hearing and speaking French. Texts (subject to modification): Hendrix and Meiden, *Beginning French.*

L53. Intermediate French. Continuation of pronunciation and practice in conversation, reading of matter dealing with France, some standard modern authors, discussion of current French problems.

L54. Intermediate French. Reading, translation, and discussion of representative French works, particularly from the nineteenth and twentieth centuries. Short stories, plays and poetry. Study of typical literary art forms of French and investigation into French modes of life and thought. Some discussion in French.

L55. Contemporary French Literature. Reading and study of post-war literary works for the light which they throw on French thought and action in present-day society. Conducted in French. Prerequisite: ability to understand spoken and written French easily. (Not offered 1956–57.)

L56. French Literature of the Third Republic. Reading and study of French literary works from 1870 to 1940. The great figures of this period. Economic, social, and philosophical trends as reflected in literature. Conducted in French. Prerequisite: ability to understand spoken and written French easily.

L57. Scientific French. Intensive preparation for graduate language requirement in French. No previous study of French required. Group meetings for discussion of ways to facilitate comprehension of grammatical and syntactical difficulties. Section meetings by Courses for reading material in the field of the student. (Open to graduate students only.)

L59. Great Books and Authors in French Literature. Reading and discussion of great works in the drama, poetry, and prose fiction of French literature. One play of each of the following: Corneille, Racine, Molière, Marivaux, Beaumarchais, and Hugo. Selections from the writings of Montesquieu, Voltaire and Rousseau. Selections from the poetry of Ronsard, Du Bellay, Lamartine, Hugo, de Vigny, de Musset and Gautier. Prose fiction: Mme. de la Fayette, *La Princesse de Clèves;* Voltaire, *Contes philosophiques;* Balzac, *Eugénie Grandet* Flaubert, *Madame Bovary;* de Maupassant, *Contes et Nouvelles;* Zola, *La Bête Humaine.* Emphasis will be placed on the comparative nature of literature. Some discussion in French. Prerequisite: ability to understand spoken and written French easily.

L61. Introduction to Spoken French. For students with three years of high-school French or the equivalent, but with little or no experience in using the spoken language. Practice in speaking French. Phonetic method for correction of accent. Mechanical devices used for improving intonation and pronunciation.

L62. Conversational French. Development of the basic vocabulary of words and phrases used in everyday conversation. Attention to individual pronunciation problems. For students with three years of high school French or the equivalent, but with little or no experience in using the spoken language. Appropriate for Fulbright candidates.

L75. Language and Society. Languages of the world, their distribution, relations, and structural classification; how languages change and develop; basic elements of language and the nature of a linguistic system; speech and writing; develop-

Modern Languages Continued

ment of systems of writing; interrelation of language and culture.

L78. Linguistic Structure. Problems and methods of the descriptive study of language. *Study of form in language:* definition and determination of linguistic elements; techniques of analysis; mathematical models for linguistic behavior (communication theory, logical syntax); construction of an objective and abstract theory of formal linguistic structure; systematic application of this theory to the description of English structure. *Study of meaning in language:* relation of linguistic form and meaning; various approaches to a theory of meaning; contemporary philosophies of language and the influence of symbolic logic; extensional and intensional structure. Comparison of the logic of natural languages with that of special purpose language systems (mathematics, science).

L91, L92. Elementary Russian. Elementary grammar; practice in reading scientific Russian. Practice in hearing and speaking in second term. Enables a good student by the end of year to read scientific articles in Russian; also lays the foundation for continued study of the language. Texts (subject to modification): Znamensky, *Elementary Scientific Russian Reader* (L91), *Conversational Russian* (L91 and L92).

L93, L94. Intermediate Russian. Continuation of pronunciation and practice in conversation, reading of matter dealing with Russia, some standard modern authors, reading of scientific Russian, individual written translations from recent scientific works.

L97. Scientific Russian. Intensive preparation for graduate language requirement in Russian. No previous study of Russian required. Group meetings for discussion of ways to facilitate comprehension of grammatical and syntactical difficulties. Section meetings by Courses for reading material in the field of the student. (Open to graduate students only.) (See also **6·696** Hearing, Speech and Language, listed on p. 137 and offered jointly by members of the Department of Electrical Engineering and the Department of Modern Languages.)

MATHEMATICS

Subjects M1 to M99

M100. Elementary Number Theory. Elementary theory of whole numbers, including such topics as divisibility, prime and composite numbers, greatest common divisors, solutions of equations in integers, the congruence notation and its application, sums of squares.

M11. Calculus. Fundamental ideas of differential and integral calculus. Differentiation and graphical representation of algebraic functions and of the sine and cosine. Integration of simple algebraic and trigonometric functions. Applications to problems in geometry and mechanics: maxima and minima, velocity and acceleration, plane areas, volumes, arc length, areas of surfaces of revolution, center of gravity, moment of inertia. Analytic geometry of the straight line and the conic sections. Thomas, *Calculus and Analytic Geometry.*

M12. Calculus. Further study of differentiation and integration: trigonometric, inverse trigonometric, exponential, logarithmic and hyperbolic functions. Polar coordinates and parametric representation. Complex numbers. Elementary vector analysis in the plane. Thomas, *Calculus and Analytic Geometry.*

M21. Calculus. Vector velocity and acceleration in plane curvilinear motion. Three-dimensional analytic geometry. Partial differentiation. Multiple integration. Infinite series. Thomas, *Calculus and Analytic Geometry.*

M22. Differential Equations. Treatment of ordinary first order differential equations. Introduction to the Laplace transform. Series solutions. Graphical and numerical methods. Separation of variables for partial differential equations. Fourier series and boundary value problems. Martin and Reissner, *Elementary Differential Equations.*

M221. Probability and Operations Analysis. Linear differential equations with constant coefficients, Gamma and Beta functions, probability, distribution theory, and expected values. Mathematical theory and techniques particularly appropriate to the application of the scientific method to the solution of business and industrial problems. Emphasis upon the setting up of simple mathematical models and interpretation of analytical results with reference to the primary purpose of aiding in executive decisions.

M32. Elementary Statistics. General survey of the practical application of statistical methods to scientific and engineering problems, covering frequency distributions, moments, precision of measurements, tests of significance, correlation, theory of large and small sampling, analysis of variability, and experimental design.

M333, M334. Applied Statistics Seminar. Primarily for those professionally interested in the field of statistics. Discussion of applications of statistical methods in industry and in analysis of physical and economic data, and of applications in present-day technical journals. (Not offered 1956–57.)

M341, M342. Modern Statistical Theory. Rigorous development of mathematical statistics, including such topics as generalized distribution function, characteristic functions, statistical inference, sampling theory, tests of significance, maximum likelihood statistics, hypothesis testing, theory of estimation, regression theory, introduction to multivariate statistical analysis, and time series analysis. References: S. S. Wilks, *Mathematical Statistics;* H. Cramer, *Mathematical Methods of Statistics;* N. Wiener, *Stationary Time Series.* Not offered 1956–57.)

M351, M352. Advanced Calculus for Engineers (A). Ordinary differential equations; numerical and graphical methods, integration by power series, Legendre and Bessel functions. Laplace transforms. Characteristic value problems; series of orthogonal functions, in particular, Fourier series. Vector analysis; orthogonal curvilinear coordinates. Partial differential equations of mathematical physics. Functions of a complex variable; calculus of residues, conformal mapping. Hildebrand, *Advanced Calculus for Engineers.*

M371, M372. Operations Research (A). Development of the concepts of probability and mathematical models in physical, industrial and laboratory situations as the scientific approach to small and large-scale operations. Basic problems involving probability; also inverse probability, geometrical probability, distribution theory and the construction of mathematical models, game theory, linear programming, time series and prediction theory, and stochastic processes. (M372 not offered 1956–57.)

M381, M382. Theory of Functions (A). Complex numbers, analytic functions. Complex integration, Cauchy's theorem, Cauchy's integral formula, evaluation of definite integrals. Taylor series, Laurent series, partial fractions, infinite products. Riemann's mapping theorem. Analytic continuation. Harmonic functions, solution of Dirichlet's problem, Green's function. Methods in conformal mapping. Linear differential equations, the hyper-geometric and other differential equations. Asymptotic series. Fourier and Laplace transforms.

M39. Methods of Applied Mathematics (A). Operations with matrices and determinants; linear vector spaces; characteristic-value problems. Techniques of calculus of variations; Hamilton's principle and Lagrange's equations; variational principles for deformable bodies; direct and semi-direct methods. Formulation and solution of simple linear difference equations; application of finite-difference methods to approximate solution of partial differential equations. Formulation

Mathematics Continued

and treatment of integral equations; Green's function; analytical and numerical methods of solution. Hildebrand, *Methods of Applied Mathematics.*

M411, M412. Numerical Analysis (A). Introduction to the theory and practice of the solution of equations, interpolation, numerical differentiation and integration, and the numerical solution of ordinary differential equations. Selected topics from the following: least-squares methods, smoothing of data, Gaussian quadrature, Tschebycheff approximation, harmonic analysis, approximation by exponentials. Iterative methods for determining characteristic numbers of matrices. Numerical methods for the approximate solution of partial differential equations. Hildebrand, *Introduction to Numerical Analysis.*

M421, M422. Theoretical Hydromechanics (A). General theory of perfect fluids, fundamental concepts and basic relations. One-dimensional motion. Two-dimensional motion involving subsonic and supersonic speeds; application of the theory of complex variables. Application of the theory of characteristics to hydrodynamical problems. Three-dimensional motion involving subsonic and supersonic speeds; theory of lifting surfaces. General theory of viscous fluids, fundamental concepts and basic equations, examples of exact solutions. Flow at low Reynolds numbers. Flow at high Reynolds numbers, boundary layer theory. Hydrodynamic stability. Turbulent flows, mixing length theories and statistical theories. Other selected topics of current interest.

M441. Projective Geometry. More precise study of curves and surfaces of the second degree than given in M11 and M12. Fundamental notions of projective geometry including Pascal's theorem and the theory of involution. Plücker coordinates, pentaspherical coordinates and non-Euclidean geometry. (Not offered 1956–57.)

M442. Elementary Differential Geometry. Plane and space curves. First and second differential form of a surface. Theorems of Meusnier and Euler. Lines of curvature, asymptotic lines, conjugate lines, geodesics. Theorems of Gauss and Codazzi. Developable surfaces, surfaces of rotation, Liouville surfaces. Differential parameters. Problems of mapping. Struik, *Differential Geometry.*

M451, M452. Fourier Series and Integrals (A.) Elementary theory of Fourier series and integrals as developed along modern lines. Stress on practical applications and development of the necessary analysis from the beginning.

M461. Seminar in Mathematics (A). Reading, consultation and discussion of current mathematical research. (Not offered 1956–57.)

M481, M482. Topology (A). Discussion of basic concepts of Topology: topological spaces, metric spaces, closed sets, open sets, connected sets, mappings, general concept of dimension. Demonstration of classical theorems on the topology of Euclidean spaces (Invariance theorem, Jordan theorem, Fixed Point theorem), using the modern methods of mapping into spheres. Applications of two-dimensional topology to function theory and differential equations. Combinatorial topology: Complexes, Betti groups. Proof of the invariance of Betti groups. Duality theorems. Homology theory in topological spaces.

M483. Advanced Topology (A). Differentiable manifolds. Fibre bundles and their characteristic cohomology classes. Existence of tensor fields with prescribed properties on a differentiable manifold. Imbedding in Euclidean space. Differential forms and de Rham's theorem. Content varying from term to term so that graduate students taking the subject in successive terms may have an introduction to several important phases of topology.

M491, M492. Geometry of Manifolds (A). Real and complex manifolds, Riemannian and Hermitian manifolds, differential forms, abelian integrals, theta functions, the Riemann-Roch theorem, the generalized Gauss-Bonnet theorem, relations between curvature properties and topological properties, the Hodge theorem, Kahler manifolds; with applications to Riemann surfaces and functions of one and several complex variables. (Not offered 1956–57.)

M50. Fundamentals of Mechanics of Continua. Analysis of strain, small and large deformations; analysis of stress, stress-strain relations. Equation of continuity, equations of motion. Equation of state, equation of energy, and other thermodynamical considerations. Curvilinear coordinates. Invariance of physical laws under transformation of coordinates. Introduction to tensor calculus in the study of mechanics of continua.

M521, M522. Topics in the Theory of Numbers (A). Discussion of the Riemann Zeta Function. Proof of the prime number theorem through contour integration, the method of contour integration applied to the divisor problem, the solution of Waring's problem via the circle method of Hardy-Littlewood and Vinogradoff's improvements, other applications of the circle method, the general sieve method of Selberg with application to primes, twin primes, Goldbach's problem. Proofs of certain best possible results of the sieve. Content varying from year to year, so that graduate students may take the subject in successive years.

M54. Mathematical Laboratory. Practical instruction in numerical, graphical and mechanical calculation and analysis as required in the engineering or applied mathematical sciences, numerical solution of equations; graphical methods; nomography and the construction of graphical charts; curve fitting to empirical data, approximate methods of integration, differentiation and interpolation; use and principles of construction of instruments employed in calculation, and many kindred topics. Lipka, *Graphical and Mechanical Computation.* (Not offered 1956–57.)

M551, M552. Functions of a Real Variable (A). Theory of the Lebesgue integral with applications to important topics of the theory of functions of a real variable. Connections between real and complex variable theory. Content varying from one year to another, so that graduate students taking the course for successive years can have an introduction to several important chapters of the theory of functions. (Not offered 1956–57.)

M561, M562. Functions of Complex Variables (A). Holomorphic functions, Cauchy's formula, power series in several variables. Ideals of holomorphic functions. Cousin's problems, analytic subvarieties of complex manifolds, and Chow's theorem. Cohomology with coefficients in a sheaf, analytic sheaves, coherent sheaves. Content varying from one year to another so that graduate students may take the subject in successive years. (M562 not offered 1956–57.)

M571, M572. Differential Equations (A). Existence theorems and approximation methods. Various aspects of the linear differential equations including boundary problems, solution of certain more common equations by series and integrals, singularities in complex domain. Relationship between integral and differential equations. Schmidt-Fredholm theory of linear integral equations. Non-linear differential equations studied by analytical and topological methods. Singularities of various types with stress on physical interpretation. Poincaré-Liapounoff stability theory. Periodic orbits. Limit cycles. Perturbation methods. Coddington and Levinson, *Theory of Ordinary Differential Equations.*

M581, M582. Continuous Groups (A). Elementary properties, subgroups and quotient groups, covering groups, Haar measure, Peter Weyl theorem, Tannaka theorem, Lie groups, Lie algebras of Lie groups, complex groups, complexification of real Lie groups, structure theorem for Lie algebras and Lie groups, topological structure of Lie groups.

M591, M592. Partial Differential Equations (A). Geometric approach to first and second order partial differential equations. Characteristics and wave fronts. Stress on second order equations, their classification and physical significance. Boundary value problems, initial value problems. Adjoint equation, variational methods, operational methods. Maximum principle. Applications.

M61. Mathematical Logic (A). Classical calculi of propositions and classes together with their principal applications. Tracing of the main lines of Whitehead and Russell's derivation of classical analysis from logic, emphasizing the

Mathematics Continued

marked resemblance between its intermediate stages and various developments in modern algebra. An account of the general theory of logical and mathematical systems, according central places to the theorems of Goedel on incompleteness and the axiom of choice, and to the theory of constructive decidability. (Not offered 1956–57.)

M62. Modern Algebra. Polynomials, determinants, linear equations, linear transformations, matrices, linear independence, introduction to groups. Birkhoff and MacLane, *Survey of Modern Algebra.*

M63. Algebra (A). Group theory, including the fundamental theorem on Abelian groups and rotation groups. Elementary theory of rings and fields. Elementary divisors of matrices, reduction to Jordan and other canonical forms. Quadratic and Hermitian forms; symmetric, Hermitian, orthogonal, and unitary matrices. The dual of a vector space, introduction to tensor algebra.

M631. Integral Equations (A). Objectives: (1) to show how to express physical problems in the form of integral equations, (2) to provide a treatment of the theory of integral equations, and (3) to describe the methods available for solving such equations. Applications to problems arising in several branches of physics and engineering. (Not offered 1956–57.)

M633. Abstract Algebra (A). Groups with operators and rings of endomorphisms. Theory of fields and their extensions. Introduction to valuation theory. Structure of rings and algebras.

M634. Topics in Algebra (A). Study of algebraic number fields, including such topics as factorization of ideals, splitting and ramification of prime ideals, the group of units, quadratic and cyclotomic fields, general ideal theory and valuation theory. Content varying from year to year so that graduate students may take the subject in successive years.

M641. Tensor Calculus (A). Tensor algebra and analysis. The geometry of Riemannian space. Applications to mechanics and especially to general relativity.

M651, M652. Functional Analysis (A). Locally convex topological vector spaces, Banach spaces. Completely continuous operators. Banach algebras. Spectral theorem for operators in Hilbert space. Algebras of bounded operators in Hilbert space. Semigroups of operators.

M661. Topics in Foundations of Mathematics (A). Topics in mathematical logic, effective computability, and axiomatic set theory, with emphasis on the second of these. Brief study of certain classical systems of mathematical logic with related results.

M671, M672. Algebraic Functions (A). Closed Riemann surfaces and corresponding algebraic function field. Differentials and abelian integrals. Riemann-Roch theorem. Abel's theorem and Jacobi's theorem. Unramified extensions and covering Riemann surfaces. Algebraic correspondences. Elliptic functions. (Not offered 1956–57.)

M691, M692. Characteristic Value Problems (A). Linear algebra, orthogonal functions, linear integral equations; characteristic value problems of mathematical physics; applications of the calculus of variations; special functions defined by characteristic value problems. Courant-Hilbert, *Methoden der Mathematischen Physik*, Vol. I; or Margenau and Murphy, *The Mathematics of Physics and Chemistry.* (Not offered 1956–57.)

M711. Theory of Games. Probabilities in games. Strategies. Mixed strategies. "Optimal" strategies and the minimax theorem for two-person zero-sum games. Information pattern analysis. Applications to statistical decision and programming. Non-cooperative games, behavior strategies, applications to economics, poker. Cooperative games, coalitions, theory of von Neumann and Morgenstern, other theories, the area of unsolved problems. Two person cooperative games, precise treatment of duopoly situations. (Not offered 1956–57.)

M73. Review of Mathematics. Review of college algebra, trigonometry, elementary calculus, differential equations. (Primarily for selected officers of the U. S. Army, Navy and Coast Guard.)

M761, M762. Theory of Probability (A). Elements of combinatorial analysis. Random variables and expectations. Laws of large numbers. The central limit theorem and its applications. Distributions, Laplace's theorem, continuous probabilities, Monte Carlo method, stochastic processes. W. Feller, *An Introduction to Mathematical Probability and Its Applications.*

M791, M792. Theoretical and Applied Elasticity (A). Analysis of stress and strain in three dimensions. Stress-strain relations. Minimum principles in elasticity, their theory and application to the approximate solution of boundary value problems. Theory of plane stress and strain, Airy's stress function, use of elements of complex variable theory. Bending of flat plates, linear and non-linear theory. Bending and stretching of thin shells. Elastic stability theory. Elements of the finite deformation theory of elasticity. (Not offered 1956–57.)

M831, M832. Analysis. Dedekind cuts, Bolzano-Weierstrass theorem, Heine-Borel theorem, least upper, greatest lower bounds, Cauchy criteria for convergence, monotone sequences, simple tests for convergence of series, power series. Functions of one variable, continuity, uniform continuity, sequences of functions and uniform convergence, bounded variation and arc length. Derivative, Taylor's theorem, Weierstrass approximation theorem, differentiation of series. Riemann integral, Riemann-Stieltjes integral, interchange of order of limit and integral, fundamental theorem of calculus. Functions of several variables, Jacobians, inverse functions, functional dependence. Multiple integration, change of variables, line integrals, Green's theorem, elementary discussion of surface area. Integral in n-dimensional space, Fubini's theorem, differentiation in 1 dimension. Fourier series, orthogonality and Bessel inequality, simple convergence tests, Cesaro summability. Buck, *Advanced Calculus.*

M833. Analysis. Abstract sets; cardinal and ordinal numbers and their simplest properties. Elements of point set topology; topological and metric spaces, completeness, compactness, connectedness, products of spaces, mappings, continuity, applications to analysis. Linear spaces; norm, operators, completely continuous operators, basic properties of Hilbert space. Abstract measure and integral theory; Borel rings, set functions, absolute continuity, measure, integral. (Not offered 1956–57.)

M851. Potential Theory (A). Potentials arising from electrical and gravitational attraction, fluid flow, heat conduction. Gauss's, Stokes's, and Green's formulas. Laplace's equation. Minimal surfaces, the Dirichlet principle. Harmonic functions and consequences of Green's formulas. Special harmonic functions. Boundary value problems for linear elliptic equations. Application of linear integral equations to solution of boundary value problems. Potential theory on surfaces. Generalized Green's functions. (Not offered 1956–57.)

M90. Mathematical Reading (A). Reading of advanced mathematical treatises under the supervision of some member of the department. Choice of treatise and allotment of time according to individual cases. For graduate students finding it desirable to do advanced work not provided for in the regular subjects. Open to undergraduates only under exceptional circumstances.

MILITARY SCIENCE

SUBJECTS MS11 TO MS99

MS11, MS12. MILITARY SCIENCE. Leadership, drill and exercise of command; military organization; American military history; individual weapons and marksmanship; and United States in world affairs.

MS21, MS22. MILITARY SCIENCE. Map and aerial photo reading; small unit tactics; weapons and gunnery; elementary communications and leadership, drill and exercise of command.

MS312, MS322. CORPS OF ENGINEERS, ADVANCED. Leadership, drill and exercise of command; organization of engineer units; battalion staff procedures; engineer supply; vehicle operation, maintenance, and motor movements; engineer signal communication; military teaching methods; advanced map reading; military bridging; tactics of engineer units; and individual weapons and marksmanship.

MS313, MS323. SIGNAL CORPS, ADVANCED. Leadership, drill and exercise of command; communication security; signal orders; field wire communication techniques; field radio communication fundamentals; applied signal communication (Division); message center and communication center operational procedure; signal supply and repair; career guidance plan for Signal Corps officers.

MS314, MS324. ORDNANCE CORPS, ADVANCED. Leadership, drill and exercise of command; organization of the Ordnance Corps; automotive materiel; small arms materiel; ammunition materiel; ammunition supply; artillery materiel; fire control materiel; individual weapons and marksmanship.

MS316, MS326. CHEMICAL CORPS, ADVANCED. Leadership, drill, and exercise of command; motor vehicles; decontamination; collective and tactical protection; field behavior of chemical, biological, and radiological agents; employment of chemical, biological, and radiological agents; signal communications; chemical combat intelligence; operation of M-2 and M-3 smoke generators; individual weapons and marksmanship; instruction for summer camp.

MS318, MS328. QUARTERMASTER CORPS, ADVANCED. Leadership, drill and exercise of command; station supply; depot supply; storage, warehousing, and materials handling; procurement, storage, and distribution of petroleum products; quartermaster field service activities; quartermaster activities at post, camp, and station; food service activities; individual weapons and marksmanship; security and defense of quartermaster installations.

MS412, MS422. CORPS OF ENGINEERS, ADVANCED. Military administration; military law and boards; psychological warfare; geographical foundations of national power; leadership, drill; and exercise of command; reconnaissance and intelligence, military roads and airfields; engineers in the theatre of operations; barrier tactics; river crossing operations; amphibious operations; construction, utilities, and job management; service orientation.

MS413, MS423. SIGNAL CORPS, ADVANCED. Military administration; military law and boards; military teaching methods; psychological warfare; geographical foundations of national power; leadership, drill and exercise of command; higher echelon signal communication systems and equipment; post signal operations and administrative procedure; career guidance plan for Signal Corps officers; command and staff; combat intelligence; wire communication-materiel; radio communication-materiel; Signal Corps photographic activities and laboratory techniques.

MS414, MS424. ORDNANCE CORPS, ADVANCED. Military administration; military law and boards; military teaching methods; psychological warfare; geographical foundations of national power; leadership, drill and exercise of command; command and staff; military intelligence; materiel specialty; guided missiles; Ordnance maintenance and supply service.

MS416, MS426. CHEMICAL CORPS, ADVANCED. Military administration; military law and boards; military teaching methods; psychological warfare; geographical foundations of national power; leadership, drill, and exercise of command; logistics, supply, and field service; duties of chemical staff officers; responsibilities and duties of Chemical Corps officers; employment of Chemical Corps units; operations and training; review and new developments.

MS418, MS428. QUARTERMASTER CORPS, ADVANCED. Military administration; military law and boards; military teaching methods; psychological warfare; geographical foundations of national power; leadership, drill and exercise of command; fiscal and procurement procedures; command and staff; combat intelligence; technical intelligence; research and development; quartermaster operations in zone of interior; quartermaster operations in theater of operations.

MUSIC

SUBJECTS MU1 TO MU99

Mu31. INTRODUCTION TO MUSIC. Designed to familiarize students (with little or no knowledge of music) with the language of music and its universal literature. Includes contemporary music. Rudiments of harmony and ear-training, and terminology of music. Analysis of representative masterworks through lectures and demonstrations. Listening to recordings and readings.

Mu32. WESTERN MUSIC FROM THE MIDDLE AGES TO THE PRESENT. Study of representative composers in their historic perspective with emphasis on outstanding examples of masterworks of Middle Ages, Renaissance, Baroque and Classic eras. Detailed analysis of compositions by Bach, Haydn, Mozart, Beethoven, and by romantic and contemporary composers. Listening to recordings and readings required.

Mu42. TWENTIETH-CENTURY MUSIC. Study of principal works by masters of twentieth century. Tradition and innovation as exemplified in the music of Schönberg, Stravinsky, Bartok, Hindemith, Copland, Ives, Prokofieff, Honegger, and other composers. The interrelationship of Art music, Folk music and Popular music. Concerts, recordings and group discussion.

Mu43. THE OPERA. Study of the nature and development of the music drama. Illustrations at the piano and from recordings.

Mu44. THE CLASSIC STRING QUARTET. Study of the literature for string quartet in its importance as "absolute music" and as origin of the symphony. Representative quartets analyzed in detail with special emphasis on the quartets of Beethoven. Rudiments of score reading taught and practiced. Concerts, recordings, and group discussion.

Mu46. PRINCIPLES OF MUSIC CRITICISM. Study of music criticism as an application of aesthetics. Focus on the establishment and validity of aesthetic concepts both general and specifically musical in an attempt to shed light on the background and bases of our value judgments in music.

Mu51. SEMINAR IN MUSIC. Detailed discussion of various phases and aspects of music. Discussion of topics varying from year to year, and including elementary harmony, the piano sonata, Bach's cantatas and oratorios, Mozart's operas, Beethoven's *Missa Solemnis*, poetry and music, the Pythagorean tradition. Lectures, concerts, discussions, assigned reading, and listening.

NUCLEAR ENGINEERING

Subjects N1 to N99

N1–N3. Engineering Practice School at Oak Ridge (A). The Engineering Practice School at Oak Ridge, Tennessee, in the Diffusion Plant, the Electromagnetic Plant, and the Oak Ridge National Laboratory of the Atomic Energy Commission, all operated by Union Carbide Nuclear Company, is available for qualified graduate students in any department who are United States citizens, subject to security clearance by the Atomic Energy Commission. Under the direction of Institute faculty residing at Oak Ridge, the work will emphasize the application of engineering principles to the solution of plant problems, and is designed to develop initiative, resourcefulness, and cooperative effort in large-scale industrial operations. These courses are offered twice during the year — (1) in the Fall term, (2) in the Spring term. Each series carries academic credit for 48 units. Application should be made three to four months in advance to allow ample time for clearance.

N10. Introduction to Nuclear Technology (A). Review of the physical and chemical background especially important in nuclear engineering; elementary nuclear reactor theory; design characteristics of nuclear reactors; raw materials and processes used in the production of uranium and thorium; chemical and metallurgical processes associated with reactors; and isotope separation methods. Emphasis on the engineering problems of nuclear reactors and the methods developed to solve them. Primarily for seniors and graduate students with no prior training in nuclear physics, who wish a general knowledge of nuclear engineering and do not plan to take more advanced subjects in this field. Kaplan, *Nuclear Physics;* Glasstone, *Principles of Nuclear Reactor Engineering*.

N20. Biological Effects of Nuclear Radiation (A). Review of interactions of nuclear radiations with matter and the effects of energy absorbed from nuclear radiation on simple and complex chemical systems, various organisms, and living tissues. Theories of the action of radiations on living matter, and considerations of various factors which affect the biological response, such as time and type of radiation. Theory and practice of radiation dosimetry with special reference to practical applications. Biological and physical bases for safety standards.

N21. Nuclear Reactor Theory I (A). Nuclear Transformations carried out in reactors; neutron and element balances in nuclear reactions; types and functions of nuclear reactors; theory of production and utilization of neutrons in chain-reacting systems; diffusion and slowing-down of neutrons; Fermi age and multigroup treatment of unreflected homogenous reactors; reflected thermal reactors; and heterogenous reactors. Emphasis on the engineering point of view, with development of theoretical principles to the extent necessary for engineering use. Glasstone and Edlund, *Elements of Nuclear Reactor Theory*.

N22. Nuclear Reactor Theory II (A). Continuation of N21. Study of topics selected from the following: time behavior of reactors: reactor perturbation theory; neutron transport theory, advanced methods for reactor design, including the Serber-Wilson and Monte Carlo methods; and the general theory of slowing down of neutrons.

N23. Nuclear Reactor Engineering (A). Engineering problems of nuclear reactors, including production, transfer and utilization of heat in nuclear reactors; change of reactivity with fuel irradiation; fuel cycles for nuclear reactors; engineering of reactor control systems; and shielding of nuclear radiation. A final reactor design project to bring together information developed in N21 and N23. Glasstone, *Principles of Nuclear Reactor Engineering*.

N31. Nuclear Chemical Engineering (A). Applications of chemical engineering to the processing of materials for and from nuclear reactors. Topics treated include: fuel cycles for nuclear reactors; chemistry of uranium, plutonium and fission products; refining of uranium; production of materials for nuclear reactors; separation of products of nuclear reactors; inorganic solvent extraction as applied to nuclear reactor materials; disposal of radioactive wastes; processes for isotope separation; and theory of isotope separation. Benedict and Pigford, *Nuclear Chemical Engineering*.

N41. Nuclear Engineering Laboratory I (A). Study of the properties of the particles and radiations resulting from the fission process. Use of scintillation counters, ionization chambers, proportional counters, Geiger counters, health physics instruments, and other detection devices employed in reactor technology. Study of the experimental methods for determining the macroscopic properties of nuclear reactors including cross section measurements, cadmium ratios, diffusion lengths, albedoes, Fermi age, and neutron multiplication of a subcritical assembly. Brief study of some radioactive chemical separation methods.

N90. Special Problems in Nuclear Engineering (A). Designed to meet the needs of special and graduate students who wish to carry out some minor investigation in a particular field. Subject and hours arranged to fit individual requirements.

N91, N92. Seminar in Nuclear Engineering (A). For graduate students engaged on Doctoral Theses.

SUBJECTS OF INSTRUCTION TABULATED

The information below is subject to change. The list of subjects actually to be given will be published with the Class Schedule prior to the beginning of each term.

The number at the left is the subject number.

The numbers following the names of subjects indicate the prerequisite subjects (those in italics may be taken simultaneously).

To the right of the prerequisites are noted the year and term and the Professional Courses in which the subjects are scheduled.

(A) following the year indicates that the subject is primarily for Graduate students. (R) means that the subject is restricted to the special groups indicated at the end of the description of the subject.

Then follows the time distribution of the subject in units (a unit representing fifteen hours work). The total units credit for a subject is obtained by adding the units allotted to Exercise (Recitation, Lecture, Laboratory, Drawing or Fieldwork), and Preparation. One unit of Recitation or Lecture credit is equivalent to one semester hour. Two units of Drawing or Laboratory credit are equivalent to one semester hour.

At the extreme right is given the name of the Instructor in charge of the subject.

CIVIL AND SANITARY ENGINEERING—1·00–1·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
1·001	Conserv. of Natural Resources.	——	1	2	Elective	2	—	4	C. L. Miller
1·01	Surveying I	M12	2	1	I	2	6	0	C. L. Miller
1·02	Surveying II	1·01	2	2	I	2	6	0	C. L. Miller
1·04‡	Surveying, Adv.	1·02	4	2	Elective	2	3	4	C. L. Miller
1·06	Photogrammetric Eng.	——	4	1 or 2	Elective	2	2	4	C. L. Miller
1·201	Transportation Planning	——	4	1	Elective	3	3	3	Roggeveen
1·202	Transportation Eng.	1·02	4	2	Elective	3	3	3	Bone
1·251	Traffic Engineering	1·201 or 1·202 or 1·28	G(A)	1	Elective	2	—	4	Bone
1·252	High. Location & Geom. Des.	1·201 or 1·202 or 1·28	G(A)	2	Elective	2	—	4	Bone
1·261	Airport Planning & Admin.	1·201 or 1·202 or 1·28	G(A)	1	Elective	2	—	4	Bone
1·262	Airport Design	1·201 or 1·202 or 1·28	G(A)	2	Elective	2	4	0	Roggeveen
1·27	Spec. Stud. in Transport. Eng.	1·201 or 1·202 or 1·28	G(A)	1 or 2	Elective	2	—	4	Roggeveen
1·28	Highways & Airports	——	4	1	Elective	3	—	3	Bone
1·282	Highway & Airport Pave.	1·201 or 1·202 or 1·28	G(A)	2	Elective	2	—	4	Bone
1·30	Soil Mech. & Found. Eng.	1·41T	3	2	I	3	3	6	J. E. Roberts
1·31‡	Soil Engineering	1·30	4	1	Elective	3	—	6	Aldrich
1·35	Soil Mech. & Found. Eng.	2·002	4	1	I (56–57)	3	3	6	J. E. Roberts
1·354	Soil Engineering	1·35	4	2	Elective	3	—	6	Aldrich
1·361	Soil Mechanics	2·002	G(A)	1	Elective	3	—	6	
1·363	Mechanics of Soil	2·002	G(A)	1	Elective	3	—	6	
1·365	Seep. Through Soil; Frost Act.	2·002	G(A)	1	Elective	2	—	4	Aldrich
1·366	Embankments; Highways; Earth Dams	1·361; or 1·363 & 1·365	G(A)	2	Elective	3	—	6	
1·367	Soil Technology	——	G(A)	1	Elective	2	—	4	Lambe
1·368	Found.; Lat. Earth Press.	1·361; or 1·363 & 1·365	G(A)	2	Elective	3	—	6	Aldrich
1·37	Soil Mech. Lab.	*1·361*	G(A)	1	Elective	0	3	3	J. E. Roberts
1·40	Structural Analysis	2·002	3	2	Elective	3	—	6	Mirabelli
1·40T	Statics & Dynamics	8·02, M12	2	2	I	3	—	5	Biggs

‡ Not offered 1956–57.

Civil and Sanitary Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
1·41	Structural Analysis	1·40	4	1	I(56–57), XVII(56–57)	3	—	6	Mirabelli
1·41T	Materials & Mechanics	1·40T	3	1	I	4	2	6	Dietz, McGarry
1·42	Structural Analysis	1·401 or 1·41	4	2	I(56–57), XVII(56–57)	3	—	6	Norris
1·42T	Materials & Mechanics	1·41T	3	2	I	4	2	6	J. A. Murray, McGarry
1·43‡	Materials, Adv.	1·42T	4	1	Elective	2	—	4	——
1·44T	Structural Eng., Elem.	*1·42T*	3	2	I	3	3	2	Hansen
1·441	Structural Design	*1·41*, 1·44	4	1	I_1(56–57), I(not 56–57)	2	4	0	Mirabelli
1·442	Reinforced Concrete Des.	*1·42*, 1·44	4	2	I	2	4	0	Holley
1·443‡	Structural Design	*1·44T*, *1·451*	4	1	Elective	3	4	2	Mirabelli
1·444‡	Reinforced Concrete Des.	*1·44T*, *1·452*	4	2	Elective	3	4	2	Holley
1·451‡	Structural Analysis	1·44T	4	1	I	3	—	6	Mirabelli
1·452‡	Structural Analysis	1·451	4	2	Elective	3	—	6	Norris
1·521	Structural Lab.	1·42	G(A)	1	Elective	2	3	1	Hansen
1·531	Spec. Prob. in Structural Eng.	1·571, 1·572	G(A)	1 or 2	Elective		★		Norris
1·541	Reinf. Conc. Des., Adv.	1·42, 1·44	G(A)	1	Elective	2	4	0	**Holley**
1·542	Reinf. Conc. Des., Adv.	1·42, 1·44	G(A)	2	Elective	2	4	0	Holley
1·551	Structural Design, Adv.	1·42	G(A)	1	Elective	2	—	4	Biggs, Wilbur
1·552	Structural Design, Adv.	1·42	G(A)	2	Elective	2	—	4	**Biggs**
1·561	Structural Mechanics, Adv.	1·42, M22	G(A)	1	Elective	3	—	6	**Norris**
1·562	Structural Mechanics, Adv.	1·42, M22	G(A)	2	Elective	3	—	6	**Norris**
1·571	Stat. Indet. Structures	1·42	G(A)	1	Elective	4	—	8	H. Simpson
1·572	Stat. Indet. Structures	1·42	G(A)	2	Elective	2	—	4	H. Simpson
1·59	Structural Eng. Seminar	1·571	G(A)	1	Elective	1	—	2	Norris
1·601T	Fluid Mechanics	1·40T	3	1	I	2	—	4	Ippen, Daily
1·602T	Fluid Mechanics	1·601T	3	2	I	3	—	6	Ippen, Daily
1·611T	Fluid Mechanics	2·002	3	1	XIII	3	—	6	Harleman
			3	2	XV-A				
1·612	Fluid Mechanics	2·002	G	1	**XIII-A**	3	—	6	Daily
1·613	Fluid Resist. & Turb. Diff.	2·002	4	2	Elective	3	—	6	Harleman
1·621	Fluid Mechanics Lab.	1·601	4	1	I_1(56–57)	0	6	0	**Harleman**
1·63	Applied Hydromechanics	1·602 or 1·612	G(A)	1	Elective	3	—	6	Daily
1·64	Hydraulic Machinery	1·602 or 1·613	G(A)	2	Elective	2	—	4	Daily
1·65	Free Surface Flow	1·602	G(A)	1	Elective	3	—	6	Ippen
1·66	Hydraulic Structures, Des.	1·65	G(A)	2	Elective	0	6	0	Ippen, G. R. Williams
1·67	Hydromechanics, Seminar	1·602	G(A)	2	Elective	1	—	2	Ippen, Daily
1·681	Exp. Hydromechanics	1·602	G(A)	1	Elective	2	—	4	Ippen
1·682	Exp. Hydromechanics	1·681	G(A)	2	Elective	0	9	0	**Harleman**
1·683	Exp. Hydromechanics	1·63	G(A)	2	Elective	0	6	0	Harleman
1·69	Rivers & Harbors	1.65 or 1·681	G(A)	2	Elective	2	—	4	Ippen
1·70	Hydrology	1·601 or 1·613	4	1	Elective	3	3	6	G. R. Williams
1·701	Hydrol. & Hydraulic Eng.	——	4	1	Elective	3	—	6	G. R. Williams
1·702‡	Hydraulic Eng.	1·701	4	2	Elective	3	—	6	G. R. Williams
1·71	Hydraulic Eng.	1·70	4	2	Elective	3	3	3	G. R. Williams
1·711	Hydraulic Eng.	1·601 or 1·613; 1·701	4	2	Elective	3	—	3	G. R. Williams
1·72	Hydrol. & Hydraulic Eng.	1·601 or 1·613	4	1	Elective	3	—	3	G. R. Williams
1·731	Water Power Eng.	1·71	G(A)	1	Elective	2	3	4	G. R. Williams
1·732	Water Power Eng.	1·731	G(A)	2	Elective	2	3	4	G. R. Williams
1·75	Water Supply & Purif.	1·601	4	1	Elective	3	3	6	**Stanley**
1·751	Water Supply & Purif.	1·601	4	1	Elective	3	—	6	Stanley
1·76	Sewer. & Sew. Treatment	1·601	4	2	Elective	3	3	3	**Stanley**
1·761	Sewer. & Sew. Treatment	1·601	4	2	Elective	3	—	6	Stanley
1·77	Water Sup. & Sewerage	1·601	4	2	Elective	3	—	3	**Stanley**
1·781‡	Sanitary Science	5·02	4	1	Elective	3	—	6	McKinney
1·782‡	Sanitary Eng.	1·701	4	2	Elective	3	—	6	McKinney
1·79	Sanitary Eng. Design	1·75 or *1·76*	4	2	Elective	0	6	0	Stanley
1·811	Sanitary Eng., Adv.	*1·75*	G(A)	1	Elective	3	—	6	Eliassen
1·812	Sanitary Eng., Adv.	*1·76*	G(A)	2	Elective	3	—	6	Eliassen
1·821	Sanitary Eng. Lab.	*1·75*, *1·831*	G(A)	1	Elective	2	3	4	Sawyer
1·822	Sanitary Eng. Lab.	*1·76*, 1·831	G(A)	2	Elective	2	3	4	Sawyer
1·831	Sanitary Chemistry	5·02	G	1	Elective	2	4	4	Sawyer
1·832	Chem. & Indus. Waste Treat.	1·76, 1·831	G(A)	2	Elective	2	4	4	Sawyer
1·84	Sanitary Microbiology	*1·831*	G	1	Elective	3	3	4	McKinney
1·85	Sanitary Biochemistry	1·84	G(A)	2	Elective	3	3	4	McKinney
1·86	Pub. Health Engineering	*1·84*	G(A)	1	Elective	3	—	6	Eliassen
1·861	Indust. Health Eng. & Atmospheric Pollution	1·86	G(A)	2	Elective	3	—	6	Eliassen, H. L. Hardy

‡Not offered 1956–57.

★Time specially arranged.

Civil and Sanitary Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
1·87	Pub. Health Statistics	1·86	G(A)	2	Elective	3	—	6	Eliassen
1·871	Pub. Health Admin.	1·86	G(A)	2	Elective	3	—	6	Horwood
1·872	Pub. Health Eng. Fldwk.	1·86	G(A)	2	Elective	2	3	4	Horwood
1·881	Sanitary Design, Adv.	*1·811*	G(A)	1	Elective	1	5	2	Stanley
1·882	Sanitary Design, Adv.	*1·812*	G(A)	2	Elective	1	5	2	Stanley
1·883	Spec. Stud. in San. Eng.	1·811, 1·812, 1·831, 1·84	G(A)	1	Elective		★		Eliassen
1·884	Spec. Stud. in San. Eng.	1·811, 1·812, 1·831, 1·84	G(A)	2	Elective		★		Eliassen
1·891	San. Eng. Seminar	*1·811* or 1·812	G(A)	1	Elective	1	—	2	Eliassen
1·892	San. Eng. Seminar	1·811 or *1·812*	G(A)	2	Elective	1	—	2	Eliassen
1·901	Civil Eng. Projects I	——	2	1	I	2	4	4	G. R. Williams
1·902	Civil Eng. Projects II	——	2	2	I	2	2	2	G. R. Williams
1·911	Eng. Construction	1·902	3	1	I	3	2	4	Babcock, Gumpertz
1·921‡	Building Construction	1·911	4	1	Elective	3	—	3	Gumpertz
1·922‡	Construction Mgt.	1·911	4	2	Elective	3	—	3	Gumpertz
1·931‡	Dwelling House Constr.	——	4	1	Elective	3	—	3	Dietz
1·94	Professional Prob.	——	4	2	I (56–57)	2	—	4	Wilbur

MECHANICAL ENGINEERING — 2·00–2·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2·001	Applied Mechanics I	8·02, M12	2	1	II, III, IV-A, VI, IX-B, XIII, XV-A, XVI, XIX (56–57)	3	—	5	Crandall
			3	1	X				
2·002	Applied Mechanics II	2·001	2	2	II, III, VI, IX-B, XIII, XV-A, XIX (56–57)	3	—	5	Dahl
			3	2	X				
2·003	Applied Mechanics III	2·002, M22	3	S	II-B(B)	4	—	8	Adkins
			3	1	II				
			3	2	II-B(A)				
2·04	Strength of Materials	2·001	2	2	IV-A, XVI	3	—	6	Dahl
2·046	Strength of Mat. & Dynamics	——	G	S	XIII-A	6	—	8	Dahl
2·06	Vibrations	2·003	4	2	Elective	3	—	6	Crandall
2·07	Dynamics	2·002 or 2·04	3	2	Elective	3	—	6	Reswick
2·081	Strength of Materials	2·002 or 2·04	3	1	XIII	3	—	6	Den Hartog
			4	1	II(4,5,6,8), II-B(4,5,6,8)				
			G	1	XIII-A				
2·032	Mech. Eng. Problems	2·003; 2·25; 2·42 or 2·421	4	2	II, II-B	3	—	6	Wilson
2·09	History of Mechanics	2·003 or 2·04	G	1	Elective	3	—	6	Adkins
2·11	Industrial Plant Eng.	2·002 or 2·04	4	2	Elective	3	—	6	Schwarz
2·121	Photoelasticity	2·002 or 2·04	4	1 or 2	Elective	1	2	3	W. M. Murray
2·125	Res. in Exp. Stress Anal.	2·121 or 2·126 or 2·128	G(A)	1 or 2	Elective		★		W. M. Murray
2·126	Exp. Stress Analysis	*2·081*	4	1 or 2	Elective	2	3	4	W. M. Murray
2·128	Exp. Stress Analysis	*2·081*	4	1 or 2	Elective	2	6	4	W. M. Murray
2·211	Mechanics, Adv.	2·081	G(A)	1	Elective	3	—	9	Den Hartog
2·212	Mechanics, Adv.	2·003	G(A)	2	Elective	3	—	9	Den Hartog
2·213	Gas Turbines	2·252 or 2·47; 2·42 or 2·421	G(A)	1	Elective	3	—	9	E. S. Taylor
2·214	Gas Turbines	2·213	G(A)	2	Elective	3	—	9	E. S. Taylor
2·215	Methods of Eng. Anal.	M352	G(A)	1	Elective	3	—	9	Crandall
2·216	Plates & Shells	2·211	G(A)	2	Elective	3	—	6	Dahl
2·221	Plasticity	2·002 or 2·04	G(A)	2	Elective	3	—	9	McClintock
2·222	Sem. in Plasticity	2·221	G(A)	1 or 2	Elective		★		McClintock
2·225	Phys. of Strength & Plast.	2·37, 3·11	G(A)	1	Elective	3	—	9	Orowan

‡Not offered 1956–57.

★Time specially arranged.

Mechanical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2·226	Phys. of Strength & Plast.	2·225	G(A)	2	Elective	3	—	9	Orowan
2·228	Research in Materials	*2·31*, 2·37	G(A)	1 or 2	Elective		★		Orowan
2·231	Elasticity, Theory	2·211	G(A)	2	Elective	3	—	9	Adkins
2·25	Fluid Mechanics	2·002; *2·40* or *2·403*; M22	3	1	II-B(B)	4	—	8	A. H. Shapiro
			3	2	II				
			4	S	II B(A)				
2·252	Fluid Mechanics	2·25	4	1	II(1,2,3), II-B(1,2,3)	3	—	6	A. H. Shapiro
			4	2	Elective				
2·261	Lubrication & Friction	2·25	4	2	Elective	2	—	4	Rightmire
2·262	Lubrication, Research	2·261	G(A)	1 or 2	Elective		★		Rightmire
2·263	Lubrication & Friction	2·25	G(A)	1	Elective	3	—	6	Rightmire
2·28	Fluid Machinery	2·49	G(A)	2	Elective	3	—	9	A. H. Shapiro
2·31	Mech. Prop. of Mat.	2·002 or 2·04; 3·11	4	1	II(5), II-B(5)	4	—	6	Orowan
2·32	Mech. Prop. of Mat.	2·31	4	2	II(5), II-B(5)	4	—	6	Orowan
2·37	Mech. Behavior of Materials	2·002 or 2·04; 3·11	3	2	II	2	2	4	Shank
			4	1 or 2	II-B				
2·371	Test. Materials Lab.	*2·002* or *2·04*	3	1	III (56–57)	0	2	2	Shank
			4	1	XIII, XIII-B				
2·40	Heat Engineering	8·02, M21	3	S	VI-A(A) Elective, XVI-B	4	—	5	Svenson
			3	1	VI Elective, VI-A(B) Elective, IX-B, XIII, XV-A, XVI				
			3	2	XIX (56–57)				
2·401	Heat Engineering	2·41 or 8·07	3	1	——	4	—	5	Svenson
2·402	Heat Engineering	——	G	1	XIII-A	4	—	8	Wadleigh
2·403	Heat Engineering	8·02, M21	3	S	II-B (B)	4	—	8	Keenan
			3	1	II				
			3	2	II-B(A)				
2·41	Heat Engineering	8·02, M21	4	2	I (not 56–57)	4	—	5	Svenson
			4	2	Elective				
2·411	Heat Engineering	2·41 or 8·07	3	1	——	5	—	7	Svenson
2·42	Heat Engineering	2·40	3	2	IX-B, XIII, XV-A	3	—	6	Svenson
2·421	Heat Engineering	2·403	3	1	II-B(B)	3	—	6	Svenson
			3	2	II				
			4	S	II-B(A)				
2·422	Heat Engineering	2·402	G	2	——	2	1	4	Wadleigh
2·43	Heat Engineering	2·25; 2·40 or 2·403	4	1	II(1,3,9), II-B(1,3,9)	3	—	6	Kaye
			4	2	Elective				
2·44	Des. Prob. in Heat Eng.	2·43	4	2	Elective	3	—	6	Kaye
2·451	Eng. Thermodyn., Adv.	2·43, *M351*	G(A)	1	Elective	3	—	9	Keenan
2·452	Eng. Thermodyn., Adv.	2·451	G(A)	2	Elective	3	—	9	Keenan
2·453	Projects in Thermodyn., Adv.	2·451	G(A)	1	Elective		★		Collins
2·46	Statistical Mechanics	2·40 or 2·403	4	1 or 2	Elective	3	—	6	J. A. Fay
2·47	Aircraft Propulsion	2·25 or 16·02; 2·40 or 2·403	4	1	II(2), II-B(2)	3	—	6	E. S. Taylor
2·48	Gas Turbines	2·252 or 2·47; 2·42 or 2·421	4	2	II(2), II-B(2)	4	—	5	E. S. Taylor
2·49	Fluid Mechanics, Adv.	2·25, *M351*	G(A)	1	Elective	3	—	9	A. H. Shapiro
2·491	Compressible Fluid Mechanics	2·403, 2·49, *M352*	G(A)	2	Elective	3	—	9	A. H. Shapiro
2·492	Topics in Fluid Mech., Adv.	2·49	G(A)	1 or 2	Elective		★		A. H. Shapiro
2·50	Heat Transfer	2·40 or 2·403 or 3·01	4	2	Elective	2	2	4	Rohsenow
2·521	Heat Transfer, Adv.	2·42 or 2·421; *M351*	G(A)	1	Elective	3	3	6	Rohsenow
2·522	Heat Transfer, Adv.	2·42 or 2·421; M22	G(A)	2	Elective	3	—	9	Rohsenow
2·53	Heat Measurements	2·43 or 2·50	4	1 or 2	Elective		★		Rohsenow
2·56	Power Plant Eng.	2·42 or 2·421	4	2	II(1), II-B(1)	3	3	6	Holt
2·57	Power Plants, Adv.	2·56	G(A)	1	Elective	3	—	9	Holt
2·601	Food Engineering	8·04	4	1	XX, XX-A	2	2	2	Hesselschwerdt
2·602	Food Engineering	2·601	4	2	XX, XX-A	2	2	2	Hesselschwerdt
2·621	Refrigeration	2·41 or 2·42 or 2·421	4	2	II(3), II-B(3)	3	—	6	Svenson
2.641	Refrigeration Eng.	2·42 or 2·421; 2·43	G(A)	2	Elective	3	—	6	Svenson
2.642	Low Temp. Refrigeration	2·40 or 2·403	G(A)	1 or 2	Elective	3	3	6	Collins
2·661	Heating & Ventilation	——	4	1	IV-A	2	—	4	Hesselschwerdt
2·662	Heating & Ventilation	2·661	4	2	IV-A	2	—	4	Hesselschwerdt
2·663	Air Conditioning	2·40 or 2·403 or 2·41	4	1	II(3), II-B(3)	3	—	6	Hesselschwerdt

★Time specially arranged.

Mechanical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2·664	Refrigeration, App.	2·663	4	2	Elective	2	—	4	Hesselschwerdt
2·671	Air Conditioning, Adv.	2·663	G(A)	2	Elective	3	—	9	Hesselschwerdt
2·68	Engineering Lab.	2·25; 2·40 or 2·403 or 2·41 or 10·29	4	1	II(1,2,3,5,9), II-B(1,2,3,5,9)	1	3	4	Wilson
			4	2	II(6,7,8), II-B(6,7,8)				
2·681	Engineering Lab.	2·40 or 2·403 or 2·41 or 10·29	4	1	XIII, XIII-B	0	3	3	Wilson
2·685	App. of Statist. to Mech. Eng.	M21	3 or 4	1	Elective	1	—	1	McClintock
2·693	Refrig. & Air Cond Lab.	*2·621;* 2·663; 2·68 or 2·681	4	2	Elective	0	3	6	Hesselschwerdt
2·70	Creative Thinking	—	1	1, 2	Elective	3	—	3	Arnold
2·701	Machine Drawing	D11	2	1	II	0	6	0	Lent
2·711	Product Design	—	2	1	Elective	0	6	0	Arnold
2·73	Machine Design	2·002, D11	3	S	II-B(B)	2	2	2	T. P. Goodman
			3	1	II				
			3	2	II-B(A)				
2·731	Machine Design	2·002 or 2·04; 2·73; 3·11	3	1	II-B(B)	2	3	4	Reswick
			3	2	II				
			4	S	II-B(A)				
2·732	Machine Design	2·731	4	1	II(6,7), II-B(6,7)	2	2	5	R. W. Mann
2·734	Creative Engineering	—	4	1 or 2	Elective	0	6	3	Arnold
2·735	Creative Engineering	2·734	4	2	Elective	0	6	3	Arnold
2·751	Systems Design	2·003 or 2·07; 2·25; 2·403	G(A)	1	Elective	2	4	4	Hrones
2·78	Hydraulic Mach. & Controls	2·003 or 2·07; 2·25	4	1	II(6), II-B(6)	2	3	4	Shearer
2·782	Automation I	M22	4	1	Elective	3	—	6	Hrones
2·783	Prob. in Automatic Control	2·003 or 2·07; 2·403; 2·751 or 2·78 or 2·782	G(A)	2	Elective	3	—	9	Hrones
2·784	Instruments for Meas.&Control	2·003 or 2·07	G(A)	2	Elective	3	—	6	S. Lee
2·79	Int. Comb. Eng., Elem.	2·002 or 2·04; 2·40 or 2·403 or 2·41 or 10·29	4	1	Elective	3	—	6	Rogowski
2·791	Internal Combustion Eng.	2·002 or 2·04; 2·42 or 2·421	4	1	II(4), II-B(4)	3	—	6	Rogowski
2·792	Internal Combustion Eng.	2·79 or 2·791	4	2	II(4), II-B(4)	3	—	6	Rogowski
2·7941	Int. Comb. Eng. Lab.	*2·79* or *2·791*	4	1	II(4), II-B(4)	0	2	2	Rogowski
2·7942	Int. Comb. Eng. Lab.	2·7941	4	2	II(4), II-B(4)	0	2	2	Rogowski
2·797	Int. Comb. Eng. Adv.	2·79 or 2·791	G(A)	1	Elective	3	—	9	C. F. Taylor
2·798	Int. Comb. Eng. Adv.	2·797	G(A)	2	Elective	3	—	9	C. F. Taylor
2·80	Automotive Vehicles	2·003 or 2·07	4	2	Elective	3	—	6	C. F. Taylor
2·801	Spec. Prob. in Int. Comb. Eng.	2·48 or 2·79 or 2·791	G(A)	1	Elective		★		C. F. Taylor
2·802	Spec. Prob. in Int. Comb. Eng.	2·48 or 2·79 or 2·791	G(A)	2	Elective		★		C. F. Taylor E. S. Taylor
2·82	Combustion	2·25, 2·43	G(A)	1	Elective	3	—	9	Toong
2·83	Res. in Combustion	2·82 or 10·70	G(A)	1 or 2	Elective		★		Toong
2·85	Machine Tools, Int.	—	2	1	II, XV-A	0	4	1	P. A. Smith
2·851	Machine Tool Lab.	—	2	1	XIII	0	4	0	P. A. Smith
2·853	Metal Cutting, Prin.	2·86	4	1 or 2	Elective	3	—	6	M. C. Shaw
2·855	Metal Cutting, Th.	2·002 or 2·04; 3·11	G(A)	1 or 2	Elective	3	—	6	M. C. Shaw
2·858	Mach. Tools & Metal Cut., Res.	2·85 or 2·851	G(A)	1 or 2	Elective		★		M. C. Shaw
2·859	Manufacturing Technology	2·85 or 2·851	4	2	Elective	3	—	6	M. C. Shaw
2·86	Machine Tool Fund.	2·85, 3·11	3	S	II-B(B)	2	1	2	P. A. Smith
			3	2	II				
			4	S	II-B(A)				
2·901	Fabric Struct., Prin.	8·02	4	1	II(8) II-B(8)	3	—	6	Schwarz
2·902	Fabric Struct., Prin.	2·901	4	2	Elective	3	—	6	Schwarz
2·903	Textile Manufact., Elem.	8·02	4	1	II(8), II-B(8)	3	—	6	Schwarz
2·904	Textile Manufact., Prin.	2·903	4	2	II(8), II-B(8)	3	—	6	Schwarz
2·905	Textile Eng. Anal.	2·002 or 2·04; 8·03	G(A)	1	Elective	3	—	6	Backer
2·906	Textile Eng. Anal.	2·905	G(A)	2	Elective	3	—	6	Backer
2·907	Textile Microscopy	8·04	G(A)	1	Elective	2	3	2	Schwarz
2·908	Textile Microscopy	2·907	G(A)	2	Elective	2	3	2	Schwarz
2·911	Textile Research Lab.	*2·905, 2·93*	G(A)	1	Elective	0	6	2	Backer
2·912	Textile Research Lab.	*2·906,* 2·911	G(A)	2	Elective	0	6	2	Backer
2·913	Textile Tech. Seminar	*2·905, 2·907*	G(A)	1	Elective	2	—	2	Backer, Schwarz

★ Time specially arranged.

Mechanical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Lab. Prep.	Instructor in Charge
2·914	Textile Tech. Seminar	*2·906, 2·908*	G(A)	2	Elective	2	—	2	Backer, Schwarz
2·93	Experiment Planning & Anal.	M22	G(A)	1	Elective	3	—	6	Schwarz
2·951	Industrial Practice	—	3	S	II-B(A)		40 h.p.w.		W. M. Murray
			4	S	II-B(B)				
2·952	Industrial Practice	—	3	1	II-B(A)		40 h.p.w.		W. M. Murray
			3	2	II-B(B)				
2·991	Mechanical Eng. Seminar	—	G(A)	1	Elective	2	—	2	Kaye
2·992	Mechanical Eng. Seminar	—	G(A)	2	Elective	2	—	2	Kaye

METALLURGY — 3·00–3·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Lab. Prep.	Instructor in Charge
3·00T	Extractive Metallurgy	—	2	2	III	4	2	4	Gaudin
3·01	Metallurgical Eng.	5·61	3	2	III	4	—	4	Elliott
3·011	Metallurgical Eng. Lab. I	*3·01*	2	2	III	0	3	1	Elliott
3·02	Metallurgical Eng. II	3·01	4	1	Elective	4	—	4	T. B. King
3·021	Metallurgical Eng. Lab. II	*3·02*	4	1	Elective	0	3	1	T. B. King
3·03	Metallurgical Eng. III	3·02	4	2	Elective	3	—	6	T. B. King, Grant
3·10	Metal. Plant Visits	—	4	S	III	0	3	1	Elliott
3·11	Engineering Metals	—	2	1	III	4	2	4	Wulff, Backofen
			2	2	II, XIII				
			3	1	IX-B, XV-A				
3·113	Engineering Metals	—	2, 3, 4	1, 2	Elective	4	—	4	Wulff, Backofen
3·12	Metal Processing	3·11 or *3·32*	3	2	Elective	2	3	4	H. F. Taylor
3·13	Foundry Engineering	3·11 or 3·31	4	2	Elective	2	—	4	H. F. Taylor
3·15	Welding Engineering	3·11 or 3·31	4	1, 2	Elective	2	—	4	C. M. Adams
3·16	Powder Metallurgy	3·11 or 3·31	4	1	Elective	2	—	4	Wulff
3·18	Plastic Working of Metals	3·11 or 3·31	4	2	Elective	2	—	4	Backofen
3·20	Metal. Thermodynamics	5·62	4	1	III	4	—	4	Wagner
3·21	Steelmaking, Prin.	3·20	G(A)	2	Elective	3	—	6	Chipman
3·22	Thermo. of Metallic Solutions	3·20, 3·32	G(A)	2	Elective	2	—	4	Wagner
3·25	Experimental Meth. in Metal.	5·62 or 8·04	G(A)	1	Elective	1	2	0	Grant
3·31	Physical Metallurgy I	5·02, 8·04	3	1	III	4	3	4	Bever
3·32	Physical Metallurgy II	3·31	3	2	Elective	3	3	6	M. Cohen
3·33	Physical Metallurgy III	3·32	4	2	Elective	2	4	4	Floe
3·34	Physical Metal., Adv.	3·20, 3·32, 3·50	G(A)	1	Elective	4	—	4	M. Cohen
3·35	Physical Metal., Adv.	3·20, 3·32, 3·50	G(A)	2	Elective	4	—	4	Averbach
3·38	Physical Metal., Adv.	—	G	1	Elective	0	3	3	—
3·39	Physical Metal., Adv.	3·38	G	2	Elective	2	3	3	—
3·391	Properties of Metals	—	G	1	XIII-A	2	1	3	Floe
3·392	Properties of Metals	3·391	G	2	XIII-A	2	1	3	Bever
3·396	Tech. of Nucl. React. Mat.	—	G	1	Elective		★		Kaufmann
3·42	Electrochemistry	5·62	4	1	Elective	2	—	4	Uhlig
3·43	Corrosion	5·62	G(A)	2	Elective	2	—	4	Uhlig
3·44	Behavior of Metals at Elevated Temperatures	3·32	G(A)	2	Elective	2	—	4	Grant
3·50	X-ray Metallurgy	3·31	4	1	III	2	2	4	J. T. Norton
3·51	Physics of Metals	3·50	4	2	Elective	2	—	4	J. T. Norton
3·52	Physics of Metals, Adv.	3·51	G(A)	1	Elective		★		J. T. Norton
3·53	X-ray Metallurgy, Adv.	3·50	G(A)	2	Elective		★		J. T. Norton
3·54	Radiographic Inspection	—	G	2	Elective	1	3	2	Ogilvie
3·61T	Elec. & Magn. Materials	3·11 or 3·31; 8·051	4	2	Elective	2	—	4	Averbach
3·62	Spec. Prob. in Metallurgy	—	G(A)	1	Elective		★		Staff
3·63	Spec. Prob. in Metallurgy	—	G(A)	2	Elective		★		Staff
3·70	Ceramics	5·02, 8·04	4	1	Elective	2	—	4	F. H. Norton
3·701	Ceramics Lab.	*3·70*	4	1	Elective	0	3	0	Kingery
3·71	Ceramics Seminar	3·70	G(A)	1	Elective	1	—	2	Economos
3·72	Ceramics Seminar	3·70	G(A)	2	Elective	1	—	2	Economos
3·73	Ceramic Processes I, Fund.	3·70, 5·62	G(A)	2	Elective	3	—	4	F. H. Norton
3·74	Ceramic Processes II, Fund.	3·73	G(A)	1	Elective	3	—	4	F. H. Norton
3·75	Spec. Prob. Ceramics	3·70	G(A)	1	Elective		★		F. H. Norton
3·76	Spec. Prob. Ceramics	3·70	G(A)	2	Elective		★		F. H. Norton

★ Time specially arranged.

Metallurgy Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
3·77T	Ceramics Lab., Adv.	3·70	G(A)	2	Elective	1	5	4	Kingery
3·79	Ceramic Products, Adv.	3·70	G(A)	1	Elective	3	—	6	Kingery
3·81	Mineral Engineering I	8·04	3	1	III (56–57)	3	2	4	de Bruyn
3·82	Mineral Engineering II	3·81	3	2	Elective	4	—	4	de Bruyn
3·83	Mineral Engineering III	3·82	4	1	Elective	2	4	4	de Bruyn
3·85	Quantitative Mineragraphy	3·82	4	1 or 2	Elective	1	4	2	de Bruyn
3·86	Quantitative Mineragraphy	3·83	G(A)	1 or 2	Elective		★		de Bruyn
3·87	Ore Testing	3·83	4	1	Elective	0	10	0	de Bruyn
3·89	Mineral Dressing Design	3·83	G(A)	1 or 2	Elective		★		Gaudin
3·90	Mineral Engineering, Adv.	3·83	G(A)	1 or 2	Elective	2	—	4	Gaudin
3·901	Mineral Dressing Lab., Adv.	3·83	G(A)	1 or 2	Elective		★		Gaudin

ARCHITECTURE AND PLANNING — 4·00–4·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
4·00	Structure of the City	——	1	2	Elective	3	—	3	——
4·02	Form & Design	——	2	1	IV-A	0	9	11	Filipowski
			2	2	Elective				
4·04	Light & Color	4·02	5	1	IV-A (not 55–56)	0	9	11	Kepes
			5	2	Elective				
4·051	Graphic Presentation	4·041	5	1	IV-A (56–57)	0	6	0	Kepes
4·052	Graphic Presentation	4·051	5	2	IV-A (56–57)	0	6	0	Kepes
4·06	Advanced Visual Design	4·04	G(A)	1, 2	Elective		★		Kepes
4·11	Architectural Design	——	2	2	IV-A	0	9	11	Anderson
			2	1	Elective				
4·131	Architectural Design	4·11	3	1	IV-A	0	9	11	Anderson
4·132	Architectural Design	4·131	3	2	IV-A	0	9	11	Anderson
4·141	Architectural Design	4·132, 4·32	4	1	IV-A	0	12	8	Anderson
4·142	Architectural Design	4·141	4	2	IV-A	0	12	8	Anderson
4·151‡	Architectural Design	4·142	5	1	IV-A	0	12	8	Anderson
4·161	Architectural Design	4·151	G(A)	1	Elective	0	15	15	Anderson
4·162	Architectural Design	4·161	G(A)	2	Elective		★		Anderson
4·17	Arch. Design, Spec. Prob.	——	5	1, 2	Elective		★		Anderson
4·18	Collaborative Design	4·142	5	1	Elective	0	9	11	Kelly
4·231	Representation	4·11	4	1	Elective	0	12	12	Lynch
4·233	Representation	——	4	1	Elective	0	5	1	Lynch
4·241	Community Plan. Des.	4·132 or 4·231	G	1	Elective	0	12	12	Lynch
4·261	City & Reg. Plan.	4·241	G(A)	1	Elective	0	12	12	Greeley
4·262	City & Reg. Plan.	4·261	G(A)	2	Elective	0	12	12	F. J. Adams
4·31	Structural Analysis	2·002 or 2·04; 4·11	3	1	IV-A	2	6	0	Gelotte
4·32	Structural Analysis	4·131, 4·31	3	2	IV-A	2	6	0	Gelotte
4·33	Structures Seminar	4·32	4	1	Elective	2	—	4	Weidlinger
4·34	Structures Seminar	4·33	4	2	Elective	2	—	4	Weidlinger
4·41T	Architectural Acoustics	8·02	4	1	Elective	3	—	5	Newman
4·42	Arch. Acoustics, Spec. Prob.	4·41	G(A)	1 or 2	Elective		★		Newman
4·51	Regional Planning, Prin.	——	4	1	Elective	2	—	4	Greeley
4·53	City Planning Theory	——	3	1	IV-A	2	—	4	F. J. Adams
4·54	City Planning Techniques	4·53	G	2	Elective	3	—	6	J. T. Howard
4·55	City Planning Techniques	4·54	G(A)	1	Elective	3	—	6	J. T. Howard
4·56	Regional Planning Seminar	4·51 or 4·55	G(A)	2	Elective	2	—	4	Greeley
4·57	Form of the City	4·53	G(A)	2	Elective	3	—	3	Lynch
4·62	Inside Architecture	4·141 or 4·741	4,5,G	2	Elective	2	—	4	E. Kaufmann
4·65	History of Architecture	H22	3	1	IV-A	3	—	5	Bush-Brown
			5	1	IV-A (56–57)				
4·66	History of Architecture	4·65	3	2	IV-A	3	—	5	Bush-Brown
			5	2	IV-A (56–57)				
4·70	Urban Sociology	——	4	2	Elective	2	—	4	Greeley
4·71	Plan. Legis. & Admin.	4·54 or 14·941	G(A)	1	Elective	2	—	4	Kelly
4·73	Human Dimensions of Plan.	——	G(A)	1	Elective	2	—	4	L. K. Frank
4·751	Architectural Design	4·742	5	1	IV-A(56–57)	0	12	9	Anderson
4·77	Housing Problems	4·141 or 4·241	G(A)	1	Elective	2	—	5	Rodwin

‡ Not offered 1956–57.

★ Time specially arranged.

Architecture and Planning Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
4·78	Housing Seminar	4·77	G(A)	2	Elective	3	—	6	Rodwin
4·81	Land Economics	4·54, 14·01	5	1	IV-A (56–57)	2	—	4	Rodwin
4·82	Land Economics Seminar	4·81	G(A)	2	Elective	3	—	6	Rodwin
4·84	Land-Use Prob. in Develop. Areas	——	G(A)	1	Elective	3	—	6	Rodwin
4·87	Indust. Loc. & Reg. Develop.: Prin.	4·81; or 14·01 & 14·02	G(A)	1	Elective	3	—	6	Isard
4·88	Indust. Loc. & Reg. Develop.: Prob.	4·81; or 14·01 & 14·02	G(A)	2	Elective	3	—	6	Isard
4·95	City Plan. Research	4·241	G(A)	1	Elective	2	—	4	F. J. Adams
4·96	City Plan. Research	4·95	G(A)	2	Elective	2	—	4	Greeley
4·97	Office Practice	——	G	S	Elective	0	30	0	F. J. Adams

CHEMISTRY — 5·00–5·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
5·01	Chemistry, General	——	1	1	All courses, except IV-A	4	2	5	Stephenson
			1	1	IV-A Elective				
5·02	Chemistry, General	5·01	1	2	All courses, except IV-A	4	2	5	Stephenson
			1	2	IV-A Elective				
5·061	Inorganic Chem., Adv.	5·12	4	1	V	2	—	4	Schumb
5·062	Inorganic Chem., Adv.	5·061	4	2	V	2	—	4	Schumb
5·066	Topics Theoret. Inorg. Chem.	5·061	G(A)	2	Elective	2	—	4	Cotton
5·071	Spec. Topics Inorg. Chem.	5·062	G(A)	1	Elective	2	—	4	Schumb
5·09	Radiochemistry	5·061, 5·12	G(A)	1	Elective	3	—	3	Coryell, Irvine
5·091	Radiochemistry Lab.	5·061, 5·12	G(A)	1	Elective	0	3	2	Coryell, Irvine
5·10	Qualitative Analysis	5·02	2	1	V	3	8	3	S. G. Simpson
5·11	Qualitative Analysis	5·02	2	1	IX-A, IX-C, X, XV-B	3	4	3	S. G. Simpson
5·12	Quantitative Analysis	5·10 or 5·11	2	2	VII, IX-A, X, XV-B, XX	3	4	3	S. G. Simpson
			3	2	IX-C (a)				
5·13	Quantitative Analysis	5·10	2	2	V	4	8	4	S. G. Simpson
5·15	Instrumental Analysis	5·42, 5·62	3	2	XX, XX-B	2	—	2	Hume, Rogers
			4	2	Elective				
5·151	Instrumental Anal. Lab.	5·15	3	2	XX, XX-B	0	4	2	Hume, Rogers
			4	2	Elective				
5·192	Analytical Chem. I, Adv.	5·13	G(A)	1	Elective	2	—	4	Rogers
5·193	Analytical Chem. II, Adv.	5·13	G(A)	2	Elective	2	—	4	S. G. Simpson
5·194‡	Analytical Chem. III, Adv.	5·13	G(A)	1	Elective	2	—	4	Hume
5·196‡	Analytical Chem. IV, Adv.	5·13	G(A)	2	Elective	2	—	4	Whiteker
5·41	Organic Chemistry I	5·12 or 5·13; 8·04	3	1	V, VII X, XV-B, XX, XX-B	4	—	4	Sheehan
5·414	Organic Preparations I	5·13, *5·41*	3	1	V	0	9	0	Nelson
5·416	Organic Preparations I	5·12, *5·41*	3	1	VII, X, XV-B, XX-B	0	6	0	Swain, Ashdown
5·42	Organic Chemistry II	5·41	3	2	V, X, XV-B, XX-B	4	—	4	F. D. Greene
5·424	Org. Prep. II & Anal.	5·414	3	2	V	0	9	0	House
5·426	Qual. Org. Anal.	5·416	3	2	X, XX-B	0	6	0	Nelson, Ashdown
5·43	Organic Chemistry III	5·42	4	1	V	2	—	4	F. D. Greene
5·44	Organic Chemistry IV	5·43	4	2	V	2	—	4	Sheehan
5·51	Organic Chem.: Synth., Adv.	5·44	G(A)	1	Elective	2	—	4	House
5·54	Phys. Org. Chem., Adv.	5·43	G(A)	2	Elective	2	—	4	Swain
5·55	Org. Chem.: Natural Prod.	5·44	G(A)	1	Elective	2	—	4	Buchi
5·60	Physical Chemistry	5·02, 8·02, *M21*	2	1	Elective	3	—	6	Beattie
5·61	Physical Chem. I	5·12, 8·03, M21	3	1	III, V, VII, IX-A, X, XV-B, XX, XX-B	4	—	4	Stockmayer
5·611	Physical Chem. Lab. I	*5·61*	3	1	VII	0	4	2	Shoemaker, Garland
5·612	Physical Chem. Lab. I	*5·61*	3	1	X, XX-B	0	2	0	Shoemaker, Garland
5·613	Physical Chem. Lab. I	*5·61*	3	1	V	0	6	2	Shoemaker, Garland
5·62	Physical Chem. II	5·61	3	2	III, V, VII, IX-A, X, XV-B, XX. XX-B	4	—	4	Amdur
5·621	Physical Chem. Lab. II	5·611, *5·62*	3	2	VII	0	4	2	Shoemaker, Garland
5·622	Physical Chem. Lab. II	5·612, *5·62*	3	2	X, XX-B	0	2	0	Shoemaker, Garland
5·623	Physical Chem. Lab. II	5·613, *5·62*	3	2	V	0	6	2	Shoemaker, Garland

‡ Not offered 1956–57.

Chemistry Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
5·66	Surface & Colloid Chem.	5·62	4	2	Elective	2	—	4	Scatchard
5·67	Atomic & Molec. Struct., Int.	5·62	4	1	Elective	2	—	4	Lord
5·68	Kin. of Chem. Reactions	5·62	4	2	Elective	2	—	4	Amdur
5·71	Chem. Thermodynamics I	5·62	G(A)	1	Elective	2	—	4	Beattie
5·72	Chem. Thermodynamics II	5·71, *M351*	G(A)	2	Elective	3	—	6	Beattie
5·73	Chem. Thermodynamics III	5·72	G(A)	1	Elective	3	—	6	Scatchard
5·75	Atomic Struct. & Atomic Spectra	5·62, 8·04	G(A)	1	Elective	2	—	4	L. Harris
5·76	Molec. Spectra & Molec. Struct.	5·75, M351	G(A)	2	Elective	3	—	6	Lord
5·77	Crystal Struct. & Chem. Bond	5·76	G(A)	1	Elective	3	—	6	Shoemaker
5·78	Statistical Mechanics	5·71, 5·75, M351	G(A)	2	Elective	3	—	6	Stockmayer
5·79	Kinetic Theory	5·71, 5·78	G(A)	1	Elective	3	—	6	Amdur
5·90	Spec. Prob. in Chem.	—	G(A)	1, 2	Elective		★		Irvine
5·912	Inorg. Chem., Seminar	5·062	G(A)	2	Elective	1	—	2	Schumb
5·913	Organic Chem., Seminar	5·44	G(A)	1	Elective	1	—	2	Cope
5·914	Organic Chem., Seminar	5·913	G(A)	2	Elective	1	—	2	Cope
5·915	Anal. Chem., Seminar	—	G(A)	1	Elective	1	—	2	Whiteker
5·916	Anal. Chem., Seminar	—	G(A)	2	Elective	1	—	2	Whiteker
5·931	Physical Chem., Seminar	—	G(A)	1	Elective	1	—	2	Shoemaker
5·932	Physical Chem., Seminar	—	G(A)	2	Elective	1	—	2	Shoemaker
5·941	Res. Conf. Inorg. Chem.	5·062	G(A)	1	Elective	1	—	2	Schumb
5·942	Res. Conf. Inorg. Chem.	5·941	G(A)	2	Elective	1	—	2	Schumb
5·951	Res. Conf. Anal. Chem.	—	G(A)	1	Elective	1	—	2	Hume
5·952	Res. Conf. Anal. Chem.	—	G(A)	2	Elective	1	—	2	Rogers
	Research	—	G(A)	1, 2	Elective		★		Chemistry Staff

ELECTRICAL ENGINEERING — 6·00–6·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6·00	Circuit Theory, Int.	*8·031, M21*	2	1	VI	4	3	5	Guillemin, Jones
6·001	Circuit Theory, Int.	*8·031, M21*	2	1	Elective	4	—	5	Guillemin
6·002	Circuit Theory Lab., Int.	6·001	2	1	Elective	0	3	0	Jones
6·01	Circuit Theory, Int.	6·00	2	2	VI	4	3	5	Guillemin
6·011	Circuit Theory, Int.	6·001	2	2	Elective	4	—	5	Guillemin
6·012	Circuit Theory Lab., Int.	6·011	2	2	Elective	0	3	0	Jones
6·02	Electronic Circuits	6·01	3	S	VI-A(A)	3	4	5	Mason, Jones
			3	1	VI				
			3	2	VIII				
6·021	Electronic Circuits	6·01	3	S	VI-A(B)	3	—	5	Mason
6·022	Electronic Circuits Lab.	6·021	3	1	VI-A(B)	0	4	0	Jones
6·03	Fields, Energy & Forces	6·01; 8·041; M22 or *M351*	3	S	VI-A(A)	4	3	5	Fano
			3	1	VI, VI-A(B)				
6·04	Elec. Energy Conversion	6·03, *M351*	3	2	VI, VI-A(A)	3	4	5	Kusko, Epstein
			4	S	VI-A(B)				
6·05	Applied Electronics	6·02	3	2	VI, VI-A(A)	3	4	5	Gray, Jones
			4	S	VI-A(B)				
6·051	Applied Electronics	6·02	3	2	Elective	3	—	5	Gray
6·052	Applied Electronics Lab.	6·051	3	2	Elective	0	4	0	Jones
6·06	Electromech. Power Modulators	6·04	4	1	VI, VI-A(A)	3	4	5	White, Woodson
			4	2	VI-A(B)				
6·07	Energy Trans. & Rad.	6·03, M351	4	1	VI	3	3	5	Adler
6·071	Energy Trans. & Rad.	6·03, M351	4	S	VI-A(A)	3	—	5	Adler
			4	1	VI-A(B)				
6·072	Energy Trans. & Rad. Lab.	6·071	4	1	VI-A(A)	0	3	0	Adler
			4	2	VI-A(B)				
6·10	Elec. Circuit Theory, Elem.	8·031, M21	2	2	VIII	4	—	8	Huffman
6·16	Electricity	8·03	3, 4	1	Elective	3	—	6	Eager
6·17	Illumination	8·03	4	2	Elective	2	—	4	P. Moon
6·18	Elec. Eng., Fund	8·03, M21	3	1	I, II, II-B(B), IX-B, IX-C, XVI(b)	3	1	6	Jones
			3	2	II-B(A), XIII, XVI(a), XVI-B				
			4	1	X-B, XV-A, XV-B, XVII(56–57)				
			4	2	X				

★Time specially arranged.

Electrical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6·19	Electronic Instrument.	6·18	3	2	XVI (b)	3	1	6	Jones
			4	2	XV-A, XVI-B(b)				
6·20	Electronic Cont. & Meas.	6·05	4	1	Elective	3	—	6	Gray
6·202	Electronic Cont. & Meas.	6·05	4	2	Elective	3	—	6	Gray
6·204	Thermionic Electron Dev.	6·03, M351	4	2	Elective	3	—	6	Haus
6·211	Graph. Tech. in Syst. Eng. Prob.	6·04	4	1	Elective	3	—	6	Boehne
6·212	Energy Conv. Comp. & Syst.	6·06	4	2	Elective	3	—	6	Wildes
6·213	Feedback Control Prin.	6·04 or 6·18; M351	4	1	Elective	3	2	5	Newton
6·225	Atomic Rad., Prod. & App.	8·031 or 8·041	4	1	Elective	3	—	6	Trump
6·227	Eng. Electrodynamics	6·03	4	2	Elective	3	—	6	Moon
6·231	Circ. & Field Analogs & Models	6·04	4	1	Elective	3	—	6	Frazier
6·232	Electromech. Control Comp.	6·06	4	2	Elective	3	—	6	Frazier
6·241	Engineering Problems	*6·06*	4	1 or 2	Elective	3	—	6	C. E. Tucker, White, Adler
6·25	Machine-Aided Anal.	M22	4	1	Elective	3	—	6	Arden
6·26	Molecular Eng.	8·04 or 8·041	4	2	Elective	3	—	6	von Hippel
6·281	Wire Com., Prin.	6·02	4	1	Elective	3	—	6	C. E. Tucker
6·291	Radar-System Engineering	6·05, *6·07*	4	1, 2	Elective	3	—	6	Reintjes
6·30	Com. & Cont. Circuit Th.	6·01, *6·05*	4	1	Elective	3	—	6	Guillemin
6·311	Communication, Prin.	6·05	4	1	Elective	3	—	6	Elias
6·312	Com. System Eng.	6·20 or 6·311	4	2	Elective	3	—	6	Wiesner
6·322	Electromagnetic Waves	6·07	4	2	Elective	3	—	6	Chu
6·35	Acoustics, Fund.	6·01, M351	4	1	Elective	3	1	5	Beranek
6·351	Engineering Acoustics	6·10, M22	G	1	—	2	2	5	L. L. Beranek, Bolt
6·36	Engineering Acoustics	6·35	4	2	Elective	3	1	5	L. L. Beranek
6·38	Pulse Circuit Analysis	6·05	4	2	Elective	3	—	6	Zimmermann
6·521	Elec. Energy Conv. Devices	6·04	G(A)	1	Elective	3	2	6	Kusko
6·522	Rot. Machine Syst., Dyn.	6·04	G(A)	2	Elective	3	2	6	White
6·524	Non-Lin. Impedance Power Mod.	6·04	G(A)	2	Elective	3	2	6	White
6·535	Dig. Comp. Coding & Logic, Int.	M22	G(A)	2	Elective	3	—	6	Arden
6·538	Electronic Comp. Lab.	M22	G(A)	2	Elective	1	3	5	Verzuh
6·54	Pulsed-Data Systems	6·56 or 6·581	G(A)	2	Elective	3	—	6	Widrow
6·55	Linear System Anal.	6·01	G(A)	1	Elective	3	—	6	Guillemin
6·56	Math. Meth. in Elec. Eng.	M351	G(A)	1	Elective	3	—	6	Guillemin
6·561	Network Anal. & Syn.	6·30 or 6·55	G(A)	1 or 2	Elective	3	—	6	Guillemin
6·562	Network Anal. & Syn.	6·561	G(A)	2	Elective	3	—	6	Guillemin
6·567	Switching Circuits	6·01 or 6·18; M22	G(A)	1	Elective	3	1	6	S. H. Caldwell
6·568	Switching Circuits	6·567	G(A)	2	Elective	3	1	6	S. H. Caldwell
6·571	Statistical Th. of Com.	6·561 or 6·581	G(A)	1 or 2	Elective	3	—	6	Y. Lee
6·573	Statistical Th. of Noise & Modulation	6·30, 6·311	G(A)	1	Elective	3	—	6	Wiesner
6·574	Statistical Th. of Inform.	6·571 or 6·573	G(A)	2	Elective	3	—	6	Fano
6·575	Information Th., Adv. Top.	6·574	G(A)	1	Elective	3	—	6	Elias
6·581	Trans. in Linear Systems	6·01; 2·07 or 8·13; M351	G(A)	1 or 2	Elective	3	—	6	Gardner
6·582	Trans. in Linear Systems	6·581	G(A)	2	Elective	3	—	6	Gardner
6·586	Eng. App. of Field Theory	M22	G(A)	2	Elective	3	—	6	P. Moon
6·59	Bioelectric Signals	—	G(A)	1	Elective	3	—	6	Rosenblith
6·602	Nonlin. & Time — Var. Syst.	6·213	G(A)	1 or 2	Elective	3	—	6	Booton
6·605	Feedback Control Th., Adv.	6·05, M351	G(A)	1	Elective	3	—	6	Newton
6·606	Feedback Cont Syst. Eng.	6·605	G(A)	2	Elective	3	—	6	Newton
6·607	Feedback Cont. Lab.	—	G(A)	1 or 2	Elective		★		Newton
6·608‡	Process Cont.	6·213	G(A)	2	Elective	3	3	6	Newton
6·621	Microwave Circuits	6·07	G(A)	1	Elective	3	—	6	Haus
6·622	Antennas	6·322	G(A)	2	Elective	3	—	6	Chu
6·623	Pulse Circuits, Prin.	6·20 or 6·311	G(A)	1	Elective	3	—	6	Zimmermann
6·626	Modulation Theory	6·311	G(A)	1	Elective	3	—	6	Baghdady
6·629	Radar System Eng.	6·02, 6·213	G(RA)	S	—	3	—	6	Reintjes
6·631	Gas. Discharge Phen.	6·20	G(A)	1	Elective	1	3	5	Edgerton
6·632	Electronic Inst. & Control	6·05	G(A)	1	Elective	3	—	6	Gray
6·633	Active-Circuit Th. Topics	6·02	G(A)	1 or 2	Elective	3	—	6	Mason
6·635	Transistors	6·05; 6·26 or 6·64 or 8·051 or 8·071 or 8·08	G(A)	2	Elective	3	—	9	Adler
6·637	Beam-Type Microwave Tubes	6·07 or 6·322; 8·08	G(A)	1	Elective	3	—	6	Smullin

‡ Not offered 1956–57.

★Time specially arranged.

Electrical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6·64	Insul., Semiconduct. & Met.	8·04 or 8·041	G(A)	2	Elective	3	—	6	von Hippel
6·68	Spec. Prob. in Elec. Eng.	—	G(A)	1 or 2	Elective		★		Gardner
6·691	Acoustics, Adv.	8·13	G(A)	1	Elective	3	—	6	Mawardi
6·692	Eng. Acoustics, Adv.	6·35 or 8·13	G(A)	2	Elective	3	—	6	Baruch
6·695	Spec. Prob. in Acoustics	—	G(A)	1 or 2	Elective		★		L. L. Beranek
6·696	Hearing, Speech, & Lang.	6·35 or 8·13	G(A)	2	Elective	3	—	6	Rosenblith, Halle
6·72	Communications Lab.	—	G(A)	1 or 2	Elective		★		Elias
6·73	Elec.Circ.&Electron.Lab.,Adv.	6·02	G(A)	1 or 2	Elective		★		Jones
6·74	Elec. Energy Conv. Lab., Adv.	6·06	G(A)	1 or 2	Elective		★		White
6·80	Elec. Circ. & Electron. Lab.	6·05	4	1 or 2	Elective		★		Jones
6·81	Elec. Com. Lab.	—	4	1 or 2	Elective		★		Elias
6·86	Elec. Energy Conv. Lab.	6·01 or 6·18	4	1 or 2	Elective		★		Kusko
6·901	Gen. Elec. Ind. Prac.	—	3	S	VI-A(B)	40 h.p.w.			Boehne
			3	1	VI-A(A)				
6·902	Gen. Elec. Ind. Prac.	—	3	2	VI-A(B)	40 h.p.w.			Boehne
			4	S	VI-A(A)				
6·903	Gen. Elec. Ind. Prac.	—	4	1	VI-A(B)	40 h.p.w.			Boehne
			4	2	VI-A(A)				
6·904	Gen. Elec. Ind. Prac.	—	G	S	VI-A	40 h.p.w.			Boehne
6·905	IBM Corporation Ind. Prac.	—	3	S	VI-A(B)	40 h.p.w.			Boehne
			3	1	VI-A(A)				
6·906	IBM Corporation Ind. Prac.	—	3	2	VI-A(B)	40 h.p.w.			Boehne
			4	S	VI-A(A)				
6·907	IBM Corporation Ind. Prac.	—	4	1	VI-A(B)	40 h.p.w.			Boehne
			4	2	VI-A(A)				
6·908	IBM Corporation Ind. Prac.	—	G	S	VI-A	40 h.p.w.			Boehne
6·911	Boston Edison Pub. Util. Prac.	—	3	S	VI-A(B)	40 h.p.w.			Boehne
			3	1	VI-A(A)				
6·912	Boston Edison Pub. Util. Prac.	—	3	2	VI-A(B)	40 h.p.w.			Boehne
			4	S	VI-A(A)				
6·913	Boston Edison Pub. Util. Prac.	—	4	1	VI-A(B)	40 h.p.w.			Boehne
			4	2	VI-A(A)				
6·914	Boston Edison Pub. Util. Prac.	—	G	S	VI-A	40 h.p.w.			Boehne
6·921	Spec. Ind. Prac.	—	3	S	—	40 h.p.w.			Boehne
			3	1	—				
6·922	Spec. Ind. Prac.	—	3	2	—	40 h.p.w.			Boehne
			4	S	—				
6·923	Spec. Ind. Prac.	—	4	1	—	40 h.p.w.			Boehne
			4	2	—				
6·924	Spec. Ind. Prac.	—	G	S	—	40 h.p.w.			Boehne
6·931	Raytheon Ind. Prac.	—	3	S	VI-A(B)	40 h.p.w.			Boehne
			3	1	VI-A(A)				
6·932	Raytheon Ind. Prac.	—	3	2	VI-A(B)	40 h.p.w.			Boehne
			4	S	VI-A(A)				
6·933	Raytheon Ind. Prac.	—	4	1	VI-A(B)	40 h.p.w.			Boehne
			4	2	VI-A(A)				
6·934	Raytheon Ind. Prac.	—	G	S	VI-A	40 h.p.w.			Boehne
6·941	Bell Tel. Lab. Ind. Prac.	—	3	S	VI-A(B)	40 h.p.w.			Boehne
			3	1	VI-A(A)				
6·942	Bell Tel. Lab. Ind. Prac.	—	3	2	VI-A(B)	40 h.p.w.			Boehne
			4	S	VI-A(A)				
6·943	Bell Tel. Lab. Ind. Prac.	—	4	1	VI-A(B)	40 h.p.w.			Boehne
			4	2	VI-A(A)				
6·944	Bell Tel. Lab. Ind. Prac.	—	G	S	VI-A	40 h.p.w.			Boehne
6·951	General Radio Ind. Prac.	—	3	S	VI-A(B)	40 h.p.w.			Boehne
			3	1	VI-A(A)				
6·952	General Radio Ind. Prac.	—	3	2	VI-A(B)	40 h.p.w.			Boehne
			4	S	VI-A(A)				
6·953	General Radio Ind. Prac.	—	4	1	VI-A(B)	40 h.p.w.			Boehne
			4	2	VI-A(A)				
6·954	General Radio Ind. Prac.	—	G	S	VI-A	40 h.p.w.			Boehne
6·961	Philco Corp. Ind. Prac.	—	3	S	VI-A(B)	40 h.p.w.			Boehne
			3	1	VI-A(A)				
6·962	Philco Corp. Ind. Prac.	—	3	2	VI-A(B)	40 h.p.w.			Boehne
			4	S	VI-A(A)				
6·963	Philco Corp. Ind. Prac.	—	4	1	VI-A(B)	40 h.p.w.			Boehne
			4	2	VI-A(A)				

★ Time specially arranged.

Electrical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6·964	Philco Corp. Ind. Prac.	—	G	S	VI-A	40 h.p.w.			Boehne
6·971	Am. Gas & Elec. Serv. Corp.	—	3	S	VI-A(B)	40 h.p.w.			Boehne
	Ind. Prac.		3	1	VI-A(A)				
6·972	Am. Gas & Elec. Serv. Corp.	—	3	2	VI-A(B)	40 h.p.w.			Boehne
	Ind. Prac.		4	S	VI-A(A)				
6·973	Am. Gas & Elec. Serv. Corp.	—	4	1	VI-A(B)	40 h.p.w.			Boehne
	Ind. Prac.		4	2	VI-A(A)				
6·974	Am. Gas & Elec. Serv. Corp. Ind. Prac.	—	G	S	VI-A	40 h.p.w.			Boehne
6·981	Naval Ord. Lab. Ind. Prac.	—	3	S	VI-A(B)	40 h.p.w.			Boehne
			3	1	VI-A(A)				
6·982	Naval Ord. Lab. Ind. Prac.	—	3	2	VI-A(B)	40 h.p.w.			Boehne
			4	S	VI-A(A)				
6·983	Naval Ord. Lab. Ind. Prac.	—	4	1	VI-A(B)	40 h.p.w.			Boehne
			4	2	VI-A(A)				
6·984	Naval Ord. Lab . Ind. Prac.	—	G	S	VI-A	40 h.p.w.			Boehne
6·991	Airforce Cambridge Res. Lab.	—	3	S	VI-A(B)	40 h.p.w.			Boehne
	Ind. Prac.		3	1	VI-A(A)				
6·992	Airforce Cambridge Res. Lab.	—	3	2	VI-A(B)	40 h.p.w.			Boehne
	Ind. Prac.		4	S	VI-A(A)				
6·993	Airforce Cambridge Res. Lab.	—	4	1	VI-A(B)	40 h.p.w.			Boehne
	Ind. Prac.		4	2	VI-A(A)				
6·994	Airforce Cambridge Res. Lab. Ind. Prac.	—	G	S	VI-A	40 h.p.w.			Boehne

BIOLOGY — 7·00–7·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
7·00	Perspect. in Life Science	—	1	2	Elective	3	—	3	Sanborn
7·01	General Biology I	—	2	1	VII, IX-C, XX	3	—	4	Herbert
7·011	General Biology Lab. I	—	2	1	VII, IX-C, XX	0	3	0	Herbert
7·02	General Biology II	7·01	2	2	VII, IX-C,	3	—	4	Sanborn
7·021	General Biology Lab. II	7·01	2	2	VII, IX-C	0	3	1	Sanborn
7·03	Genetics & Cytology	7·02, 7·021	3	1	VII, IX-C	2	4	4	H. W. Lewis
7·04	Embryology	7·03	3	2	VII, IX-C (b)	2	6	4	H. W. Lewis
7·05	Gen. Biochem. & Physiol. I	5·41, 5·62, 7·02	4	1	VII, XX, XX-A, XX-B	3	—	6	Buchanan
7·051	Gen. Biochem. & Physiol. Lab. I	*7·05*	4	1	VII	0	8	0	Gould, G. M. Brown
7·06	Gen. Biochem. & Physiol. II	7·05	4	2	VII	3	—	6	Waugh
7·061	Gen. Biochem. & Physiol. Lab. II	*7·06*	4	2	VII	0	6	0	Jenerick
7·08	Biophysics, Int.	5·02; 7·00 or 7·02; 8·04	3,4	2	Elective	2	—	4	Bear
7·13	Genetics	7·02	4	2	Elective	2	—	4	H. W. Lewis
7·14‡	Comparative Anatomy	7·02, 7·021	3	1	Elective	2	6	4	—
7·31	Biology Seminar	7·06	G(A)	1	VII	1	—	2	Sizer
7·32	Biology Seminar	7·06	G(A)	2	VII	1	—	2	Sizer
7·35	Cellular Physiology	7·06	G(A)	1	Elective	2	—	4	Jenerick
7·351	Cellular Physiology Lab.	*7·35*	G(A)	1	Elective	0	4	0	Jenerick
7·50	Physical Chem. of Proteins	7·05	G(A)	2	Elective	2	—	4	D. F. Waugh
7·51	Physical Chem. of Proteins Lab.	*7·50*	G(A)	2	Elective	0	4	0	D. F. Waugh
7·77	Biophysics Seminar	7·06	G(A)	1	Elective	1	—	2	Bear
7·78	Biophysics Seminar	7·06	G(A)	2	Elective	1	—	2	Bear
7·81	Enzymology	7·05	G(A)	1	XX-A	2	—	4	Sizer
7·811	Enzymology Lab.	*7·81*	G(A)	1	Elective	0	4	2	Sizer
7·82	Biochemistry, Adv.	7·05	G(A)	2	Elective	2	4	4	Gould
7·831	Biochem. of Microorganisms	7·05	4	2	Elective	3	4	4	Gould
7·832	Biochem. of Microorganisms	7·831	G(A)	2	Elective	0	6	0	Gould
7·85	Biophysics I, Methods	7·06, 8·04	G(A)	1	Elective	2	2	4	Hall
7·86	Biophysics II, Methods	7·06, 8·04	G(A)	2	Elective	2	—	4	Waugh
7·87	Mathematical Biophysics	7·06	G(A)	1	Elective	2	—	4	—
7·882	Biophysics Lab.	7·06, 8·04	G(A)	2	Elective	0	4	0	Waugh
7·90	Sem. in Enzymology	7·81	G(A)	2	Elective	2	—	4	Sizer
7·91	Elec. Instrument. in Biol. I	8·04	G(A)	1	Elective	3	4	6	Lion

‡ Not offered 1956–57.

Biology Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
7·92	Elec. Instrument. in Biol. II	7·91	G(A)	2	Elective	0	4	0	Lion
7·93	Selected Topics in Biology	*7·05*	G(A)	1 or 2	Elective		★		Staff
7·941	Research Problems	——	G(A)	1	Elective		★		Staff
7·942	Research Problems	——	G(A)	2	Elective		★		Staff
7·95	Electron Microscopy	7·85 or 8·04	G(A)	2	Elective	3	—	6	Hall
7·96	Electron Microscopy Lab.	7·95	G(A)	2	Elective	0	2	1	Hall
7·97	Tissue Ultrastructure	7·06	G(A)	1	Elective	2	—	4	Schmitt
7·98	Tissue Ultrastructure	7·97	G(A)	2	Elective	2	—	4	Schmitt
7·99	Molec. Config. in Biol. Syst.	7·06	G(A)	1	Elective	2	—	4	Bear

PHYSICS — 8·00–8·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
8·01	Physics (Mechanics)	——	1	1	All courses	4	1	6	Ingard
8·012	Physics (College Transfer)	M11	1	1	——	4	—	4	——
8·02	Physics (Mech.: Heat & Kinetic Th.)	8·01	1	2	All courses	4	1	6	Ingard
8·03	Physics (Elec. & Magnetism)	8·02, M12	2	1	All courses except VI, VIII, XII, XVIII	4	1	5	Bitter
8·03S	Physics	——	G	S	XIII-A	4	—	6	——
8·031	Physics (Electromagnetism)	8·02, M12	2	1	VI, VIII, XII, XVIII	4	1	5	Rossi
8·034	Physics (College Transfer)	M11	2	2	——	4	—	4	——
8·04	Physics (Optics & Atomic Phys.)	8·03	2	2	All courses except VI, VIII, XII, XVIII	4	1	5	Bitter
8·041	Physics (Electromag. & Electromag. Th. of Light)	8·031	2	2	VI, VIII, XII, XVIII	4	1	5	Rossi
8·05	Phys.: Atoms, Molec. & Nucl. I	8·04 or 8·041	3	1	VIII	4	—	6	Zacharias
8·051	Atom. & Nucl. Physics I	8·04 or 8·041	3	S	VI-A(A) Elective	4	—	5	Buechner
			3	1	VI Elective, VI-A(B) Elective, IX-C				
			4	1	II(9), II-B(9)				
			G	1	XIII-A				
8·052	Atom. & Nucl. Physics II	8·051	4	2	II(9), II-B(9)	4	—	5	Buechner
8·06	Phys.: Atoms, Molec. & Nucl. II	8·05	3	2	VIII	4	—	6	F. L. Friedman
8·07	Thermo. & Statist. Mech.	8·04 or 8·041	3	2	IX-A, XIX (56–57)	4	—	5	Frisch
			4	2	VIII				
8·08	Electronics	8·04 or 8·041	3	1	VIII, IX-A	4	—	5	Harvey
8·09	Exp. Atomic Physics I	8·04 or 8·041	3	1	VIII	0	6	3	Strandberg
8·10	Exp. Atomic Physics II	8·05, 8·08, 8·09	3	2	VIII	0	4	2	Kraushaar
8·11	Experimental Physics	8·10	4	1	VIII	2	6	4	Frisch
8·13	Vibration and Sound	8·04 or 8·041; M22	4	2	Elective	3	—	6	Ingard
8·135	Spec. Problems in Acoustics	8·13	G(A)	1 or 2	Elective		★		Ingard
8·14‡	Sound Prop. in Moving Media	8·13, 8·71	G(A)	1	Elective	3	—	9	Ingard
8·15	Photography	——	3	2	Elective	2	—	1	A. C. Hardy
8·16	Optics	8·04 or 8·041	3	2	Elective	3	—	6	A. C. Hardy
8·17	Color Measurements	8·04 or 8·041	4	2	Elective	0	3	2	A. C. Hardy
8·18	Spec. Problems in Optics	8·16	G(A)	1 or 2	Elective		★		A. C. Hardy
8·191	Select. Topics in Phys. Optics I	8·72	G(A)	1	Elective	2	—	4	Mueller
8·192	Select. Topics in Phys. Optics II	8·191	G(A)	2	Elective	2	—	4	Mueller
8·21	Physical Electronics	8·08	G(A)	1	Elective	3	—	6	Nottingham
8·212	Physical Electronics Lab.	8·21	G(A)	2	Elective	2	3	3	Nottingham
8·231	Elec. Discharges in Gases	8·05, 8·07	G(A)	1	Elective	3	—	6	S. C. Brown
8·232	Elec. Discharges in Gases, Th.	8·231, *8·72*	G(A)	2	Elective	3	—	6	Allis
8·25	Spec. Prob. in Electronics	8·08, *8·21*	G(A)	1 or 2	Elective		★		Staff
8·27	X-rays & Crystal Physics	8·05, M352	G	1	Elective	3	1	6	Warren
8·28	X-ray Diffraction	8·27	G(A)	2	Elective	3	—	6	Warren
8·30	Spec. Prob. in Crystal Phys.	8·27	G(A)	1 or 2	Elective		★		Warren
8·32	Line Spectra	8·05	G(A)	1	Elective	3	—	6	Bradley
8·34	Spec. Prob. in Spectroscopy	8·32	G(A)	1 or 2	Elective		★		Harrison
8·361	Quantum Th. of Matter I	3·51 or 5·67 or 5·75 or 8·05 or 8·051	G(A)	1	Elective	3	—	6	Slater
8·362	Quantum Th. of Matter II	8·361	G(A)	2	Elective	3	—	6	Slater

‡ Not offered 1956–57.

★ Time specially arranged.

Physics Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
8·363	Select. Topics in Th. of Solids I	8·362	G(A)	1	Elective	2	—	4	Slater
8·364	Select. Topics in Th. of Solids II	8·363	G(A)	2	Elective	2	—	4	Slater
8·38	Sp. Prob. in Nucl. Magnet.	8·05, 8·07	G(A)	1 or 2	Elective		★		Bitter
8·411‡	Statistical Thermodyn. I	*8·731*	G(A)	1	Elective	3	—	9	Tisza
8·412‡	Statistical Thermodyn. II	8·411	G(A)	2	Elective	3	—	9	Tisza
8·43	Microwave Physics	8·361 or 8·731	G(A)	2	Elective	3	2	6	Strandberg
8·45	Sp. Prob. in Solid State Phys.	8·362 or 8·412	G(A)	1 or 2	Elective		★		Staff
8·511	Nuclear Physics I	8·06, *8·71*	G(A)	1	Elective	3	—	6	M. Deutsch
8·512	Nuclear Physics II	8·511	G(A)	2	Elective	3	—	6	M. Deutsch
8·513	Nuclear Physics Lab.	8·511	G(A)	2	Elective	1	3	3	M. Deutsch
8·52	Applied Nuclear Physics, Adv.	8·512 or 8·532	G(A)	2	Elective	3	—	6	R. D. Evans
8·531	Nuclear Phys. for Eng. I	8·051 or 8·06	G(A)	1	Elective	3	—	6	R. D. Evans
8·532	Nuclear Phys. for Eng. II	8·531	G(A)	2	Elective	3	—	6	R. D. Evans
8·541	Adv. Topics in Nucl. Phys.	8·06	G(A)	1	Elective	2	—	4	Schluter
8·551	Nuclear Structure I, Theory	8·732	G(A)	1	Elective	3	—	9	Weisskopf
8·552	Nuclear Structure II, Theory	8·551	G(A)	2	Elective	3	—	9	Weisskopf
8·56‡	Cosmic Rays & High Energy Phenomena	8·71, 8·72	G(A)	2	Elective	3	—	6	Rossi
8·58‡	Meson Physics	8·06, 8·732	G(A)	2	Elective	3	—	6	Feld
8·59‡	Statist. Fluctuations in Phys. Proc.	8·052 or 8·06	G	2	Elective	2	—	4	R. D. Evans
8·60	Sp. Problems in Nuclear Phys.	8·511	G(A)	1 or 2	Elective		★		Staff
8·71	Int. to Th. Physics I (Mechanics)	M352 . G(A) except 4	VIII	2	Elective VIII	4	—	8	M. H. Friedman
8·72	Int. to Th. Physics II (Electromagnetic Theory)	M352 . G(A) except 4	VIII	1	Elective VIII	4	—	8	M. H. Friedman
8·731	Int. to Quantum Th. I	8·71, 8·72	G(A)	1	Elective	3	—	9	Feshbach
8·732	Int. to Quantum Th. II	8·731	G(A)	2	Elective	3	—	9	Feshbach
8·74	App. of Group Th. to Theoret. Phys.	M62	G(A)	2	Elective	3	—	9	Koster
8·791‡	Methods of Theoret. Phys. I	8·71, 8·72	G(A)	1	Elective	3	—	9	Morse
8·792‡	Methods of Theoret. Phys. II	8·791	G(A)	2	Elective	3	—	9	Morse
8·80	Advanced Mechanics	8·71, 8·72	G(A)	2	Elective	3	—	9	Harvey
8·861‡	Rel. Quantum Mechanics I	8·732	G(A)	1	Elective	3	—	9	Villars
8·862‡	Rel. Quantum Mechanics II	8·861	G(A)	2	Elective	3	—	9	Villars
8·90	Sp. Prob. in Theoret. Phys.	8·791	G(A)	1 or 2	Elective		★		Staff

CHEMICAL ENGINEERING — 10·00–10·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
10·11	Chemical Eng.	5·02	2	1	X	1	—	1	Fairbanks
			4	1	XV-B				
10·15	Thesis Reports	——	4	1	X	0	3	0	Baddour
10·17	Industrial Chemistry	5·02	2	1	X	3	—	4	Baddour
			3	1	XX-B				
			4	1	XV-B				
10·18	Industrial Chemistry	5·61, 10·17	3	2	X	3	—	6	Baddour
10·21	Industrial Chemistry	5·42, 5·62	4	1	X, X-B	3	—	6	Satterfield
10·25	Industrial Chemistry	5·42, 5·62	G(A)	1	Elective	5	—	7	Meissner
10·26	Industrial Chem. Lab.	10·17	4	1	X	0	10	0	Merrill
10·27	Chemical Eng. Lab.	10·17	4	1	X	0	10	0	Gilliland
10·28	Chemical Eng.	10·17	2	2	X	4	—	6	Sherwood
			4	2	XV-B				
10·29	Chemical Eng.	10·28	3	1	X	4	—	6	Sherwood
10·30	Eng. Equipment	10·32	4	2	X-B	0	9	0	Vivian
10·31	Chemical Eng.	2·41, 10·17; or *3·20;* or 10·17, 10·28	4	1	X, X-B	4	—	6	Gilliland
10·311	Heat Transfer	——	G	2	XIII-A	3	—	3	McAdams
10·32	Chemical Eng.	10·29	4	1	X-B	4	—	6	Vivian
			4	2	X				
10·33	Anal. Treat. of Chem. Eng. Processes	5·62, M22	G(A)	2	Elective	3	—	6	Mickley

‡ Not offered 1956–57.

★ Time specially arranged.

Chemical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
10·36	Process Design	10·31	4	2	Elective	3	—	5	Sherwood
10·37	Chemical Kinetics	5·62, 10·17, 10·29	4	1	Elective	3	—	6	G. C. Williams
10·40	Chem. Eng. Thermodyn.	5·62, 10·29	G(A)	1, 2	Elective	4	—	8	Weber
10·41	Distillation	10·32	G(A)	2	Elective	3	—	6	Gilliland
10·45	Distil. & Absorption	10·32	G(A)	1	Elective	4	—	8	Vivian
10·46	Absorption & Extraction	10·32	G(A)	2	Elective	3	—	6	Sherwood
10·47	Ion Exchange	5·62, 10·32	G(A)	2	Elective	2	—	4	Baddour
10·50	Heat Transmission	10·31	G(A)	1	Elective	2	—	4	McAdams
10·52	Chemical Eng. II	10·32	G(A)	1	Elective	3	—	6	Mickley
10·53	Chem. Eng. Design	10·31, *10·32*	G(A)	2	Elective	3	—	6	G. C. Williams
10·55	Econ. Balance in Chem. Ind.	10·32	G(A)	1 or 2	Elective	3	—	6	G. C. Williams
10·62	Thermodynamics, Adv.	10·40	G(A)	2	Elective	3	—	6	Meissner
10·63	Industrial Chemistry II	10·661	G(A)	2	Elective	3	—	6	Michaels
10·65	App. Chem. Kinetics	5·62, 10·29	G(A)	2	Elective	3	—	6	Satterfield
10·66	Colloid Chemistry	5·42, 5·62	G(A)	1	Elective	3	—	5	Michaels
10·67	App. Surface Chem.	5·66 or 10·21 or 10·63 or 10·661	G(A)	2	Elective	3	—	6	Michaels
10·69	High Polymer Tech.	5·061 or 10·21	G(A)	2	Elective	3	—	6	Michaels
10·691‡	Colloid Chem. of Silicon	5·061 or 10·21	G(A)	1	Elective	2	—	4	Michaels
10·70	Combustion, Prin	—	G(A)	1	Elective	3	—	6	Hottel
10·71	Fuel Engineering	—	G(A)	2	Elective	3	—	6	G. C. Williams
10·74	Furnace Design	10·31	G(A)	2	Elective	3	—	6	Hottel
10·81	Sch. Chem. Eng Practice (Bangor Station)	10·32	G(A)	1 or 2	Elective	0	16	0	Vivian
10·82	Sch. Chem. Eng. Practice (Parlin Station)	10·32	G(A)	1 or 2	Elective	0	16	0	Vivian
10·83	Sch. Chem. Eng. Practice (Buffalo Station)	10·32	G(A)	1 or 2	Elective	0	16	0	Vivian
10·84	Sch. Chem. Eng. Practice (Bangor Station)	10·32	4	2	X-B	0	12	0	Vivian
10·85	Sch. Chem. Eng. Practice (Parlin Station)	10·32	4	2	X-B	0	12	0	Vivian
10·86	Sch. Chem. Eng. Practice (Buffalo Station)	10·32	4	2	X-B	0	12	0	Vivian
10·90	Exp. Research Problem	—	G(A)	1, 2	Elective		★		G. C. Williams
10·991	Seminar in Chem. Eng.	10·32	G(A)	1	Elective	2	—	4	Gilliland
10·992	Seminar in Chem. Eng.	10·32	G(A)	2	Elective	2	—	4	Gilliland

GEOLOGY AND GEOPHYSICS — 12.00–12.99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
12·00	Earth Science (Geol., Geophys. Geochem.)	—	1	2	Elective	2	—	4	Brace
12·001	Astronomy	—	1	1,2	Elective	3	—	3	Pinson
12·011T	Mineralogy I	5·02	2	1	XII	3	4	3	Dennen
12·012T	Mineralogy II	12·011T	2	2	Elective	3	4	3	Dennen
12·05	Mineralogical Seminar	12·202	G(A)	1	Elective	2	—	4	Buerger
12·14	Petrology	12·011T, 12·301T	3	2	Elective	2	—	4	Fairbairn
12·15	Petrology Laboratory	12·231	3	2	Elective	0	6	0	Fairbairn
12·161	Min. Deposits & Petrol. Sem.	12·14, 12·40	G(A)	1	Elective	2	—	4	Fairbairn, Hurley
12·162	Min. Deposits & Petrol. Sem.	12·161	G(A)	2	Elective	2	—	4	Hurley, Fairbairn
12·17	Petrology Laboratory, Adv.	12·15	G(A)	1	Elective	0	4	2	Fairbairn
12·201‡	Crystallography	—	2	1	Elective	2	2	2	Buerger
12·202‡	Crystallography	12·201	4	2	Elective	2	—	4	Buerger
12·231	Optical Crystallog.	12·011T or 12·201	3	1	Elective	0	6	2	Fairbairn
12·232	Optical Crystallog., Adv.	12·231	G(A)	2	Elective	0	3	1	Fairbairn
12·27	Crystallographic Res.	12·201	G(A)	1 or 2	Elective		★		Buerger
12·301T	Physical Geology	—	2	1	XII	3	4	4	Dennen
12·302	Historical Geology	12·301T	2	2	XII	3	4	4	Mencher
12·303T	Geological Surveying	12·301T	3	S	XII	0	7	0	Parks
12·304T	Field Investigations & Reports	12·301T	3	S	XII	0	17	0	Staff
12·308	Sediment., Stratigraphy	12·302	3	2	Elective	3	2	3	Mencher
12·321	Engineering Geology	—	3	1	I	2	2	2	Brace

‡ Not offered 1956–57.

★ Time specially arranged.

Geology and Geophysics Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
12·322	Engineering Geology	—	G	2	Elective	2	—	4	Brace
12·40	Mineral Deposits	12·011T, 12·301T	4	1	Elective	3	—	5	Hurley
12·42	Ore Guides	12·40, 12·702, 12·87	4	2	Elective	2	4	2	Hawkes
12·432	Mineral Dep. Lab., Adv.	12·40	G(A)	2	Elective	0	4	1	Hurley
12·44T	Petroleum Geology	12·308, 12·702	4	1	Elective	3	—	5	Mencher
12·45	Petroleum Geology Lab.	*12·44T*	4	1	Elective	0	4	2	Mencher
12·461	Petroleum Geology Seminar	12·44T	G(A)	1	Elective	2	—	4	Mencher
12·462	Petroleum Geology Seminar	12·461	G(A)	2	Elective	2	—	4	W. L. Whitehead
12·51	Paleontology	12·302	3	1	Elective	2	4	2	Shrock
12·52	Paleontology, Adv.	12·51	G(A)	2	Elective		★		Shrock
12·581‡	Sedimentology	12·15, 12·301T	4	2	Elective	2	4	2	Shrock
12·582	Sedimentology, Adv.	12·15, 12·581	G(A)	1 or 2	Elective		★		Shrock, Mencher
12·583	Sedimentology Seminar	12·581	G(A)	2	Elective	2	—	4	Shrock, Mencher
12·65	Special Problems	—	4	1 or 2	Elective		★		Staff
12·66	Special Problems	—	G(A)	1 or ?	Elective		★		Staff
12·702	Structural Geology	12·301T	3	1	Elective	2	2	4	W. L. Whitehead, Brace
12·721	Tectonics Seminar	12·73	G(A)	1	Elective	2	—	4	W. L. Whitehead
12·722	Tectonics Seminar	12·15, 12·702	G(A)	2	Elective	2	—	4	Fairbairn
12·73	Tectonic Elements	12·702	4	2	Elective	2	2	4	W. L. Whitehead, Brace
12·80	Geochemistry	5·62, 8·04, 12·14, 12·15	4	2	Elective	2	—	4	Dennen
12·801T	Theoretical Geology I	12·14, M352	G	1	Elective	3	—	9	MacDonald
12·802T	Theoretical Geology II	12·801T	G	2	Elective	3	—	9	MacDonald
12·803T	Theoretical Geology III	12·802T	G(A)	1	Elective	3	—	9	MacDonald
12·804T	Theoret. Geology IV	12·803T	G(A)	2	Elective	3	—	9	MacDonald
12·81	Spectrochemical Anal.	12·80	G(A)	1	Elective	2	2	3	Dennen
12·831	Elements of Geophys. I	8·041, M22	3	1	Elective	3	—	6	Doell
12·832	Elements of Geophys. II	12·831	3	2	Elective	3	—	6	Doell
12·86	Seismology, Elements	M22	4	1	Elective	2	—	4	S. M. Simpson
12·87	Geophysics, Int.	12·302, M22	3	2	Elective	2	—	4	Hurley
12·873	Geophysics, Adv.	M352	G(A)	1	Elective	3	—	6	Staff
12·874	Geophysics, Adv.	12·873	G(A)	2	Elective	3	—	6	Staff
12·881	Geophysics Seminar	12·87, 12·874	G(A)	1	Elective	2	—	4	S. M. Simpson
12·882	Geophysics Seminar	12·881	G(A)	2	Elective	2	—	4	S. M. Simpson
12·89	Isotope Geology	8·04, 12·301T	G(A)	2	Elective	2	—	4	Hurley
12·91	Mining, Elements	—	4	1	Elective	3	—	6	Parks
12·92	Mining Methods & Practice	12·91	4	2	Elective	3	—	6	Parks
12·94	Mineral Economics	—	4	1	Elective	3	—	6	Parks
12·95	Valuation of Min. Property	12·92	G(A)	2	Elective	3	—	6	Parks
12·96	Mineral Econ. Seminar	12·94	G(A)	1 or 2	Elective		★		Parks
12·97	Min. Valuation Seminar	12·95	G(A)	1 or 2	Elective		★		Parks

NAVAL ARCHITECTURE AND MARINE ENGINEERING — 13·00–13·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
13·01	Naval Architecture I	8·01, M21	3	1	XIII	3	1	5	Manning
13·012	Naval Architecture	8·01, M21	G	2	XIII-A	4	1	7	Manning
13·02	Naval Architecture II	13·01	3	2	XIII	3	1	5	Abkowitz
13·03	Principles of Ship Design	13·46	G(A)	1	Elective	3	2	6	Manning, D'Arcangelo
13·031	Preliminary Design of Ships	13·03	G(A)	1,2	Elective		★		J.H.Evans, Powell
13·04	Ship Design, Advanced	13·03	G(A)	2	Elective	2	—	8	Manning
13·05T	Hydromech. of Ship Des., Adv.	13·02	G(A)	1	Elective	3	—	5	Abkowitz
13·06	Spec. Prob. in Nav. Arch. & Mar. Eng.	—	G(A)	1, 2	Elective		★		Troost
13·12	Warship General Arrangements	13·20	G(R)	2	XIII-A	3	—	5	Obermeyer
13·13	Warship Structure, Theory I	2·046, 2·081	G(RA)	1	XIII-A	3	—	6	J. H. Evans
13·14	Warship Structure, Theory II	13·13	G(RA)	2	—	3	—	6	J. H. Evans
13·15	Warship Basic Design I	13·012, 13·12, 13·13	G(RA)	1	XIII-A	3	2	6	Manning, D'Arcangelo
13·16	Warship Basic Design II	13·12, 13·22	G(RA)	1	XIII-A	3	—	6	Obermeyer
13·17	History of Warships	—	G(R)	1	XIII-A	3	—	4	Obermeyer
13·20	Ship Design, Elem.	—	G	S	XIII-A	1	4	0	Obermeyer
13·21	Warship Form Design	13·20	G(R)	2	XIII-A	0	5	0	Abkowitz
13·22	Warship General Design	13·01, 13·12, 13·21	G(R)	1	XIII-A	0	5	0	D'Arcangelo
13·24	Warship Structure, Design I	13·13	G(RA)	2	—	0	5	0	D'Arcangelo

‡ Not offered 1956–57.

★ Time specially arranged.

Naval Architecture and Marine Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
13·241	Warship Structure, Design I	13·13	G(RA)	2	XIII-A	0	3	0	D'Arcangelo
13·25	Warship Structure, Design II	13·14, 13·24	G(RA)	1	——	0	5	0	D'Arcangelo
13·26	Prelim. Design of Warships	13·15, 13·16	G(RA)	2	XIII-A	0	9	0	Obermeyer
13·40	Elem. Ship. Des. & Constr. I	——	2	1	XIII	2	2	1	Allmendinger
13·41	Elem. Ship Des. & Constr. II	13·40	2	2	XIII	2	2	1	Allmendinger
13·42	Hull Form Design	13·41	3	1	XIII	0	5	0	Allmendinger
13·43	Ship Structural Drawing	13·42, 13·45	4	1	XIII, XIII-B	0	3	0	J. H. Evans
13·45	Ship Structures	2·081, 13·40	3	2	XIII	3	—	6	J. H. Evans
13·46	Ship Design	13·02, 13·43, 13·53	4	2	XIII, XIII-B	1	8	2	J. H. Evans, Powell
13·52	Marine Engineering I	2·40, 13·40	3	2	XIII	3	—	3	Burtner
13·53	Marine Engineering II	1·611, 2·42, 6·18, 13·52	4	1	XIII, XIII-B	3	—	5	Burtner
13·54	Marine Eng. Dynamics	2·002	4	2	XIII, XIII-B	2	—	4	F. M. Lewis
			G	1	XIII-A				
13·56	Marine Eng. Economics	6·18, 13·02, 13·53	G(A)	2	Elective	3	—	9	Powell
13·61	Marine Eng. Design III	13·52	4	1	XIII, XIII-B	1	4	0	Burtner
13·62	Marine Eng. Design IV	13·53, 13·61	4	2	XIII, XIII-B	1	4	0	Burtner
13·71¶	Ship Propulsion I	13·53, 13·54	G(A)	1	Elective	3	—	6	Burtner, Powell
13·711T¶	Ship Machinery Design I	13·53, 13·54	G(A)	1	Elective	2	—	4	Burtner, Powell
13·72¶	Ship Propulsion II	13·53, 13·54	G(A)	2	Elective	2	—	4	Burtner, Powell
13·721T¶	Ship Machinery Design II	13·53, 13·54	G(A)	2	Elective	2	—	4	Burtner, Powell
13·73	Mechanical Vibration	2·002 or 2·046	G(A)	1	Elective	3	—	6	F. M. Lewis
13·74	Mechanical Vibration	13·73	G(A)	2	Elective	4	—	8	F. M. Lewis
13·75	Warship Propulsion I	2·402, 10·311	G(RA)	1	XIII-A	3	2	6	Thornbury, Powell
13·76	Warship Propulsion II	13·75	G(RA)	2	XIII-A	2	4	4	Thornbury, Powell
13·791	Marine Propellers	1·601; *13·012* or 13·02	G(A)	1 or 2	Elective	3	—	6	Troost, Powell
13·90	Warship Elec. Eng.	6·18, 6·19	G(RA)	1	XIII-A	3	—	4	Thornbury
13·91	Warship Elec. Eng., Adv.	6·10, 6·213	G(RA)	2	——	3	—	4	Thornbury
13·911	Warship Elec. System Des.	6·10, 6·213, *13·91*	G(RA)	2	——	0	2	0	Thornbury

ECONOMICS AND SOCIAL SCIENCE — 14·00–14·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
14·01	Economic Principles I	H12	2	1	XIV-A, XIV-B, XV-A, XV-B, XXI-A(a), XXI-B(a)	3	—	5	Bishop
			3	1	VI-A(B)				
			3,4	1,2	Elective (but required for graduation by I, II, II-B, III, IV-A, VI, XIII, XIII-B, XVI, XVI-B, XVII, XX, XX-A, XX-B)				
			4	2	VI-A(A) (not 56–57)				
14·02	Economic Principles II	14·01	2	2	XIV-A(a), XIV-B(a), XXI-A(a), XXI-B(a)	3	—	5	E. C. Brown
			3,4	1,2	Elective				
14·03	Prices & Production	14·02	3,4	1	Elective	3	—	5	Bishop
14·04	Indust. Org. & Pub. Pol.	14·02	3,4	2	Elective	3	—	5	Bishop
14·09	Economic Problems Sem.	14·02	4	1,2	Elective	3	—	5	Kindleberger
14·101	Math. for Economists	——	G	1	Elective	3	—	6	H. A. Freeman
14·102	Math. for Economists	14·101	G	2	Elective	3	—	6	H. A. Freeman
14·114	Econ. & Finance: Prin. & Pol. I	——	G	S	——	4	—	9	R. E. Freeman
14·115	Econ. & Finance: Prin. & Pol. II	14·114	G	1	——	3	—	6	E. C. Brown, E. Shapiro
14·116	Econ. & Finance: Prin. & Pol. III	14·115	G(A)	2	——	3	—	6	Adelman Kindleberger
14·117	Econ. & Indust. Manage.	——	G	2	——	3	—	6	Solow, E. C. Brown
14·121	Economic Analysis	14·03	G(A)	1	Elective	3	—	6	Bishop
14·122	Economic Analysis	14·121	G(A)	2	Elective	3	—	6	Samuelson
14·132	Schools of Econ. Thought	14·121	G(A)	2	Elective	3	—	6	Bishop
14·151	Math Approach to Econ.	14·122	G(A)	1	Elective	3	—	6	Samuelson
14·161	Economic History	*14·121*	G(A)	1	Elective	3	—	6	W. W. Rostow
14·162	Economic History	*14·121*	G(A)	2	Elective	3	—	6	W. W. Rostow
14·171	Economic Growth, Th.	14·122, 14·451	G(A)	1	Elective	3	—	6	Rosenstein-Rodan
14·172	Res. Seminar in Econ. Develop.	14·171	G(A)	2	Elective	3	—	6	Millikan

¶ Approximately one year's practical experience with Marine Engineering Plants or design essential. Experience to be evaluated prior to acceptance of enrollment.

Economics and Social Science Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
14·174	Non-Econ. Factors in Econ. Growth	14·171	G(A)	2	Elective	3	—	6	Hagen
14·191	Economics Seminar	14·121	G(A)	1	Elective	3	—	6	R. E. Freeman
14·192	Economics Seminar	14·121	G(A)	2	Elective	3	—	6	R. E. Freeman
14·195	Read. Sem. in Econ.	14·121	G(A)	1	Elective		★		——
14·196	Read. Sem. in Econ.	14·121	G(A)	2	Elective		★		——
14·20	Building Economics	14·01	5	2	IV-A (56–57)	2	—	4	Maclaurin
			4	2	Elective				
14·21‡	Economics of Invention	14·01	4	2	Elective	3	—	5	Maclaurin
14·271	Industrial Econ., Prob.	14·03	G(A)	1	Elective	3	—	6	Adelman
14·272	Gov. Regulation of Industry	14·271	G(A)	2	Elective	3	—	6	Adelman
14·281	Econ. of Entrepren. & Innova.	14·03	G(A)	1	Elective	3	—	6	Maclaurin
14·282	Econ. of Innova. Sem.	14·281	G(A)	2	Elective	3	—	6	Maclaurin
14·291	Industrial Econ. Seminar	14·271	G(A)	1	Elective	3	—	6	——
14·292	Industrial Econ. Seminar	14·271	G(A)	2	Elective	3	—	6	——
14·30	Statistics, Elem.	M12	3	2	Elective	2	—	4	Mills
14·32	Statistical Qual. Cont.	14·30 or 14·33	4	2	Elective	3	—	6	H. A. Freeman
14·33	Statistics, Elem.	M12	3	1	XIV-A(a), XIV-B(a)	3	—	5	Mills
14·371	Statistical Theory	M21	G	1	Elective	3	—	6	H. A. Freeman
14·372	Statistical Theory	14·371	G	2	Elective	3	—	6	H. A. Freeman
14·381	Statistical Method	——	G	1	Elective	3	—	6	Solow
14·382	Economic Statistics	14·371	G(A)	2	Elective	3	—	6	Solow
14·391	Res. Seminar in Econ.	14·122, 14·371	G(A)	1	Elective	2	—	7	Solow
14·40	Money & Income	14·02	3, 4	2	Elective	3	—	5	R. E. Freeman
14·43	Public Finance	14·02	4	1	Elective	3	—	5	E. C. Brown
14·451	National Income	14·40	G(A)	1	Elective	3	—	6	Millikan
14·461	Monetary & Banking Prob.	14·40	G(A)	1	Elective	3	—	6	R. E. Freeman
14·472	Fiscal Policy	14·451	G(A)	2	Elective	3	—	6	E. C. Brown
14·481	Business Cycles	14·451	G(A)	1	Elective	3	—	6	Solow
14·51	International Relations	H22	3, 4	1, 2	Elective	3	—	5	Padelford
14·52	Amer. Dipl., Prin. & Prob.	14·51	3, 4	1, 2	Elective	3	—	5	Pye
14·521	Strategic & Polit. Geog.	——	G	1	Elective	3	—	6	Whittlesey
14·53	Sem. in International Pol.	14·52	3, 4	1	Elective	3	—	5	Pye
14·531	Asian Polit. & U. S. For. Pol.	14·121 or 14·52	G(A)	2	Elective	3	—	6	Pye
14·533	Soc. Sci. & U. S. Foreign Pol.	14·117	G(A)	1	Elective	3	—	6	Millikan
14·54	International Trade	14·01; 14·02 or 14·51	4	2	Elective	3	—	5	Kindleberger
14·571	Major Prob. in U. S. Foreign Pol.	——	G	1	Elective	3	—	6	Padelford
14·581	International Economics	14·40	G(A)	1	Elective	3	—	6	Kindleberger
14·582	International Economics	14·581	G(A)	2	Elective	3	—	6	Kindleberger
14·61	Industrial Relations	15·30	4	1	Elective	3	—	6	D. V. Brown
14·63	Labor Relations	H22	3	1, 2	Elective	3	—	5	Shultz
14·64	Labor Ec. & Pub. Policy	14·01 or 14·73; 14·63	4	1, 2	Elective	3	—	5	Siegel
14·671	Prob. in Labor Econ.	14·61	G(A)	2	Elective	3	—	6	Shultz, Siegel
14·672	Public Pol. on Labor Rel.	14·61	G(A)	1	Elective	3	—	6	Myers
14·673	Labor-Manage. Rel. & Pub. Pol.	14·762	G(A)	1	——	3	—	6	D. V. Brown, Shultz
14·681	Personnel Admin., Sem.	14·61	G(A)	1	Elective	3	—	6	Pigors
14·682	Personnel Admin., Sem.	14·681	G(A)	2	Elective	3	—	6	Pigors
14·691	Res. Sem. in Indust. Rel.	14·671 or 14·672	G(A)	1	Elective	3	—	6	Myers
14·692	Res. Sem. in Indust. Rel.	14·691	G(A)	2	Elective	3	—	6	Myers
14·693	Collect. Bargaining & Union-Manage. Coop.	14·61	G(A)	1	Elective	3	—	6	——
14·694	Sem. in Union-Manage. Coop.	14·693	G(A)	2	Elective	3	—	6	——
14·70	Introductory Psychology	——	2	2	IX-C	3	—	5	——
			3	1, 2	Elective				
14·72	Union-Manage. Rel.	14·61 or 14·63	4	1	Elective	3	—	6	Lesieur
14·73	Org. & Commun. in Groups	——	3, 4	1, 2	Elective	3	—	5	——
14·75	Experimental Psychology	14·70 or 14·73	3, 4	2	Elective	3	—	5	Licklider
14·762	Human Rel. & Labor Rel.	——	G	S	——	4	—	8	Myers
14·765	Quant. Meth. in Psych. Sem.	——	G	1	Elective	3	—	6	Licklider
14·766	Quant. Meth. in Psych. Sem.	14·765	G	2	Elective	3	—	6	Licklider
14·77	Psychology of Communication	14·70 or 14·73	4	1	Elective	3	—	5	Jenkins
14·771	Interpersonal Relations Sem.	——	G	1	Elective	3	—	6	Shepard
14·772	Indust. Sociology Sem.	14·771	G(A)	2	Elective	3	—	6	Shepard
14·774	Soc. Psych. Sem.	——	G(A)	1	Elective	3	—	6	Bauer
14·775‡	Anal. of Behavior Sem.	——	G(A)	1	Elective	3	—	6	Licklider

‡ Not offered 1956–57.

★Time specially arranged.

Economics and Social Science Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
14·776‡	Anal. of Behavior Sem.	14·775	G(A)	2	Elective	3	—	6	Licklider
14·784‡	Psychological Theory Sem.	—	G(A)	2	Elective	3	—	6	—
14·79	Psych. of Learn. & Motiv.	14·70, 14·77	4	2	Elective	?	—	5	Jenkins
14·791	Read. Sem. in Social Science	—	G(A)	1	Elective		★		—
14·792	Read. Sem. in Social Science	—	G(A)	2	Elective		★		—
14·81	Personality & Social Structure	—	4	2	Elective	3	—	5	Bauer
14·90	Govt., Politics & Tech.	H12	2	2	XIV-A(b), XIV-B(b), XXI-A(a), XXI-B(a)	3	—	5	Bauer
			3	1,2	Elective				
14·91	Amer. Polit. System	H22	3	1,2	Elective	3	—	5	Olton
14·92	Comp. Polit. & Econ. Systems	H22	3	2	Elective	3	—	5	L. W. Martin
14·93	Sem; Issues in Contemp. Amer. Pol.	14·91 or 14·92	4	1,2	Elective	3	—	5	Olton
14·941‡	Govt. & Public Admin.	—	G	1	Elective	3	—	6	—
14·95	Politics, Soc. & Policy Making	14·01 or 14·51 or 14·91 or H31 or H32	3	1	XXI-A(a), XXI-B(a)	3	—	5	Pool
			4	1	Elective				
14·951‡	Behav. Factors in Internat. Pol.	14·95 or H82	G(A)	2	Elective	3	—	6	Pool
14·953	Mass Media & Com. Syst.	—	G	1	Elective	3	—	6	Lerner
14·954	Methods of Com. Research	14·953	G(A)	2	Elective	3	—	6	Lerner
14·956	Public Opinion & Prop.	14·77	G	2	Elective	3	—	6	Pool
14·957	Res. Sem. in Internat. Com.	—	G(A)	1,2	Elective	3	—	6	Pool
14·96	Influences on Pol. Decis.	14·95	4	2	Elective	3	—	5	Bauer
14·97‡	Political Science Seminar	14·53 or 14·93 or 14·96 or H81	4	1,2	Elective	3	—	5	Padelford

INDUSTRIAL MANAGEMENT AND BUSINESS AND ENGINEERING ADMINISTRATION — 15·00–15·99

GRADUATE SUBJECTS IN INDUSTRIAL MANAGEMENT
UNDERGRADUATE SUBJECTS IN BUSINESS AND ENGINEERING ADMINISTRATION

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
15·01	Indust. Manage. I	14·01	2	2	XV-A, XV-B	3	—	6	Alexander
15·02	Indust. Manage. II	M221	3	1	XV-A, XV-B	3	—	6	Whitin
15·11	Indust. Manage., Int.	14·01	4	1,2	Elective	3	—	6	Moore
			G	2	XIII-A				
15·17	Hist. Stud. in Innovation	15·201	G(A)	2	Elective	3	—	6	Morison
15·18	Accounting & Production	—	G	S	—	5	—	10	Gordon, Goetz
15·183	Struct. of Amer. Law & Indust. Change	15·18	G(A)	1	Elective	3	—	6	Krebs, Morison
15·185	Management Prob.	15·18	G(A)	1	Elective	3	—	6	Tallman, Goetz
15·201	Prob. in Amer. Pol. Econ.	—	G	1	—	3	—	6	Morison
15·30	Personnel Administration	*14·01*	3	2	XV-A, XV-B	3	—	6	Pigors
15·312	Labor Management Relations	—	G	2	—	3	—	6	D. V. Brown
15·352	Meas. of Hum. Behavior	14·381	G(A)	2	Elective	3	—	6	Torgerson
15·371	Social Psychology	—	G	1	—	3	—	6	McGregor
15·372	Lab. in Indust. Behavior	14·762	G(A)	2	—	3	—	6	McGregor
15·41	Finance	15·50	3	2	XV-A, XV-B	3	—	6	Kuh
			4	1	Elective				
15·412	Finance	15·501	G	2	—	3	—	6	Kuh
15·42	Investments	15·41	4	1	Elective	3	—	6	W. Beranek
15·46	Fin. Adm. of Industry	15·412	G(A)	1	Elective	3	—	6	E. Shapiro
15·50	Accounting	14·01	3	1	XV-A, XV-B	3	2	4	T. M. Hill
			3	2	Elective				
15·501	Accounting	*15·511*	G	1	—	3	—	6	T. M. Hill
15·502	Industrial Accounting	15·501	G	2	—	2	—	4	Shillinglaw
15·51	Indust. Accounting	15·50 or 15·52	4	2	Elective	3	2	4	Gregory
15·511	Econ. of the Firm	*15·501*	G	1	—	3	—	6	Alexander
15·52	Bus. & Nat. Income Accounting	14·01	3	2	XIV-A(a), XIV-B(a)	3	—	5	Gordon
15·531	Prob. in Account. Control	15·502, 15·511	G(A)	1	Elective	3	—	6	Gordon
15·542	Manage. Inform. Systems	15·501 or 15·52	G(A)	2	Elective	3	—	6	Gregory
15·591	Quant. Anal. of Indust. Prob.	14·381	G(A)	1	Elective	3	—	6	Whitin
15·61	Business Law	*14·01*	4	1,2	Elective	3	—	6	Macmillan
15·65	Labor Law	15·61	4	2	Elective	3	—	6	Jacks
15·66	Fund. Legal Principles	15·312, 15·412 15·712, 15·812	G(A)	2	Elective	3	—	6	Krebs

‡ Not offered 1956–57.

★ Time specially arranged.

Industrial Management and Business and Engineering Administration Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
15·71	Production Manage.	15·02	3	2	XV-A, XV-B	3	—	6	Fetter
			4	2	II(7), II-B(7)				
15·712	Production Manage.	14·381, 15·511	G	2	—	3	—	6	Bowman
15·72T	Indust. Standardization	14·01	4	1	Elective	3	—	6	Moore
15·73	Management Lab.	14·01	4	1,2	Elective	3	3	3	Goodwin
15·74	Management Lab., Adv.	15·73	4	2	Elective	3	3	3	Goodwin
15·741	Management Lab., Adv.	15·712	G(A)	1	Elective	3	3	3	Goodwin
15·75	Manufact. Analysis	15·71	4	1	Elective	3	—	6	W. V. Clark
15·751	Manufact. Analysis	15·712	G(A)	1	Elective	3	—	6	Goetz
15·781	Manufact. Control Sem.	15·712	G(A)	1	Elective	3	—	6	Fetter
15·792‡	Manufact. Policy Sem.	15·712	G(A)	2	Elective		★		—
15·81	Marketing	15·01	3	1	XV-A, XV-B	3	—	6	Jack
			3	2	Elective				
15·812	Marketing	—	G	2	—	3	—	6	Jack
15·82	Sales Promotion: Strategy & Methods	15·81	4	1	Elective	3	—	6	P. S. King, Enos
15·821	Marketing Policy & Admin.	15·812	G(A)	1	Elective	3	—	6	P. S. King
15·83	Marketing Research	15·82	4	2	Elective	3	—	6	Cunningham, Enos
15·86	Prod. Planning & Develop.	15·812	G(A)	2	Elective	3	—	6	Tallman
15·90	Organization	15·30, 15·41, 15·71, 15·81	4	1	Elective	3	—	6	Rubenstein
15·91T	Admin. Policy	15·90	4	2	Elective	3	—	6	Hudgins
15·92T	Organization	15·312, 15·412, 15·712, 15·812	G(A)	1	Elective	3	—	6	Rubenstein
15·93T	Admin. Policy	15·92T	G(A)	2	Elective	3	—	6	Hudgins
15·942	Admin. Policy Seminar	15·18 or 15·92T	G(A)	1,2	Elective	3	—	6	Hudgins
15·951	Spec. Stud. in Management	—	G(A)	1	Elective		★		T. M. Hill
15·952	Spec. Stud. in Management	—	G(A)	2	Elective		★		T. M. Hill
15·96	Adm. Th. & Practice	15·312, 15·412, 15·712, 15·812	G(A)	1	Elective	3	—	6	Schell
15·971	Seminar in Res. Mgt.	—	G	1	Elective	4	—	5	Shepard, Rubenstein
15·972	Mgt. of Res. & Develop.	—	G	2	Elective	3	—	6	Rubenstein
15·98	Seminar in Admin.	15·18	G(A)	1	—	3	—	6	Johnson
15·99	Seminar in Admin.	15·18	G(A)	2	—	3	—	6	Johnson

AERONAUTICAL ENGINEERING — 16·00–16·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
16·00	Aeromechanics	2·001, *M22*	2	2	XVI	3	1	5	Halfman
16·01	Aeromechanics	16·00	3	S	XVI-B	4	1	5	Halfman
			3	1	XVI				
16·02	Aerodynamics	2·40, 16·01	3	2	XVI, XVI-B	4	2	6	Ashley
16·03T	Aerodynamics, Prin.	16·02	G	1 or 2	Elective	4	—	5	Ashley, Bicknell, Trilling
16·04	Aerodyn.—Viscous Fluids	16·02	G(A)	2	Elective	3	—	6	Bicknell
16·051	Aerodyn. of Compress. Fluids I	16·02, *M351*	G(A)	1	Elective	3	—	9	Trilling
16·052	Aerodyn. of Compress. Fluids II	16·051	G(A)	2	Elective	3	—	9	Trilling
16·061‡	Steady & Unst. Potent. Flows	16·03T	G(A)	1	Elective	3	—	9	Ashley, Trilling
16·062‡	Steady & Unst. Potent. Flows	16·03T	G(A)	2	Elective	3	—	9	Ashley, Trilling
16·063	Viscous Flows	16·03T	G(A)	2	Elective	3	—	9	Finston, Trilling
16·064	Thermal Effects	16·03T	G(A)	1	Elective	3	—	9	Finston
16·065‡	Waves, Shocks, & Combustion	16·051	G(A)	2	Elective	3	—	9	Stever
16·066‡	Hypersonics & Superaerodyn.	16·051	G(A)	1	Elective	3	—	9	Stever, Trilling
16·10	Applied Aerodynamics	*16·01*, 16·82	3	1	XVI	4	—	8	Ober
			3	2	XVI-B				
16·105	Applied Aerodynamics	16·02, 16·10	G(A)	1 or 2	Elective	3	—	6	Ober
16·13	Airpl. Stab. & Control	16·01, 16·10	3	2	XVI	3	—	6	Bicknell
			4	S	XVI-B				
16·15	Stab. & Cont. of Aircraft, Adv.	16·13	G(A)	1	Elective	3	—	6	Larrabee

‡ Not offered 1956–57.

★ Time specially arranged.

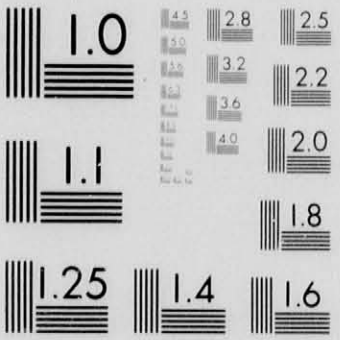
Aeronautical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
16·18	Guided Missiles	16·051 or 16·105; 16·13	G(A)	1	Elective	3	—	6	Stever
16·20	Aircraft Structures	2·04	3	1	XVI(a)	4	—	6	Sandorff
			3	2	XVI(b), XVI-B				Bisplinghoff
16·21	Aircraft Structures	16·20	3	2	XVI(a)	4	—	6	Mar
			4	2	XVI-B(a)				
16·22	Aircraft Struct. Theory	16·21	G(A)	1	Elective	3	—	6	Bisplinghoff
16·23	Aircraft Struct. Des.	16·20	4	2	Elective	3	—	5	Sandorff
16·25	Aircraft Struct., Adv.	16·21	G(A)	2	Elective	3	—	6	Pian
16·30	Automatic Control, Prin.	16·01	4	1	XVI, XVI-B	3	—	9	McKay
16·302	Aeronautical Systems	16·30	4	2	Elective	3	—	6	Hoffman
16·31	Inst. & Control, Prin.	2·003 or 2·07 or 6·02 or 16·02	G(A)	1	Elective	4	—	8	Lees
16·32	Inst. & Control, Prin.	16·31	G(A)	2	Elective	4	—	8	Lees
16·33	Inst. & Control Lab.	*16·31*	G(A)	1	Elective	2	2	6	Li
16·35	Spec. Prob. in Inst. & Cont.	16·32	G(A)	1 or 2	Elective		★		McKay
16·36	Dynamic Measurements	2·003 or 2·07 or 8·13 or 13·73 or 16·31	G(A)	2	Elective	2	3	6	Li
16·37	Random Proc. in Auto. Cont.	16·32 or 16·42	G(A)	2	Elective	3	—	9	Battin
16·38	Control Systems Components	16·31 or 16·41	G(A)	2	Elective	3	—	6	R. K. Mueller
16·39	Vector Kin. & Gyr. Inst. Th.	*16·31* or *16·41*	G(A)	1	Elective	3	—	6	McKay
16·40	Auto. Control Equip. for Aircraft	16·13, 16·31, 16·39	G(A)	2	Elective	3	—	6	Whitaker
16·41	Fire Control Prin.	—	G(RA)	1	—	4	—	8	Lees
16·42	Fire Control Systems	16·39, 16·41	G(RA)	2	—	4	—	8	Wrigley
16·43	Fire Cont. Instr. Lab.	*16·41*	G(RA)	1	—	1	3	5	R. K. Mueller
16·44	Fire Cont. Instr. Lab., Adv.	*16·42*	G(RA)	2	—	1	3	5	R. K. Mueller
16·45	Fire Control Systems, Adv.	16·42	G(RA)	1	—	4	—	8	Wrigley
16·46	Fire Control Systems, Adv.	16·45	G(RA)	2	—	3	—	6	Wrigley
16·472	Rockets, Guided Missiles & Projectiles	16·13	G(RA)	1	—	3	—	6	Stever, Trilling
16·48	Struct. Prob. in Weapons	2·04, 16·41	G(RA)	2	—	3	—	9	Mar
16·49	Spec. Prob. in Fire Control	16·42	G(RA)	1 or 2	—		★		Wrigley
16·50	Rotating Wing Aircraft	16·10	G(A)	1	Elective	3	—	6	Miller
16·51	Rotating Wing Aircraft, Adv.	16·50	G(A)	2	Elective	3	—	6	Miller
16·53	Aircraft Propulsion	2·40; 2·25 or 16·02	4	1	XVI, XVI-B	3	—	6	E. S. Taylor
16·56	Jet Propulsion Engines	2·213 or 2·47 or 16·53	G(A)	2	Elective	3	—	9	E. S. Taylor
16·60	Aero. Prob., Adv.	16·13 or 16·20	G(A)	1 or 2	Elective		★		Staff
16·61	Aeronautics Seminar	—	G(A)	1 or 2	—	2	—	2	—
16·63	Aerodynamic Lab.	16·65	4	2	Elective	2	2	5	Ober
16·65	Aeronautical Eng. Lab.	16·13, 16·20, *16·30*	4	1	XVI, XVI-B	3	3	6	Ober
16·70	Aircraft Detail Des.	D12	2	1	XVI	3	6	0	Bentley
16·71	Aeronautical Eng.	16·13, 16·20, 16·70	4	1	XVI, XVI-B	0	10	0	Koppen
16·72	Aeronautical Eng.	16·30, 16·71	4	2	XVI, XVI-B	0	9	3	Koppen
16·74	Airplane Design, Adv.	16·105, 16·13, 16·72	G(A)	1	Elective	2	6	4	Miller
16·76	Orbital Vehicles	M22	4	2	Elective	3	—	6	Sandorff
16·81	Aeronautics, General	M21	4	1 or 2	Elective	3	—	6	Markham
16·82	Aeronautical Eng., Int.	*M21*	2	1	XVI	3	—	1	Markham
16·851	Industrial Practice	—	3	S	XVI-B		40 h.p.w.		Markham
16·852	Industrial Practice	—	3	1	XVI-B		40 h.p.w.		Markham
16·91	Aeroelasticity	16·02	G(A)	1	Elective	3	—	6	Mollö-Christensen
16·92	Aeroelasticity, Adv.	16·91	G(A)	2	Elective	3	—	9	Ashley
16·93	Aeroelasticity Lab.	*16·91*	G(A)	1	Elective	2	2	2	Halfman
16·94	Dyn. of Aircraft Struct.	16·21, 16·91	G(A)	2	Elective	3	—	9	Pian

BUILDING ENGINEERING AND CONSTRUCTION — 17·00–17·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
17·40	Job Management	17·31T	4	2	XVII (56–57)	2	—	4	Gumpertz
17·401	Job Management, Adv.	17·40	G(A)	1	Elective	3	—	6	Gumpertz
17·402	Construction Mgt. Seminar	—	G(A)	2	Elective	3	—	6	Voss, Gumpertz
17·41	Building Management	17·31T, 17·40	G(A)	1	Elective	3	—	6	Gumpertz
17·43	Building Construction	1·91	4	1	Elective	2	3	4	Heger

★ Time specially arranged.



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Building Engineering and Construction Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
17·44	Specifications	1·43, 1·921	G(A)	2	Elective	3	—	6	Gumpertz
17·45	Construction Problems	17·31T	4	1 or 2	Elective		★		Dietz
17·53T	Wood Des. & Graph. Anal.	1·44	4	1	XVII (56–57)	4	1	6	Heger
17·531	Reinf. Concrete Des., Adv.	1·42, 17·54T	G(A)	1	Elective	3	—	6	H. Simpson
17·532	Reinf. Concrete Des., Adv.	17·54T	G(A)	2	Elective	3	—	6	H. Simpson
17·54T	Concrete Design	17·53T	4	2	XVII (56–57)	3	1	5	Heger
17·542	Structural Steel Des., Adv.	1·42, 1·44	G(A)	2	Elective	3	—	6	H. Simpson
17·73	Mat.—Wood, Plastics, Fabrics	8·02	3	2	IV-A	3	—	3	Dietz
17·74	Materials—Masonry & Metals	8·03	4	2	IV-A	3	2	4	J. A. Murray, McGarry
17·741	Eng. Prop. of Plastics	2·002	4	1	Elective	2	—	4	Dietz
17·742	Eng. Laminates	2·002	G(A)	2	Elective	3	—	6	Dietz, McGarry
17·76	Res. in Organic Struct. Mat.	17·742	G(A)	1 or 2	Elective		★		Dietz
17·771	Cementitious Materials	17·72 or 17·75	4	1	Elective	2	—	4	J. A. Murray
17·772	Concrete	17·771	G(A)	2	Elective	3	—	6	J. A. Murray
17·78	Res. in Cementitious Mat.	17·772	G(A)	1 or 2	Elective		★		J. A. Murray

METEOROLOGY — 19·00–19·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
19·00	General Meteorology	8·02, M12	2	1	XIX (56–57)	3	3	3	Keily
19·001	General Meteorology	8·02, M12	2	1	Elective	3	—	3	Keily
19·003	Meteorology I, Elem.	——	1	1, 2	Elective	3	—	3	Wurtele
19·01	Descriptive Meteorol. I	——	3	1	XIX (56–57)	3	—	6	Willett
19·02	Descriptive Meteorol. II	19·01	3	2	XIX (56–57)	3	—	6	Willett
19·14	Long Range Weather Fore.	19·44	G(A)	1	Elective	3	8	6	Willett
19·21	Meteorological Observations	*19·00*	3	1	XIX (56–57)	1	3	2	Keily
19·22	Meteorological Inst.	19·02	G(A)	2	Elective	2	4	6	Keily
19·23	Micrometeorological Inst.	19·21	G(A)	1	Elective	2	2	4	Keily
19·30	General Climatology	——	3	2	XIX (56–57)	2	—	4	J. M. Austin
19·32	Microclimatology	8·02, M12	G	1	Elective	2	—	4	J. M. Austin
19·33	Applied Climatology	19·30	G(A)	2	Elective	3	—	6	J. M. Austin
19·44	Synoptic Meteorol. I	19·51, 19·601	4	2	XIX (56–57)	3	—	6	J. M. Austin
19·45	Synoptic Meteorol. II	19·44	G(A)	1	Elective	3	—	6	J. M. Austin
19·46	Numerical Weather Predic.	M351	G(A)	2	Elective	3	—	6	Wurtele
19·50	Meteorol. Lab., Int.	19·00	2	2	XIX (56–57)	0	3	0	Sanders
19·51	Synoptic Lab. I	19·02	4	1	XIX (56–57)	0	15	0	Sanders
19·52	Synoptic Lab. II	19·51	4	2	Elective	0	15	0	Sanders
19·53	Synoptic Lab. III	19·44, 19·51	G(A)	2	Elective	0	15	0	J. M. Austin
19·601	Theor. Meteorol., Int.	8·02, M12	4	1	XIX (56–57)	3	—	6	Wurtele
19·62	Dynamic Meteorol. I	19·601	4	2	XIX (56–57)	3	—	6	Lorenz
19·64	Dynamic Meteorol. II	19·62	G(A)	1	Elective	3	—	9	Starr
19·65	Dynamic Meteorol. III	19·601	G(A)	2	Elective	3	—	6	Lettau
19·70	Phys. of Atmos., Elem.	8·03, M12	3	1	XIX (56–57)	2	—	4	Houghton
19·71	Radar Meteorology	8·03, 19·02	G(A)	1	Elective	2	1	4	P. M. Austin
19·72	Physical Meteorology	8·04, M21	G(A)	2	Elective	3	—	6	Houghton
19·83	Oceanography	8·02, M21	4	1	XIX (56–57)	2	—	4	Houghton
19·91	Meteorol. Seminar I	19·44, 19·62	G(A)	1	Elective	2	—	4	Houghton
19·911	Meteorol. Seminar I	19·44, 19·62	G(A)	1	Elective	1	—	2	Houghton
19·912	Meteorol. Seminar II	19·911	G(A)	2	Elective	1	—	2	Houghton
19·94	Spec. Prob. in Meteorol.	19·02	G	1 or 2	Elective		★		Staff
19·95	Spec. Prob. in Meteorol.	19·44, 19·62	G(A)	1 or 2	Elective		★		Staff

FOOD TECHNOLOGY — 20·00–20·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
20·00	Man's Food	——	1	1	Elective	3	—	3	Staff
20·001	Food Production	——	2	1	XX	3	3	4	Staff
20·01	Chem. & Tech. Food Supplies I	5·41	3	1	XX	3	4	3	Sherman
20·02	Chem. & Tech. Food Supplies II	20·01	3	2	XX	3	4	3	Sherman

★Time specially arranged.

Food Technology Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
20·11	Tech. of Food Products	20·02	4	1	XX, XX-A	2	4	4	Nickerson
20·12	Tech. of Food Products	20·11	4	2	XX, XX-A	2	4	4	Nickerson
20·13	Chem. Eng. Food App.	5·61	4	1	XX, XX-A, XX-B	4	—	6	Charm
20·14T	Chem. Eng. Food App.	20·13	4	2	XX, XX-A, XX-B	4	2	4	Charm
20·21	Flavor Evaluation	20·12, 20·32	G(A)	1	Elective	2	2	4	B. E. Proctor
20·22	Food Acceptance	20·12, 20·32	G(A)	2	Elective	2	2	4	B. E. Proctor
20·32	Chemistry of Nutrition	5·41, 7·05	4	1	XX, XX-A, XX-B	2	2	2	R. S. Harris
20·322	Chem. of Nutrition Lab.	5·41, 7·05	4	2	XX-A	1	4	0	R.S.Harris, Sherman
20·34	Applied Nutrition	20·32	G(A)	2	Elective	2	2	4	R. S. Harris
20·36	Nutrition, Adv.	20·32	G(A)	2	Elective	3	3	2	R.S.Harris, Sherman
20·38	Nutr. Eval. of Food Proc.	20·12, 20·32	G(A)	1 or 2	Elective	3	—	3	R. S. Harris
20·41	Bacteriology	7·01	2	2	XX	3	4	3	Dunn
20·42	Industrial Microbiology	20·41	3	1	XX, XX-B	2	4	4	Dunn
20·43	Ind. Microbiol., Adv.	20·42	G(A)	1	Elective	2	4	4	Dunn
20·44	Ind. Microbiol., Adv.	20·43	G(A)	2	Elective	2	4	4	Dunn
20·46	Bacteriology of Foods	7·05, 20·42	G(A)	2	Elective	2	4	2	Nickerson
20·47	Biochemical Eng.	20·42	4	1	XX-B	2	6	2	Dunn
20·48	Biochemical Eng.	20·47	4	2	XX-B	2	6	2	Dunn
20·51	Food Technology, Adv.	20·12	G(A)	1	XX-A	2	6	4	B. E. Proctor
20·52	Food Technology, Adv.	20·51	G(A)	2	XX-A	2	4	4	B. E. Proctor
20·53	Food App. of Ionizing Rad.	8·04, 20·12	G(A)	1	Elective	2	—	4	B. E. Proctor, Goldblith
20·531	Food App. of Ionizing Rad. Lab.	20·53	G(A)	2	Elective	1	3	2	Goldblith
20·55	Technology of Lipids	20·12, 20·32	G(A)	1	Elective	2	—	4	Sherman
20·61	Food Technology Sem.	20·12	G(A)	1	XX-A	2	—	2	B. E. Proctor
20·62	Food Technology Sem.	20·61	G(A)	2	XX-A	2	—	2	B. E. Proctor
20·71	Research Problems	—	G(A)	1	Elective		★		Staff
20·72	Research Problems	—	G(A)	2	Elective		★		Staff
20·83	Selected Topics in Food Technology	—	G(A)	1	Elective		★		Staff
20·84	Selected Topics in Food Technology	—	G(A)	2	Elective		★		Staff
20·91	Food Industry Seminar	—	G(A)	1	Elective	2	—	2	B. E. Proctor
20·92	Food Industry Seminar	—	G(A)	2	Elective	2	—	2	B. E. Proctor

AIR SCIENCE — AS1–AS99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
AS11	Air Science	—	1	1	All courses	2	1	0	Wheeler
AS12	Air Science	AS11§	1	2	All courses	2	1	0	Wheeler
AS21	Air Science	AS12§	2	1	All courses	2	1	0	Vanderpoel
AS22	Air Science	AS21§	2	2	All courses	2	1	0	Vanderpoel
AS31	Air Science, Adv.	AS11, AS12, AS21, AS22	3	1	All courses	2	1	1	Dederich
AS32	Air Science, Adv.	AS31§	3	2	All courses	2	1	1	Dederich
AS41	Air Science, Adv.	AS32§	4	1	All courses	2	1	1	York
AS42	Air Science, Adv.	AS41§	4	2	All courses	2	1	1	York

GRAPHICS — D1–D99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
D11	Engineering Drawing	—	1	1	IV-A	0	4	2	—
			1	1,2	Elective, except IV-A				
D111	Graphics Lab. I	—	1	1	Elective	0	3	2	Preusser
D12	Descriptive Geometry	—	1	1 or 2	XIII, XVI	0	4	2	—
			1	2	IV-A				
			1	1,2	Elective, except IV-A, XIII, XVI				
D121	Graphics Lab. II	—	1	2	Elective	0	3	2	Preusser
D13	Graphical Processes	—	1	1,2	Elective	2	—	4	Twigg
D14	Nomography, Elem.	—	1	2	Elective	2	—	4	D. P. Adams
D31	Nomography	M12	2,3,4	1,2	Elective	2	—	4	D. P. Adams
D32	Graphics, Adv.	D12, M12	2,3,4	1,2	Elective	2	—	4	Coons

★ Time specially arranged.
§ Sequence of subjects within first 2 years and within Advance Course may be waived for academic reasons in individual cases by Professor of Air Science.

ENGLISH — E1–E99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
E11	English Composition	—	1	1, 2	Elective	2	—	4	Urbach
E25	English Composition	—	3, 4	1 or 2	Elective		★		Rathbone
E27‡	Creative Writing	H22	3, 4	1	Elective	3	—	5	Koerner
E28‡	Creative Writing	H22	3, 4	2	Elective	3	—	5	Koerner
E31	Literature, Int.	H22	2	1	XXI-A(b), XXI-B(b)	3	—	5	W. C. Greene
			3, 4	1 or 2	Elective				
E32	Literary Theory	E31	2	2	XXI-A(b), XXI-B(b)	3	—	5	W. C. Greene
E35	Reports	—	3	1	Elective	1	—	4	Rathbone
E36	Seminar in Tech. Writing	—	3, 4	1 or 2	Elective	2	—	4	Rathbone
E37	Public Speaking	—	1	1	Elective	3	—	3	Krasnow
E38	Public Speaking	E37	1	2	Elective	3	—	3	Krasnow
E40‡	Epic Tradition in Lit.	E31	3, 4	2	Elective	3	—	5	Reiche
E42	Non-Western Lit.	E31	3, 4	2	Elective	3	—	5	W. C. Greene
E43	Eng. Drama before Ibsen	E31	3, 4	1	Elective	3	—	5	Everingham
E44	Nature of Poetry	E31	3, 4	2	Elective	3	—	5	Wood
E45	Shakespeare	E31	3, 4	1	Elective	3	—	5	C. Collins
E46	Mod. Drama since Ibsen	E31	3, 4	2	Elective	3	—	5	Everingham
E47	Nineteenth Century Amer. Lit.	E31	3, 4	1	Elective	3	—	5	C. Collins
E48	Twentieth Century Amer. Lit.	E31	3, 4	2	Elective	3	—	5	C. Collins
E49	Russia & West in Mod. Russ. Lit.	E31	3, 4	1	Elective	3	—	5	MacMaster
E50	The Bible	E31	3, 4	2	Elective	3	—	5	Reiche
E51	Modern Novel	E31	3, 4	1	Elective	3	—	5	C. Collins
E52	Comic Sensibility	E31	3, 4	2	Elective	3	—	5	Holland
E57	Special Readings	E31	4, G	1	Elective	3	—	5	Staff
E58	Special Readings	E31	4, G	2	Elective	3	—	5	Staff

HISTORY — H1–H99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
H1	Phil. & Sci. Methodology	—	1	1,2	Elective	2	—	4	Stahlman
H2	Amer. Character & Inst.	—	1	2	Elective	2	—	4	Gleicher
H11	Western Civ., Found.	—	1	1	All courses	3	—	5	Hartley
H12	Western Civ., Found.	H11	1	2	All courses	3	—	5	Hartley
H21	Humanities								
	The United States: Men & Issues	H12	2	1	All courses	3	—	5	Chandler
	Mod. Western Ideas & Val.	H12	2	1	All courses	3	—	5	I. H. Bartlett
H22	Humanities								
	The United States: Men & Issues	H21	2	2	All courses	3	—	5	Chandler
	Mod. Western Ideas & Val.	H21	2	2	All courses	3	—	5	I. H. Bartlett
H31	Amer. Soc. & Intel. Hist.	H22	3, 4	1	Elective	3	—	5	Bryant
H32	Pol. Process in Ind. Amer.	H22	3	2	XXI-A(a), XXI-B(a)	3	—	5	Blum
H34	Relig. Thought & Amer. Soc.	H22	3, 4	2	Elective	3	—	5	I. H. Bartlett
H35	Europe: Expansion of Eur.	H22	3, 4	1	Elective	3	—	5	Mahoney
H36	Mod. Europe: War, Soc. & State	H22	3, 4	2	Elective	3	—	5	Lockwood
H38	Russian Rev. & Soviet Union	H22	3, 4	2	Elective	3	—	5	MacMaster
H51	Amer. Econ. Develop.	H22	3	1	XXI-A(a), XXI-B(a)	3	—	5	Chandler
			3, 4	1	Elective				
H52T	Bus. Lead. in Amer. Econ.	H22	3	2	XXI-A(a), XXI-B(a)	3	—	5	Chandler
H55	History of Engineering	H22	3, 4	1	Elective	3	—	5	Woodbury
H56	History of Engineering	H22	3, 4	2	Elective	3	—	5	Woodbury
H58	Art & Idust. Civil.	H22	3, 4	2	Elective	3	—	5	Bush-Brown
H63	Amer. For. Policy in Action	H22	4, G	1	Elective	3	—	5	Lichterman
H65	Prob. in Econ. Develop.	H52T	4, G	1	Elective	3	—	5	W. W. Rostow
H71	Basic Ideas of W. Pol. & Eth., 500 B.C.–1500 A.D.	H22	3, 4	1	Elective	3	—	5	K. W. Deutsch
H72	Rise of Mod. Pol. & Soc. Science, 1500–1914	H35 or H36 or H71	3, 4	2	Elective	3	—	5	K. W. Deutsch
H73	Sci. & Phil., Gr. — Copernicus	H22	3	1	XXI-A(b), XXI-B(b)	3	—	5	de Santillana
			4	1	IX-C				
			3, 4	1	Elective				

‡ Not offered 1956–57.

★ Time specially arranged.

History Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
H74	Sci. & Phil., Galileo — Present	H71 or H73	3	2	XXI-A(b), XXI-B(b)	3	—	5	de Santillana
			4	2	IX-C				
			3,4	2	Elective				
H75T	Phil. Prob. & Systems	H22	3	1	XXI-A(b), XXI-B(b)	3	—	5	Reiche
			3,4	1	Elective				
H76T	Phil. Prob. & Systems	H22	3	2	XXI-A(b), XXI-B(b)	3	—	5	Meyerhoff
			3,4	2	Elective				
H77‡	Classical Philosophy	H22	3,4	1	Elective	3	—	5	Reiche
H81	Contemp. Ideas on Pol. & Econ. Dev.	Any two 14 or H subjects above H22	4,G	1	Elective	3	—	5	K. W. Deutsch
H82‡	Nationalism & National Dev.	Any two 14 or H subjects above H22	4, G	2	Elective	3	—	5	K. W. Deutsch
H83	Phil. of Science	Any two 14 or H subjects above H22	4, G	1	Elective	3	—	5	de Santillana
H84	Topics in Hist. of Science	Any two 14 or H subjects above H22	4, G	2	Elective	3	—	5	de Santillana
H85	History & Historians	Any two H subjects above H22	4	1	Elective	3	—	5	Blum
H91	Spec. Topics in History	Any two 14 or H subjects above H22	4, G	1	Elective	3	—	5	Staff
H92	Spec. Topics in History	Any two 14 or H subjects above H22	4, G	2	Elective	3	—	5	Staff
H93‡	Phil. & Lit. Seminar	—	4	1	XXI-A(b), XXI-B(b)	3	—	6	—
H94‡	Phil. & Lit. Seminar	—	4	2	XXI-A(b), XXI-B(b)	1	—	4	—
H95‡	Am. Indust. Soc. Seminar	—	4	1	XXI-A(a), XXI-B(a)	3	—	6	—
H96‡	Am. Indust. Soc. Seminar	—	4	2	XXI-A(a), XXI-B(a)	1	—	4	—

MODERN LANGUAGES — L1–L99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
L11	German, Elem.	—	1,2,3,4	1	Elective	3	—	5	Halle
L12	German, Elem.	L11	1,2,3,4	2	Elective	3	—	5	Halle
L13	German, Int.	L12, or Elem. Entrance German	2,3,4	1	Elective	3	—	5	Klugman
L14	German, Int.	L13	2,3,4	2	Elective	3	—	5	Klugman
L15	German Lit. 1919–1933	L14 (see page 164)	3,4	1	Elective	3	—	5	
L16	Lit. of Postwar Germany	L14 (see page 164)	3,4	2	Elective	3	—	5	—
L17	Scientific German	—	G.	1	Elective	3	—	6	Klugman
L20‡	Great Books & Authors in Ger. Lit.	L14 (see page 164)	3,4	2	Elective	3	—	5	—
L21	Spoken German	3 yrs. H.S. Ger.	1	1	Elective	3	—	3	Dyck
L22	Spoken German	L21	1	2	Elective	3	—	3	Dyck
L31	English for For. Stud.	—	1	1	Elective	3	—	3	Applegate
L51	French, Elem.	—	1,2,3,4	1	Elective	3	—	5	Greenfield
L52	French, Elem.	L51	1,2,3,4	2	Elective	3	—	5	Greenfield
L53	French, Int.	L52 or Elem. Entrance French	2,3,4	1	Elective	3	—	5	Koch
L54	French, Int.	L53	2,3,4	2	Elective	3	—	5	Koch
L55‡	Contemp. French Lit.	L54 (see page 164)	3,4	1	Elective	3	—	5	
L56	French Lit. of Third Repub.	L54 (see page 164)	3,4	2	Elective	3	—	5	
L57	Scientific French	—	G.	2	Elective	3	—	6	Klugman
L59	Great Books & Authors in Fr. Lit.	L54 (see page 164)	3,4	1	Elective	3	—	5	Bottiglia
L61	Spoken French, Int.	3 yrs. H.S. Fr.	1	1	Elective	3	—	3	Greenfield
L62	Conversational French	3 yrs. H.S. Fr.	1	2	Elective	3	—	3	Greenfield
L75	Language & Society	—	4,G	1	Elective	3	—	5	Chomsky
L78	Linguistic Structure	—	4	2	Elective	3	—	5	Chomsky
L91	Russian, Elem.	—	—	1	Elective	3	—	5	Znamensky
L92	Russian, Elem.	L91	—	2	Elective	3	—	5	Znamensky
L93	Russian, Int.	L92	—	1	Elective	3	—	5	Znamensky
L94	Russian, Int.	L93	—	2	Elective	3	—	5	Znamensky
L97	Scientific Russian	—	G	2	Elective	3	—	6	Znamensky

‡ Not offered 1956–57.

MATHEMATICS — M1–M99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
M100	Elem. Number Theory	—	1	1	Elective	2	—	4	Franklin
M11	Calculus	—	1	1	All courses	3	—	6	Douglass
M12	Calculus	M11	1	2	All courses	3	—	6	Douglass
M21	Calculus	M12	2	1	All courses except IV-A	3	—	6	Zeldin
M22	Diff. Equations	*M21*	2	2	All courses except IV-A XV-A, XV-B, XX	3	—	6	Zeldin
M221	Prob. & Operations Anal.	M21	2	2	XV-A, XV-B, XX	3	—	6	Wadsworth
M32	Statistics, Elementary	M21	2	2	XIX (56–57)	3	—	6	Wadsworth
			3	2	IX-C				
			4	1	II(7), II-B(7)				
M333‡	App. Statistics Seminar	*M341*, *M371*, or *M761*	4	1	Elective	2	—	2	Wadsworth
M334‡	App. Statistics Seminar	M333	4	2	Elective	2	—	2	Wadsworth
M341‡	Modern Statistical Th.	M22; M32	4	1	Elective	3	—	6	Thomas
M342‡	Modern Statistical Th.	M341	4	2	Elective	3	—	6	Wadsworth
M351	Adv. Calculus for Engineers	M22 or M221	G(A)	1	XIII-A	3	—	6	Hildebrand
			3	1	VI, VI-A, VIII, IX-A,				
M352	Adv. Calculus for Engineers	M351	G(A)	2	XIII-A	3	—	6	Hildebrand
			3	1	Elective				
			3	2	VI-A, VIII, IX-A				
M371	Operations Research	M32; M351 or M831	G(A)	1	Elective	3	—	6	Wadsworth
M372‡	Operations Research	M371	G(A)	2	Elective	3	—	6	Wadsworth
M381	Theory of Functions	M352 or M831	G(A)	1	Elective	3	—	9	Ankeny
M382	Theory of Functions	M381	G(A)	2	Elective	3	—	9	Ankeny
M39	Methods of App. Mathematics	M351	G(A)	1,2	Elective	3	—	9	Hildebrand
M411	Numerical Analysis	M351	G(A)	1	Elective	3	2	7	Hildebrand
M412	Numerical Analysis	M411	G(A)	2	Elective	3	2	7	Hildebrand
M421	Theoretical Hydromechanics	M352 or M381	G(A)	1	Elective	3	—	9	Lin
M422	Theoretical Hydromechanics	M421	G(A)	2	Elective	3	—	9	Lin
M441‡	Projective Geometry	M21, *M62*	4	1	Elective	3	—	6	——
M442	Diff. Geometry, Elem.	M22	4	2	XVIII	3	—	6	Franklin
M451	Fourier Series & Integrals	M381 or M831	G(A)	1	Elective	3	—	9	Wiener
M452	Fourier Series & Integrals	M451	G(A)	2	Elective	3	—	9	Wiener
M461‡	Seminar in Math.	M352 or M381 or M832	G(A)	1	Elective		★		Lin
M481	Topology	M62; M381 or M831	G(A)	1	Elective	3	—	9	Hurewicz
M482	Topology	M481	G(A)	2	Elective	3	—	9	Hurewicz
M483	Advanced Topology	M482	G(A)	1	Elective	3	—	9	G. W. Whitehead
M491‡	Geometry of Manifolds	*M381*, *M481*, M833	G(A)	1	Elective	3	—	9	Ambrose
M492‡	Geometry of Manifolds	M491	G(A)	2	Elective	3	—	9	Ambrose
M50	Mech. of Continua, Fund.	M352	4	2	Elective	3	—	6	Lin
M521	Th. of Numbers, Topics	M381	G(A)	1	Elective	3	—	9	Roth
M522	Th. of Numbers, Topics	M521	G(A)	2	Elective	3	—	9	Roth
M54‡	Mathematical Lab.	M22	3	2	Elective	3	—	6	Douglass
M551‡	Funct. of Real Variable	M381 or M831	G(A)	2	Elective	3	—	9	Hurewicz
M552‡	Funct. of Real Variable	M551	G(A)	1	Elective	3	—	9	Levinson
M561	Functions of Complex Var.	M381, M481	G(A)	2	Elective	3	—	9	Baily
M562‡	Functions of Complex Var.	M382	G(A)	2	Elective	3	—	9	W. T. Martin
M571	Diff. Equations	M381; M39 or M62	G(A)	1	Elective	3	—	9	Levinson
M572	Diff. Equations	M571	G(A)	2	Elective	3	—	9	Levinson
M581	Continuous Groups	*M481*, M551	G(A)	1	Elective	3	—	9	Singer
M582	Continuous Groups	M581	G(A)	2	Elective	3	—	9	Singer
M591	Partial Differential Equations	M352 or M381	G(A)	1	Elective	3	—	9	Calderon
M592	Partial Differential Equations	M591	G(A)	2	Elective	3	—	9	Calderon
M61‡	Math. Logic	M381 or M62	G(A)	1	Elective	3	—	9	H. Rogers
M62	Modern Algebra	M22	3	1	XVIII	3	—	6	Iwasawa
			3	2	Elective				
M63	Algebra	M62	G(A)	2	Elective	3	—	9	Reynolds
M631‡	Integral Equations	M22	G(A)	2	Elective	3	—	9	Crout
M633	Abstract Algebra	M62 or M63	G(A)	1	Elective	3	—	9	Reynolds
M634	Topics in Algebra	M63 or M633	G(A)	2	Elective	3	—	9	Iwasawa
M641	Tensor Calculus	M39 or M62	G(A)	2	Elective	3	—	9	L. N. Howard

‡ Not offered 1956–57.

★Time specially arranged.

Mathematics Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec.	Lab. Draw.	Prep.	Instructor in Charge
M651	Functional Anal.	M381; M551 or M832	G(A)	1	Elective	3	—	9	Calderon
M652	Functional Anal.	M651	G(A)	2	Elective	3	—	9	Calderon
M661	Found. of Math., Topics	M62	G(A)	1	Elective	3	—	9	H. Rogers
M671‡	Algebraic Functions	M381, M633	G(A)	1	Elective	3	—	9	Mattuck
M672‡	Algebraic Functions	M671	G(A)	2	Elective	3	—	9	Mattuck
M691‡	Charact. Value Prob.	M351 or M381 or M831	G(A)	1	Elective	3	—	9	Franklin
M692‡	Charact. Value Prob.	M691	G(A)	2	Elective	3	—	9	Franklin
M711‡	Theory of Games	M22	G	2	Elective	3	—	9	Nash
M73	Review of Mathematics	——	G	S	XIII-A	8	—	12	Douglass
M761	Theory of Probability	M351	G(A)	1	Elective	3	—	9	Ulam
M762	Theory of Probability	M761	G(A)	2	Elective	3	—	9	Ulam
M791‡	Th. & App. Elasticity	M351 or M381 or M831	G(A)	1	Elective	3	—	9	Reissner
M792‡	Th. & App. Elasticity	M791	G(A)	2	Elective	3	—	9	Reissner
M831	Analysis	M22, *M62*	3	1	XVIII	3	—	9	Ambrose
			4	1	XVIII (56–57)				
M832	Analysis	M831	3	2	XVIII	3	—	9	Ambrose
			4	2	XVIII (56–57)				
M833‡	Analysis	M831	4	1	Elective	3	—	6	W. T. Martin
M851‡	Potential Theory	M352 or M831	G(A)	1	Elective	3	—	9	——
M90	Math. Reading	——	G(A)	1 or 2	Elective		★		W. T. Martin

MILITARY SCIENCE — MS1–MS99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec.	Lab. Draw.	Prep.	Instructor in Charge
MS11	Military Science	——	1	1	All courses	2	1	0	Robbins
MS12	Military Science	——	1	2	All courses	2	1	0	Robbins
MS21	Military Science	MS11, MS12	2	1	All courses	2	1	0	Robbins
MS22	Military Science	MS21	2	2	All courses	2	1	0	Robbins
MS312	Corps of Engineers, Adv.	MS22	3	1	All courses	3	—	1	W. Rogers
MS313	Signal Corps, Adv.	MS22	3	1	All courses	3	—	1	Bowman
MS314	Ordnance Corps, Adv.	MS22	3	1	All courses	3	—	1	Walters
MS316	Chemical Corps, Adv.	MS22	3	1	All courses	3	—	1	Brinkley
MS318	Quartermaster Corps, Adv.	MS22	3	1	All courses	3	—	1	Keating
MS322	Corps of Engineers, Adv.	MS312	3	2	All courses	3	—	1	W. Rogers
MS323	Signal Corps, Adv.	MS313	3	2	All courses	3	—	1	Bowman
MS324	Ordnance Corps, Adv.	MS314	3	2	All courses	3	—	1	Walters
MS326	Chemical Corps, Adv.	MS316	3	2	All courses	3	—	1	Brinkley
MS328	Quartermaster Corps, Adv.	MS318	3	2	All courses	3	—	1	Keating
MS412	Corps of Engineers, Adv.	MS322	4	1	All courses	3	—	1	W. Rogers
MS413	Signal Corps, Adv.	MS323	4	1	All courses	3	—	1	Bowman
MS414	Ordnance Corps, Adv.	MS324	4	1	All courses	3	—	1	Walters
MS416	Chemical Corps, Adv.	MS326	4	1	All courses	3	—	1	Brinkley
MS418	Quartermaster Corps, Adv.	MS328	4	1	All courses	3	—	1	Keating
MS422	Corps of Engineers, Adv.	MS412	4	2	All courses	3	—	1	W. Rogers
MS423	Signal Corps, Adv.	MS413	4	2	All courses	3	—	1	Bowman
MS424	Ordnance Corps, Adv.	MS414	4	2	All courses	3	—	1	Walters
MS426	Chemical Corps, Adv.	MS416	4	2	All courses	3	—	1	Brinkley
MS428	Quartermaster Corps, Adv.	MS418	4	2	All courses	3	—	1	Keating

MUSIC — Mu1 — Mu99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec.	Lab. Draw.	Prep.	Instructor in Charge
Mu31	Introduction to Music	H22	3,4	1 or 2	Elective	3	—	5	Liepmann, G. Tucker, Levy
Mu32	Western Music from Middle Ages to Present	Mu31	3,4	1 or 2	Elective	3	—	5	Liepmann, G. Tucker, Levy
Mu42	Twentieth Century Music	Mu32	4	2	Elective	3	—	5	G. Tucker
Mu43	The Opera	Mu32	4	1	Elective	3	—	5	G. Tucker
Mu44	Classic String Quartet	Mu32	4	2	Elective	3	—	5	Liepmann
Mu46	Music Criticism, Prin.	Mu32	4	2	Elective	3	—	5	Levy
Mu51	Seminar in Music	Mu32	4	1	Elective	3	—	5	Levy

‡ Not offered 1956–57.

★ Time specially arranged.

NUCLEAR ENGINEERING — N1–N99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec.	Lab.	Draw.	Prep.	Instructor in Charge
N1	Eng. Prac. School at Oak Ridge	——	G(A)	1 or 2	Elective	0	16	0		Vivian
N2	Eng. Prac. School at Oak Ridge	N1	G(A)	1 or 2	Elective	0	16	0		Vivian
N3	Eng. Prac. School at Oak Ridge	N2	G(A)	1 or 2	Elective	0	16	0		Vivian
N10	Nuclear Technology, Int.	8·04, M22	G(A)	1,2	Elective	4	—	8		Benedict, M. Clark
N20	Biol. Effects of Nucl. Rad.	8·051	G(A)	1	Elective	3	—	6		Brownell
N21	Nucl. Reactor Th. I	8·052 or 8·06 or N10; *M352*	G(A)	1	Elective	3	—	9		Benedict
N22	Nucl. Reactor Th. II	N21	G(A)	2	Elective	3	—	9		M. Clark
N23	Nucl. Reactor Eng.	N21	G(A)	2	Elective	3	—	9		Pigford
N31	Nucl. Chemical Eng.	10·32	G(A)	1	Elective	3	—	6		Pigford
N41	Nuclear Eng. Lab. I	*N21*	G(A)	2	Elective	2	6	4		T. J. Thompson
N90	Spec. Prob. in Nuclear Eng.	——	G(A)	1 or 2	Elective		★			Benedict
N91	Seminar in Nuclear Eng.	——	G(A)	1	Elective	1	—	2		Benedict
N92	Seminar in Nuclear Eng.	——	G(A)	2	Elective	1	—	2		Benedict

★Time specially arranged.

APPENDIX A

STUDENT AID AND PRIZES

OPPORTUNITIES for financial aid include: Freshman scholarships open to students entering from secondary schools; undergraduate scholarship aid to upperclassmen; part-time campus jobs; The Technology Loan Fund and other loan funds for undergraduate and graduate students; fellowships and graduate scholarships, and full- and part-time Assistantships to aid students pursuing work leading to the Master's or Doctor's degree; and prizes.

FRESHMAN SCHOLARSHIPS

The objective of the Institute's Student Aid Program is to enable the most deserving, needy young men in the nation to come to the Institute and earn an M. I. T. degree. A wide range of scholarship assistance is available with grants in varying amounts up to and including full tuition and living costs. The Sloan National Scholarship, the General Motors Scholarships, the Lockheed National Engineering Scholarships, the William Barton Rogers Scholarship, the Development Fund Scholarship — all four-year scholarships — are open to all incoming candidates. Other scholarship grants depend, in part, upon a candidate's having some special qualification in addition to presenting evidence of scholastic ability; i.e., that he come from a particular locality, be a graduate of a certain school, etc. Limited to nineteen large metropolitan areas are the Alumni Regional Scholarships with awards for the freshman year. Furthermore, approximately two hundred Freshman Competitive Scholarships with stipends varying from $300 to full tuition are granted annually to applicants who are not selected for a four-year award or an Alumni Regional Scholarship.

Consideration for a freshman award will be limited to students who are entering the Institute directly from secondary schools and who make application to the Director of Student Aid before February 15 in advance of matriculation. Selection for a scholarship award is based in general upon the Student Financial Aid Committee's evaluation of the candidate's total record, which will include College Entrance Examination Board test scores, high school or preparatory school records, evidence of need of financial assistance supplied by Confidential Statements to the College Scholarship Service, and recommendations from former teachers, prominent citizens of his community, or Institute alumni.

In addition to grants for tuition or part-tuition the Student Financial Aid Committee will make selections for on-the-campus part-time jobs to supplement requests for financial assistance.

The figures in parentheses are the dates of establishment of the scholarship or fund.

ALUMNI REGIONAL (1926). As a means of cooperating with alumni in various Technology centers in attracting to the Institute students of exceptional ability and promise from all parts of the United States, several Regional Scholarships, carrying an award based on demonstrated need for the freshman year, are offered in Chicago, Denver, Detroit, District of Columbia, Kansas City, Los Angeles, New York, New Jersey, Northern Ohio, Philadelphia, Pittsburgh, Portland, Ore., Rochester, N. Y., San Francisco, St. Louis, Seattle, Schenectady, Southern Ohio, and Westchester County, New York. These are open to American citizens of good character and health whose standing in their preparatory school studies has been high and who have satisfied with high standing all entrance requirements.

ARMY AND NAVY (1930). Sons of regular Army, Navy, Air Force, Marine Corps, and Coast Guard Officers, who are admitted as undergraduate students to the Institute, will be considered for grants toward their tuition based on their demonstrated need, with a maximum of one-half tuition, upon recommendation of the Student Financial Aid Committee — the total number not to exceed ten each year. Preference will be given to qualified applicants admitted to the first year class. Applications should be addressed to the Director of Student Aid and should be accompanied by documentary evidence that the applicant's father is a commissioned officer in the regular Army, Navy, Air Force, Marine Corps, or Coast Guard. Holders of these scholarships, if recommended by the Committee, may continue their grants during their second and succeeding undergraduate years.

LAWRENCE D. BELL SCHOLARSHIP (1955). Established by the Bell Foundation, Inc., to be awarded to an entering freshman who is a citizen of the United States. Selection will be based on character, need, and scholarship.

BRIDGEPORT (1932). Established by the Institute through a bequest from Horace T. Smith of the Class of 1898, to be known as the Horace T. Smith Scholarship Fund. A scholarship, carrying a stipend of full tuition for the freshman year, is annually offered to a graduate of the High Schools of Bridgeport, Connecticut. Application should be made to the Director of Student Aid.

CABOT FOUNDATION SCHOLARSHIPS (1955). Established by the Cabot Foundation, Inc.; income of this fund to provide scholarships for children (sons and daughters) of employees of Godfrey L. Cabot, Inc., and its subsidiary and associated companies. Candidates are required to have certification of their eligibility for consideration for scholarship grants by first applying to the Personnel Office of Godfrey L. Cabot, Inc., and will be expected to comply with the usual policies governing the award of Institute scholarships.

CAMBRIDGE (1916). A limited number of scholarships are granted to students entering the first year class at the Institute, who are graduates of schools in Cambridge and children of legal residents of that city. These Cambridge Scholarships, which carry a stipend of full tuition, are confined to students who make application furnishing evidence of need. An award may be continued in the second, third, and fourth years upon annual reapplication, providing the holder maintains a satisfactory scholastic record and continues to furnish evidence of need. Awards will be by competition, based upon C. E. E. B. scores and general admission record.

CINCINNATI MILLING MACHINE SCHOLARSHIP (1952). Established by the Cincinnati Milling Machine Company as a four-year undergraduate scholarship in engineering at the Institute, carrying a maximum grant of $1,400 annually. Open to a secondary school graduate who plans to study in the field of engineering, preferably mechanical. Selection will be made by the Student Financial Aid Committee, with first preference being given to a resident of the Middle West (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin). For favorable consideration, the applicant will be expected (1) to meet all the academic requirements for admission to M. I. T. with better than average standing; (2) to give suitable evidence of his need for financial aid; and (3) to have demonstrated high qualities of character and have shown potentialities for future leadership. During the undergraduate period, the recipient of this scholarship will be given employment at the Company's plant during the normal summer vacation periods at the close of the sophomore and junior years.

CLASS OF 1895 SCHOLARSHIP MEMORIAL FUND (1945). Gift of the Class of 1895 on its Fiftieth Anniversary "the income annually to be used to provide scholarships for suitably qualified descendants of members of the Class of 1895. If in any year the total income is not required for this purpose, the balance shall be added to the Technology Loan Fund."

CLASS OF '22 FUND (1942). Established at the twentieth reunion of the Class of 1922, the "income and principal . . . to be used to assist students entering the Institute as freshmen from secondary schools, with preference being given to sons (or daughters) of members of the Class." Beneficiaries "are expected to issue notes agreeing to repay the face value, without interest, of amounts received."

CLASS OF 1938 SCHOLARSHIP FUND (1938). Gifts from the Class of 1938, "the income for scholarships."

WILLIAM A. CONANT (1943). Bequest of $150,000 "for the purpose of establishing a permanent fund to be known as the W. A. Conant Scholarship Fund, the income therefrom to be used for the education of native born American Protestant boys of New England of American Protestant parents, who are graduates of some high or preparatory school, public or private in New England, preference to be given to the graduates of the public schools of Brookline, Massachusetts, but without limitation thereto, and whose parents are financially unable to send them to the Institute and whose own means are insufficient to allow them to attend the Institute." One scholarship, carrying a grant of full tuition for each of the four undergraduate years, is annually offered to an entering freshman. Application should be made to the Director of Student Aid.

THOMAS C. DESMOND SCHOLARSHIP (1952). Established by the gift of Thomas C. Desmond '09. A $1,200 scholarship for the freshman year available to a student who plans to study civil engineering.

DEVELOPMENT FUND SCHOLARSHIPS (1950). Scholarships provided by gifts to the M. I. T. Development Fund with four-year grants to students who maintain academic ranking in the top quarter of the class and demonstrate continued need for financial assistance. A number of these awards will be for full tuition, others for three-quarters tuition, and some for half tuition. They are open to all candidates from secondary schools. For consideration for an award the College Entrance Examination Board tests will be required. Application for renewal of these awards for each succeeding year should be made to the Student Financial Aid Committee.

EAST BRIDGEWATER SCHOLARSHIP (1932). Established by the Institute through a bequest from Horace T. Smith of the Class of 1898, to be known as the Horace T. Smith Scholarship Fund. A scholarship carrying a stipend depending on demonstrated need, with a maximum of full tuition for the freshman year, is annually offered a graduate of the High School of East Bridgewater, Massachusetts. Application should be made to the Director of Student Aid.

FALL RIVER AND SWANSEA (1932). Established by the Institute through a bequest of Elizabeth R. Stevens, known as the Albert G. Boyden Fund. A limited number of scholarships for the freshman year, carrying stipends of part tuition, are annually offered to qualified applicants residing in Fall River or Swansea, Massachusetts. Applications must be filed with the Director of Student Aid. Selection will be based on C. E. E. B. scores and general admission record.

FRANCIS MORGAN FRASHER, JR. MEMORIAL SCHOLARSHIP (1951). Established by his parents for a graduate entering directly after acquiring his entire high school education in the secondary schools of San Antonio, Alamo Heights, or Bexar County, Texas. This applicant, if admitted to the Institute, must pursue work for a degree in science. The award covers tuition for the freshman year only. Selection will be made by the Student Financial Aid Committee at the Institute.

FRESHMAN COMPETITIVE SCHOLARSHIPS (1932). Prize awards covering part tuition for the first year. There are no geographical restrictions of eligibility, and any candidate for admission to the freshman class directly from secondary school may apply. Competition is based upon academic records and evidences of non-academic merit of the competitors and no special examinations are required.

GENERAL MOTORS SCHOLARSHIPS (1955). Four-year grants established under the General Motors College Scholarship Plan. Open to citizens of the United States, and intended for outstanding individuals. Five awards will be made to entering first-year students. Stipends will be made on a demonstrated need basis.

CHARLES HAYDEN MEMORIAL (1939). Established through a grant from the Charles Hayden Foundation, the Institute offers a number of scholarship awards in memory of the late Charles Hayden, a graduate of the English High School Class of 1886 and of the M. I. T. Class of 1890: "To aid deserving 'Boston and New York boys' — high school graduates whose parents are unable to finance the entire cost of their education — to enroll as members of the first-year class at Technology." Full particulars concerning these awards may be obtained from the Director of Student Aid.

JAKOBSON SCHOLARSHIP (1951). Established by Jakobson Shipyard Incorporated, an annual freshman scholarship carrying a grant of $1,000. First preference to a son of an employee of Jakobson Shipyard Inc. and second preference to graduates of the following high schools: Glen Cove, Huntington, Manhasset, Oyster Bay, Port Washington, Roslyn, Sea Cliff. Third preference to secondary school graduates who reside on Long Island, excepting the counties of Kings or Queens.

KNAPP MEMORIAL SCHOLARSHIPS (1951). Gift of the Knapp Fund to establish scholarships for students entering M. I. T. from the Buffalo area and Erie County. Applicants will be expected to have demonstrated good ability and achievement in their secondary school performance, show need of financial aid, and evidence an active interest in their school and community. Selection will be made by a committee from the M. I. T. Alumni Club of Buffalo and the Director of Student Aid.

AMELIA S. KNIESNER SCHOLARSHIP FUND (1944). Gift of William T. Kniesner of the Class of 1916 and his sisters, the income "to provide scholarship aid to meritorious or needy students, either entering freshmen or undergraduate students of the Institute, preference to be given to graduates of the high school or high schools of Danbury, Connecticut."

JACOB AND JENNIE LICHTER FUND (1949). "To be used for the aid of students who shall satisfy all entrance requirements of the Institute and be endorsed as to character and personality."

CHARLES E. LOCKE MEMORIAL FUND (1923). Established by the Class of 1896 to found a scholarship. Preference in making awards will be given to descendants of members of the Class of 1896, including freshmen.

LOCKHEED NATIONAL ENGINEERING SCHOLARSHIPS (1953). Established by the Lockheed Aircraft Educational Fund for worthy young men and women who are citizens of the United States. Recipients must be secondary school graduates under twenty-five years of age who plan to major in a field of engineering applicable to the aircraft industry. In the selection for this award, the Student Financial Aid Committee will give recognition to factors other than scholastic achievement. Grants will be for full tuition plus $500 toward living expenses. The grants are renewable for three additional years, or the total undergraduate period.

MARTIN AIRCRAFT SCHOLARSHIP (1954). Endowment of $25,000 to establish scholarships for male students planning to pursue courses most applicable to the activities of The Glenn L. Martin Company. Preference will be given to residents of Maryland (including the District of Columbia) and special consideration will be given to sons of employees of The Glenn L. Martin Company. Awards will be for $1,000, of which $700 will be applied to the first year; the balance being granted during the second, third and fourth years.

WALDO A. MARTIN SCHOLARSHIP FUND (1950). Established by Eleanor P. Martin in memory of her brother, Waldo A. Martin, M. I. T. 1890. First preference until 1975 to friends or relatives of Waldo A. Martin and the donor. Second preference to graduates of Milton High School, Milton Academy, or a resident of Milton for the freshman year only on the basis of character, integrity and ability.

M. I. T. CLUB OF CHICAGO SCHOLARSHIP FUND (1944). Gift of $6,000 from Harold B. Harvey of the Class of 1905 "to establish scholarships to be known as the Technology Club of Chicago Scholarship Fund," the awards to be made by a committee composed of the Honorary Secretaries of the Chicago area and the Director of Student Aid, and restricted "to boys who reside in the area of the club membership."

GEORGE H. MAY (1914). Gift of $5,000 from George H. May of the Class of 1892 to provide a scholarship "to assist graduates of the Newton High Schools who are students at M. I. T. and who have been recommended as eligible by the Superintendent and Head Master of the Newton High Schools." Beneficiaries

under this fund are expected to issue notes agreeing to repay the face value, without interest, of amounts received.

MILTON HIGH SCHOOL FUND (1885). Founded by the Institute in recognition of contributions from residents of Milton. This scholarship is conferred upon such former pupils of the Milton High School in good standing at the Institute as the Master of that school and the School Committee of the town may select.

NIARCHOS SCHOLARSHIP (1956). Established by Stavros S. Niarchos as a memorial for merchant mariners who gave their lives during World War II. These grants provide opportunities for higher education to the sons of merchant seamen. The awards will be based upon demonstrated need and achievement in secondary school experience. Holders of these scholarships will be given opportunities to work in the marine field during the summer vacations as part of their total education. In the selection of candidates, first preference will be given to sons of merchant seamen and ships' officers who lost their lives in the line of duty during wartime. In other cases, candidates' fathers must be regularly employed in a seagoing capacity, or if deceased, so last employed. These awards are not limited to courses in marine engineering and naval architecture, but consideration may be given to the desire of qualified candidates to pursue careers in these fields.

PROCTER AND GAMBLE SCHOLARSHIP (1955). Two four-year scholarships open to entering students, sponsored by The Procter and Gamble Company. Selection will be made by the Student Financial Aid Committee of one student following science courses and one student following engineering courses. Grants will cover tuition plus an added amount for books and supplies.

WILLIS WARD REEVES, JR., FUND (1945). Established by Mr. and Mrs. Willis Ward Reeves of Hazard, Kentucky, "as a memorial to their son, Willis Ward Reeves, Jr., of the Class of 1946, late Lieutenant, U. S. Army Air Forces, killed in action over France during World War II . . . the income to be used for scholarship aid to deserving undergraduate students, with preference to those from Kentucky."

WILLIAM BARTON ROGERS SCHOLARSHIP (1947). A limited number of four-year grants established in honor of William Barton Rogers, founder of the Institute, to enable young men of superior ability and future promise but of limited financial means to pursue an education in either Engineering, Science, or Architecture. A stipend of $1,400 (full tuition plus $300) will be granted for the first year. Successful applicants who maintain honor standing will continue to hold full tuition awards for their undergraduate course and will be eligible to apply to borrow up to the amount of tuition annually from the Technology Loan Fund. These scholarships are open to all freshmen candidates with no restrictions of geographical location. All applicants will be required to establish scores in the College Entrance Examination Board tests.

FRANK ARNOLD SHERMAN SCHOLARSHIP FUND (1947). Bequest of Frank Arnold Sherman, '03, "the income to be used first and preferentially for a scholarship to some boy graduate of Westerly High School, Westerly, R. I., or if no suitable candidate, preferentially to a boy graduate of some other Rhode Island high school."

SLOAN NATIONAL SCHOLARSHIPS (1953). Established by the Alfred P. Sloan Foundation, in Science and Engineering. Open to male students resident in continental United States. Sloan National Scholars will hold positions of academic honor at the Institute. Awards will be made to men of high character, sound personality, leadership potential, and academic promise. Grants will range from a $200 prize scholarship to $2,000 per annum, covering all expenses for a college year. Awards will be renewable each year, subject to performance and in accordance with changing financial need.

G. H. MILLER SMITH FUND (1945). Established by Mr. and Mrs. George Blackwell Smith of Lookout Mountain, Tennessee, "as a memorial to their son, G. H. Miller Smith of the Class of 1943, late Lieutenant, U. S. Army, killed in action in France during World War II . . . the income to be used for scholarship aid to deserving undergraduate students, with preference to those from Tennessee."

ALBERT F. SULZER SCHOLARSHIP (1955). Established under the will of Albert F. Sulzer, to be used by the Trustees of the Massachusetts Institute of Technology for the establishment and maintenance of scholarships for meritorious first-year students who are non-residents of the State of Massachusetts.

TAU BETA PI MEMORIAL SCHOLARSHIP FUND (1947). Gift from members of Tau Beta Pi, Massachusetts Beta Chapter, on their twenty-fifth anniversary. An annual award of $500 for freshmen to be selected by the M. I. T. Student Financial Aid Committee. There is to be no restriction of geographical area and candidates will be selected on high scholastic standing, character and future promise.

VERMONT (1924). Gift of $76,000 from Redfield Proctor of the Class of 1902 to found a scholarship "in memory of Vermonters who, having received their education at the Institute, served as engineers in the Armies of the Allies in the World War." The income is awarded annually "to worthy students . . . preference to any bona fide residents of Vermont doing undergraduate work at the Institute of Technology, and also Vermont students doing graduate work, or students who are graduates of or transfers from Middlebury College or Norwich University . . . who shall meet regular scholastic and other requirements."

WILLIAM B. ZIFF MEMORIAL SCHOLARSHIP (1955). A four-year grant established by the Ziff-Davis Publishing Company. Open only to Cadets in the Civil Air Patrol holding Proficiency Certificates who plan to study aeronautical engineering. Candidates will be expected to have demonstrated meritorious performance, leadership, and need for financial assistance.

UNDERGRADUATE SCHOLARSHIP AID FOR UPPERCLASSMEN

In addition to the Freshmen Scholarships, the Institute holds funds from the income of which awards are made to students in the upper undergraduate years. It is the policy of the Student Financial Aid Committee to assist as many well qualified students as possible by assigning, in general, amounts less than full tuition. Awards are made only to students who have completed at least a year of satisfactory work at the Institute.

In making selections, the ability of the student, as indicated by the scholastic record, is the primary consideration. However, account is also taken of the applicant's evidences of need for financial assistance, of his good character, and of his general worthiness and professional promise. Applications should, except as noted below, be made on blanks to be obtained at the Student Aid Center, Room 5-119.

The scholarships or funds described are arranged in the alphabetical order of their names, the figures in parentheses being the dates of establishment:

FRANK W. AND CARL S. ADAMS MEMORIAL FUND (1955). Established by Mr. and Mrs. Charles E. Adams with The First National Bank of Boston as Trustee, and named in memory of their two sons as the Frank W. and Carl S. Adams Memorial Fund. To assist needy and deserving students at M. I. T. A limited amount may also be available to assist an impecunious student who is unable to participate in recognized functions incident to Graduation.

AMERICAN BRAKE SHOE COMPANY SCHOLARSHIP (1948). Established by the American Brake Shoe Company to assist worthy students studying in the general field of Metallurgy, particularly in the fields of foundry engineering, metal processing and physical metallurgy. A full tuition grant open to a third or fourth year student, to be selected by the head of the Department of Metallurgy subject to the approval of the Student Financial Aid Committee and final approval by the American Brake Shoe Company.

AMERICAN CHICLE EDUCATIONAL TRUST (1954). A full-tuition scholarship open to a senior who is an American citizen and in his final year for a Bachelor's degree. The recipient will be offered summer employment between the junior and senior years. Seniors in Chemical Engineering, Food Technology, and Business and Engineering Administration will be considered, along with seniors in Chemistry. Selection will be made by the Student Financial Aid Committee in cooperation with the Departments.

AMERICAN SMELTING AND REFINING COMPANY (1946). Gift of the Company to establish scholarships of $500 each to Course III students. Recipients are to be selected by the Head of the Course in Metallurgy subject to approval by the Student Financial Aid Committee. Preference will be given to third or fourth year students in Metallurgy.

AMERICAN SOCIETY FOR METALS (1954). A grant of $400 to be awarded annually to a second-year student in Metallurgy. Selection will be made on the recommendation of the Department to the Student Financial Aid Committee from students in Metallurgy who have made application for assistance for the sophomore year and who have demonstrated good ability and need.

ANONYMOUS (1948). Gift of an alumnus for scholarship purposes.

ANONYMOUS (1952). A gift of $20,000 to the Institute for scholarships or some alternate form of student aid.

LOUIE G. APPLEBEE (1942). Bequest "to be expended in assisting deserving students."

ELISHA ATKINS (1894). Founded by Mrs. Mary E. Atkins of Boston with a gift of $5,000.

JASON S. BAILEY FUND (1952). Established by the estate of Jason S. Bailey for undergraduate scholarships at the Institute.

THOMAS WENDELL BAILEY (1914). Bequest of Thomas Wendell Bailey, the income to assist "needy students in the Department of Architecture."

CHARLES TIDD BAKER (1922). Bequest of $20,000 from Charles Tidd Baker, one-half of the net income "applied each year to the assistance of poor and worthy students."

BILLINGS STUDENT (1900). Bequest of $50,000 from Robert C. Billings "to found the Billings Student Fund. Any student receiving benefit from this fund is expected to abstain from the use of alcohol or tobacco in any of their varied forms."

HUSE TEMPLETON BLANCHARD FUND (1946). Bequest of Huse T. Blanchard, of the Class of 1901, for "the benefit of worthy boys of the State of New Hampshire."

LEVI BOLES (1915). Bequest of $10,000 from Frank W. Boles in memory of his father, Levi Boles, the "net income thereof to be applied annually to the assistance of needy and deserving students."

JONATHAN BOURNE (1915). Bequest of $10,000 from Hannah B. Abbe to constitute a fund "known as the Jonathan Bourne Scholarship Fund, the income only to be used in aid of deserving students."

ALBERT G. BOYDEN (1931). Bequest of $40,000 from Elizabeth R. Stevens as a permanent fund, to be known as the Albert G. Boyden Fund, "income only to be awarded as scholarships to assist worthy and needy students, preference to be given to young men or women residents of the town of Swansea or the city of Fall River."

BERTRAM BREWER SCHOLARSHIPS (1952). Bequest under the will of Bertram Brewer. "Income . . . to be used to provide annual scholarships for deserving undergraduates of good character and ability. . . ."

HARRIET L. BROWN FUND (1932). Bequest of Harriet L. Brown "to be held in trust as a scholarship . . . the income to be given to such needy and deserving young women desiring to become students at M. I. T., as would otherwise be unable to attend; and in case of two or more applicants of equal merit, preference shall be given to a native of either Massachusetts or New Hampshire."

CABOT ENDOWED SCHOLARSHIP (1955). Gift of Godfrey L. Cabot, Inc. The income from this endowment to be used as scholarships for undergraduate students of the Institute in accordance with the general Institute practices and procedures.

GODFREY L. CABOT (1950). Established by gift for scholarships . . . with preference to students of Chemistry or Chemical Engineering.

MABEL BLAKE CASE (1920). Bequest of $25,000 from Caroline S. Freeman to be "known as Mabel Blake Case Fund, income to be used to aid deserving students (preferably women) who are in need of assistance."

NINO TESHER CATLIN (1926). Gift from Maria T. Catlin to establish a fund in memory of her son, Nino T. Catlin of the Class of 1918, the income "to be awarded to needy and deserving students."

THE CHEMICAL CLUB OF NEW ENGLAND (1955). An annual grant established by the Chemical Club of New England to promote interest in work in chemistry or chemical engineering in New England. Open to junior and senior students, residents of New England, majoring in chemistry or chemical engineering, who have demonstrated substantial academic achievement and financial need.

LUCIUS CLAPP (1905). Gift from Lucius Clapp to form a fund "to aid worthy students who may not be able to complete their studies without help."

THOMAS L. CLARK MEMORIAL SCHOLARSHIP (1956). Endowment established in memory of Thomas Lynn Clark '59, by a number of his friends at M. I. T. Income of this fund is to be used to assist a worthy and needy student at the Institute as determined by the Student Financial Aid Committee.

A. V. CLARKE (1950). Gift of Mr. Clarke. "Proceeds to be used for student aid at the discretion of the Student Financial Aid Committee."

FRED L. AND FLORENCE L. COBURN (1932). Bequest of $5,000 from Fred L. Coburn, the income of which "shall be expended by said Trustees in giving aid and assistance to students of M. I. T. . . . preference being given by said Trustees to students residing in Somerville, Massachusetts."

COFFIN MEMORIAL (1929). This gift from the executors of the estate of Charles A. Coffin — a bequest — carried out the wishes of Mr. Coffin. The fund is to be used for loans or other aid to students as determined by the Executive Committee.

COLLEGE OF WILLIAM AND MARY (1904). Established by the Institute in commemoration of the early association of President William Barton Rogers with the College of William and Mary. Stipend $400 per year; granted to a student nominated by the faculty of the College of William and Mary.

ALBERT CONRO SCHOLARSHIP FUND (1943). Bequest of Mary T. Conro, sister of Emma O. Conro, of the Class of 1884, in memory of their uncle, "for the purpose of establishing and maintaining a scholarship in . . . mining engineering . . . to be known as the Albert Conro Scholarship."

THE GEORGE R. COOKE FUND (1939). Established by gift of $3,000, "the income to be awarded to a student, preferably in the Course in Civil Engineering, or in some related field of study giving preparation for Public Service and Government. Prior to matriculation, the recipient, who need not necessarily be a candidate for a degree, must have acquired practical experience and earned his living by working in some field, preferably for one year or more. Candidates are to be judged upon their evidences of character, sincerity of purpose and need for assistance."

JOHN G. CRANE SCHOLARSHIPS (1951). Gift of J. G. Crane, 1890, for undergraduate awards.

LUCRETIA CROCKER (1916). By the will of Matilda H. Crocker, the Institute was made the residuary legatee of her estate "for the establishment of one or more scholarships for women in memory of my sister, Lucretia Crocker . . . the income to aid one or more young women in need of pecuniary assistance in obtaining instruction at said Institute."

EUNICE McLELLAN CRUFT FUND (1949). Bequest of Eunice McLellan Cruft "to assist young men whose means are inadequate to pay their expenses at the Institute."

ISAAC W. DANFORTH (1903). Bequest of $5,000 from James H. Danforth for scholarship purposes as a memorial to his brother, Isaac Warren Danforth.

ARTHUR DAVIS DEAN FUND (1952). Through the bequest of Arthur Davis Dean '95, the Institute has established a number of grants to cover a portion of the rental of rooms in the undergraduate houses so that young men of limited means may live on the Institute campus. Grants will be made by the Student Financial Aid Committee to undergraduates (including entering freshmen) who have demonstrated need for financial assistance.

CARL PULLEN DENNETT MEMORIAL SCHOLARSHIP FUND (1956). Established by gift in memory of Carl Pullen Dennett for an individual, either graduate or undergraduate, in the School of Science who is deemed qualified by scholastic performance, intelligence, character and promise. Annual selection will be made by the Director of Student Aid and the Dean of Students.

ANN WHITE DICKINSON (1898). Bequest of $40,000 from Ann White Dickinson "to establish free scholarships in M. I. T. . . . such persons enjoying benefit . . . shall be worthy young men of American origin."

DORMITORY (1903). Raised by miscellaneous subscriptions and formerly known as Students' Aid Fund.

THOMAS MESSINGER DROWN (1928). Bequest of $50,000 from Mary Frances Drown, "to be used to establish scholarships for deserving undergraduate students, to be known as the Thomas Messinger Drown Scholarships."

EDGERTON, GERMESHAUSEN AND GRIER, INC., SCHOLARSHIP (1955). Gift to fund scholarship, preferably in Electrical Engineering.

FRANCES AND WILLIAM EMERSON FUND (1930). Awards not exceeding $600 to students in the School of Architecture. Applications should be made directly to the Dean of the School of Architecture.

FARNSWORTH (1889). Founded by Mrs. Mary E. Atkins of Boston with a gift of $5,000.

CHARLES LEWIS FLINT (1889). Bequest of $5,000 from Charles L. Flint, for the "support of some worthy student, preference to be given to some graduate of the English High School, Boston."

SARAH S. FORBES (1913). Originally a fund of $2,800 given in trust in 1868 by Sarah S. Forbes to William Barton Rogers and Henry S. Russell, trustees, and transferred in 1913 to the Institute, "for the maintenance and education of a scholar in M.I.T."

CLARA AND JOSEPH F. FORD SCHOLARSHIP (1951). Established by Mr. and Mrs. Joseph F. Ford, "income to be awarded to worthy and well-qualified students who have demonstrated a democratic and tolerant spirit and who are well-disposed toward people of all creeds and races."

FOUNDRY EDUCATIONAL FOUNDATION SCHOLARSHIPS (1947). Established by the Foundry Educational Foundation which represents the American Foundrymen's Association, the Gray Iron Founders' Society and the Malleable Founders' Society, and the Foundry Equipment Manufacturers Association. Tuition awards open to third and fourth year students in Business and Engineering Administration, Mechanical Engineering, and Metallurgy.

FRANK MEMORIAL SCHOLARSHIP (1952). Established by the Harrison Jules Louis Frank and Leon Harrison Frank Memorial Corporation in memory of the founders of the Bulldog Electric Products Company. A $500 scholarship to a needy and worthy junior or senior in electrical engineering who is interested in the field of distribution and/or control of electricity. Selection will be made by the Student Financial Aid Committee.

PHILIP JACOB FRIEDLANDER (1945). Gift of Israel Friedlander "in appreciation of the opportunity my son, Philip Jacob Friedlander, had of spending a little more than a year at M. I. T. before enlisting in the United States Naval Reserve . . . . the income to be used with the income from other such funds for the purpose of helping qualified students at M. I. T. regardless of race, creed, or color, or geographical origin, who may be in need of financial assistance . . ."

NORMAN H. GEORGE (1919). Bequest of Norman H. George "to be used for the assistance of needy and worthy students in obtaining an education in M. I. T."

ARTHUR B. GILMORE (1941). Bequest of $10,000 from Arthur B. Gilmore ". . . for the purpose of assisting needy students who shall be members of the Beta Theta Pi Fraternity . . . said net income to be divided among not more than two students in any one year."

BARNETT D. GORDON FUND (1942). Gift of $21,000 from Barnett D. Gordon of the Class of 1916, "the income as scholarships for deserving students at M. I. T."

JOHN A GRIMMONS FUND (1952). Established by the estate of Katie M. A. Grimmons . . . in memory of her son, John A. Grimmons, M. I. T. '21. Income to be used for scholarships for students . . . with preference to those in the Department of Electrical Engineering.

LUCIA G. HALL (1945). Bequest of Louise K. Gunn to "be known as 'The Lucia G. Hall Scholarships' . . . the income only therefrom to be used for the aid of worthy students."

HALL-MERCER SCHOLARSHIP FUND (1940). Bequest of Alexander G. Mercer ". . . . income only . . . for the benefit of such poor students as have passed through some of the Public Schools with the best reputation for character and ability."

JAMES H. HASTE (1930). Bequest of James H. Haste of the Class of 1896, "for the aid of deserving students . . . of insufficient means, said fund, together with any other sums which said institution may receive under this will, to be known as the James H. Haste Fund."

GEORGE HOLLINGSWORTH (1916). Bequest of $5,000 from Rose Hollingsworth to found the George Hollingsworth Scholarship.

LOREN C. HOLM SCHOLARSHIP FUND (1950). Established by Marie Holm in memory of her father, for worthy and needy students.

ELIAS HOWE, JR. SCHOLARSHIPS (1949). Established under the will of Julia Howe Stockwell Smith. "The income from this fund shall be available for aiding such students and in such amounts as shall be recommended by the Faculty."

SAMUEL P. HUNT (1945). Gift of Samuel P. Hunt of the Class of 1895 for scholarship purposes.

T. STERRY HUNT (1894). Bequest of $3,000 from T. Sterry Hunt, for seven years Professor of Geology at Technology, to found a scholarship in his name. Restricted to students of Chemistry and preference is given to those in the higher years.

WILLIAM F. HUNTINGTON (1892). From Susan E. Covell, the Institute received a gift of $5,000 to constitute a fund in memory of William F. Huntington of the Class of 1875, the "income to apply to payments of tuition of needy and deserving students . . . preference to be given to students in Civil Engineering."

DAVID L. JEWELL (1928). Bequest of $25,000 from Colonel David L. Jewell "to be known as the David L. Jewell Fund the income therefrom to be used to pay the tuition charges of five young men who may be selected by the President or Board of Trustees of the Institute as worthy of assistance, and who, were it not for such assistance, might be unable to pursue their studies at such Institute."

CHARLES STONE JONES SCHOLARSHIP (1953). A full tuition scholarship established by Charles Stone Jones for an undergraduate student who has shown ambition and demonstrated talent for a career in the engineering field. Selection will be made by the Student Financial Aid Committee.

EDWARD A. JONES SCHOLARSHIP FUND (1947). Bequest of $25,000 from Edward A. Jones "to be used for the establishment and maintenance of one or more scholarships."

JOY (1886). Established by the gift of Nabby Joy and created pursuant to a decree of the Supreme Judicial Court of Massachusetts for the benefit of "one or more women studying Natural Science at M. I. T."

WILLIAM R. KALES SCHOLARSHIP FUND (1953). Endowed by gift of the Whitehead and Kales Company for scholarship purposes. ' Income of this fund to be used to assist worthy and needy undergraduates. Selection will be made by the Student Financial Aid Committee.

KENNECOTT COPPER CORPORATION SCHOLARSHIP (1954). Open to incoming seniors in Business and Engineering Administration. Selection will be made by the Student Financial Aid Committee on recommendation of candidates by the Department, in cooperation with a representative of the company.

KULJIAN SCHOLARSHIPS (1951). Gift of Harry A. Kuljian, '19, to establish two $500 scholarships for outstanding seniors in engineering departments who are in need of financial aid. Candidates will be nominated by the Departments to the Dean

of Humanities and Social Studies as young men of superior professional promise and aware of the significance of the humanities in their professional education, and who have shown exceptional capacity in humanity subjects. Selection will be made by the Student Financial Aid Committee.

KURRELMEYER FUND (1947). Raised by contributions "for undergraduate scholarship award to a needy student."

PAUL WEEKS LITCHFIELD SCHOLARSHIP (1954). Established in honor of Paul W. Litchfield '96 for scholarship aid to worthy and needy students at the Institute. Preference in selection will be given to those students who have been members of the Boy Scouts of America.

WILLIAM LITCHFIELD (1910). Bequest of $5,000 from William Litchfield to establish "a single scholarship . . . known as William Litchfield Scholarship, income to be awarded and paid annually to such student in said Institute as may, upon a competitive examination, be determined by the President of said Institute to be entitled thereto for excellence in scholarship and conduct."

RICHARD W. LODGE (1955). Established by the will of Mary L. Lodge in memory of Richard W. Lodge '79. The income is to be used for worthy and needy students.

ELISHA T. LORING (1890). Bequest of $5,000 from Elisha Thacker Loring, for "the assistance of needy and deserving pupils."

LOWELL INSTITUTE (1923). Gift from the alumni of the Lowell Institute School to found a Fund, the income of which is annually awarded to assist some graduate of that School who desires to enter upon undergraduate studies at M. I. T. Applications must be filed at the Office of the Director of Student Aid.

PERCIVAL LOWELL SCHOLARSHIPS (1955). Gift, income of which is to be used for scholarships to be awarded from time to time at the discretion of the President of the Massachusetts Institute of Technology to students in Astronomy, Physics and Mathematics.

ALICE MACLAURIN (1951). Gifts to create a scholarship in memory of Mrs. Richard C. Maclaurin.

FRANCISCO MARCUCELLA (1953). Gift of Francisco Marcucella '27 for scholarship purposes.

RUPERT ANDERSON MARDEN (1933). Established by an anonymous gift "toward a memorial to be known as the Rupert Anderson Marden Scholarship Fund, income available annually to aid a worthy student at M. I. T. — Protestant and of American origin — preference to a student taking the Cooperative Course in Electrical Engineering."

MARGARET A. MATTHEWS FUND (1947). Bequest from Margaret A. Matthews "the income for the benefit of such of the women students at M. I. T. who intend to become teachers."

THE GEORGE J. MEAD PRIZE SCHOLARSHIPS (1951). Bequest of George J. Mead '16 to establish prize scholarships in aircraft propulsion. Open to juniors, seniors, and graduate students in this field. Consideration will also be given to candidates from related engineering fields as applied to aircraft propulsion. Recommendation will be made by the Department of Aeronautical Engineering to the Student Financial Aid Committee.

CHARLES E. MERRILL SCHOLARSHIP FUND (1955). Gift of Charles E. Merrill for "students having financial need . . . . who have demonstrated through personality traits, initiative, or by scholastic achievement, that they will become substantial democratic citizens." One-half the income will be used to meet the overhead expense of the Institute.

ROBERT W. MILNE FUND (1943). Bequest of $70,000 as "an endowment fund under the title of 'The Robert W. Milne Fund' the income thereof to be used and applied for the assistance of worthy and needy students in obtaining an education in said Institute."

JAMES H. MIRRLEES (1886). Gift of $2,500 from James Buchanan Mirrlees of Glasgow, Scotland, to constitute a scholarship in memory of his son, James Henry Mirrlees, who died in 1886 while attending the Institute. The income is awarded to the "student in the third or fourth year of the Mechanical Engineering Course most deserving pecuniary assistance."

MORNINGSTAR SCHOLARSHIP (1953). For undergraduates with first preference given to those in the Physics Department. Grants will be equivalent to one term's tuition and be continued to a recipient for entire undergraduate period.

FRED W. MORRILL SCHOLARSHIP FUND (1941). Bequest of Hattie B. Morrill the "income from which is to be used for the purpose of providing financial assistance to some student or students at the discretion of the Trustees of said Institute. . . ."

NATIONAL ASSOCIATION OF ENGINE AND BOAT MANUFACTURERS, INC. (1950). Scholarship of $600 to be awarded to a student in Naval Architecture and Marine Engineering who is particularly interested in small boat design.

NAVAL ARCHITECTURE AND MARINE ENGINEERING (1953). An annual scholarship established by gift of the Gulf and South American Steamship Company to assist students who plan to spend the fifth year in Shipping and Shipbuilding, Course XIII-B. Also an annual scholarship for secondary school graduates who plan to go into the field of Naval Architecture and Marine Engineering. Selection will be made by the Department of Naval Architecture and Marine Engineering and the Student Financial Aid Committee.

GERTRUDE B. NEWMAN SCHOLARSHIP (1952). Bequest from the estate of Mrs. Gertrude B. Newman to aid worthy and deserving students.

NICHOLS (1895). Bequest of $5,000 from Mrs. Betsy F. W. Nichols to constitute The Nichols Scholarship in memory of her son William Ripley Nichols of the Class of 1869, for sixteen years Professor of General Chemistry at the Institute. Preference is given to students in the Course in Chemistry.

CHARLES C. NICHOLS (1904). Bequest of $5,000 from Charles C. Nichols to constitute a scholarship.

WILLIAM E. NICKERSON SCHOLARSHIP FUND (1949). Established by the Nickerson Trust, the income to be used for a scholarship for a worthy student.

HOWARD A. NOBLE SCHOLARSHIPS (1955). Established under the will of Katherine B. Noble. Income to be used to maintain one or more scholarships in engineering.

JOHN FELT OSGOOD (1909). Bequest of $5,000 from Elizabeth P. Osgood "to establish and maintain a scholarship in Electricity in memory of my husband, John Felt Osgood."

LOUISE PARKS KNIGHT AND CHARLES F. PARKS MEMORIAL (1952). Established as a memorial to Louise Parks Knight and her father, Charles F. Parks, of the class of 1875. To be used for the aid of poor but worthy students who have already entered upon a course of study but are unable to finish owing to lack of funds.

GEORGE L. PARMELEE (1921). Bequest from George L. Parmelee of "one third of my property and estate, interest thereof to be used for tuition of worthy students, either special or regular, according to the direction of the Faculty."

FRANK STETSON PECKER FUND (1947). Established by the wills of Frank Stetson Pecker and Annie J. Pecker for scholarship.

RICHARD PERKINS (1887). Bequest of $100,000 from Richard Perkins, the income from half of which is available for the "support of free scholarships in said Institute."

CHARLES H. AND HELEN BARTLETT PRAY FUND (1950). Established under the wills of Charles H. and Helen Bartlett Pray "for scholarships for needy young men."

FLORENCE E. PRINCE FUND (1943). Bequest of Florence E. Prince "for the aid of worthy students who may need assistance in the matter of maintenance and living expenses while pursuing their studies."

THOMAS ADELBERT READ (1934). Bequest of $10,000 from Julia A. Read "to establish the Thomas Adelbert Read Scholarship, in memory of my late brother of that name; the income of said fund to be awarded to some worthy and needy student of that institution, preferably to a resident of Fall River. . . ."

RHODES FOUNDATION SCHOLARSHIP (1953). Gift of the Rhodes Foundation for a student at the Massachusetts Institute of Technology. Selections for this grant will be limited to U. S. citizens of good character who show academic promise and give evidence of financial need. First preference will be given to a student in engineering.

CHARLES A. RICHARD'S FUND (1939). Bequest of approximately $30,000 "to be known as the Charles A. Richard's Fund . . . the income only for assistance of poor Protestant students in the Institute."

JOHN ROACH (1937). Bequest of $2,400 from Emeline Roach to constitute a fund "to be known as the John Roach Scholarship Fund, the income to be used to provide an annual scholarship to a needy and deserving student pursuing the Course in Naval Architecture and Marine Engineering."

KARL ROBBINS (1951). Gift of the Robbins Foundation. First preference for either a graduate or undergraduate in Textile Technology; second preference to students in Mechanical Engineering.

RICHARD LEE RUSSEL (1904). Gift of Theodore E. Russel. Income to be used to assist a worthy and needy student of high standing in the Department of Civil Engineering, either undergraduate or postgraduate.

WILLIAM P. RYAN MEMORIAL (1935). Established by friends of the late Professor William P. Ryan of the Class of 1918, the income to be used for scholarship aid (graduate or undergraduate) in Chemical Engineering, the award to be made on recommendation of the Head of the Department of Chemical Engineering.

JOHN P. SCHENKL (1922). Bequest of $20,000 from Johanna Pauline Schenkl "to be held in trust to establish one or more scholarships in the Department of Mechanical Engineering" in memory of her father, John P. Schenkl.

GEORGE SCHER (1949). Gift to establish aid for needy and worthy students.

SCIENCE TEACHING SCHOLARSHIPS (1955). Established by the Institute to encourage young people who wish to follow a career in science teaching in secondary schools. Open to students who have completed two years at the Institute and plan to follow the curriculum of Course IX-C. Grants will be based on demonstrated need, with a maximum of full tuition which will be renewable through the balance of the five-year program.

PAUL D. SEGHERS, JR., SCHOLARSHIP (1948). Established by the estate of May Towles Kirk Seghers in memory of Second Lieutenant Paul Dotrenge Seghers, Jr., U. S. Army Corps of Engineers, M. I. T. Class of 1945, who was killed in action in the Asiatic area on July 11, 1945, to aid worthy and needy students at the discretion of the Institute.

IRVING SHAKNOV SCHOLARSHIP (1954). Established as a memorial for Irving Shaknov '43. Income to be available for an undergraduate scholarship for a student in the Department of Physics.

THOMAS SHERWIN (1871). Founded with a gift of $5,000 from the English High School Association in memory of Thomas Sherwin. Holders must be graduates of the English High School of Boston and must be pursuing a regular course at the Institute.

SKIDMORE, OWINGS AND MERRILL TRAVELLING FELLOWSHIP (1950). An award to a student graduating in the Department of Architecture, for foreign travel. Gift from the firm of Skidmore, Owings and Merrill for scholarship grants to students in the Department of Architecture.

H. HILLIARD SMITH FUND (1950). Bequest of Grace J. F. Smith in memory of her husband, H. Hilliard Smith 96, for the purpose of assisting young men in Architecture.

HORACE T. SMITH (1931). Bequest from Horace T. Smith of the Class of 1898, to provide scholarships to worthy students, preference to be given to graduates of the East Bridgewater (Massachusetts) and Bridgeport (Connecticut) High Schools.

SONS AND DAUGHTERS OF NEW ENGLAND PURITAN COLONY (1931). Gift of $600 from the Sons and Daughters of New England Puritan Colony. Holders of this scholarship must be of New England ancestry.

ANNA SPOONER FUND (1939). Bequest of approximately $7,500 "the income therefrom . . . to be used . . . in assisting meritorious students."

MARY THACHER SCHOLARSHIP (1956). A bequest to establish a scholarship fund . . . the income of which is to be applied against tuition of needy students, with first preference to students from Yarmouth, Massachusetts; secondly to students from the Cape Cod region, and thirdly to students from the Commonwealth of Massachusetts.

SAMUEL E. TINKHAM (1924). Established by the Boston Society of Civil Engineers to aid a worthy student in Civil Engineering.

F. B. TOUGH (1924). Established "for the purpose of extending financial assistance to worthy students." Preference is given to students in Mining or Oil Production.

Y. T. TSAI MEMORIAL SCHOLARSHIP (1955). Established by gift for worthy and needy students. Selection to be made by the Student Financial Aid Committee.

UNION CARBIDE AND CARBON CORPORATION SCHOLARSHIP IN CHEMICAL AND MECHANICAL ENGINEERING (1952). Established by the Carbide and Carbon Chemicals Company, a Division of Union Carbide and Carbon Corporation. A tuition scholarship plus a cash stipend for a Senior in Chemical Engineering or Mechanical Engineering. Award will be made by the Student Financial Aid Committee on recommendation of the Departments in accordance with customary procedure.

UNION CARBIDE AND CARBON CORPORATION SCHOLARSHIP IN METALLURGICAL ENGINEERING (1953). Established by the Electro Metallurgical Company, a division of Union Carbide and Carbon Corporation. A full tuition scholarship plus a cash stipend for a Senior in Metallurgy. Award will be made by the Student Financial Aid Committee on recommendation of the Department of Metallurgy.

SUSAN UPHAM (1892). Gift of $1,000 from Susan Upham "to assist students deserving financial aid."

SAMSON R. URBINO (1927). Bequest of $1,000 from Samson R. Urbino, "to be used to aid students who need assistance, Germans preferred."

VERMONT (1924). Gift of $76,000 from Redfield Proctor of the Class of 1902 to found a scholarship "in memory of Vermonters who, having received their education at the Institute, served as engineers in the Armies of the Allies in the World War." The income is awarded annually "to worthy students . . . preference to any bona fide residents of Vermont doing undergraduate work at the Institute of Technology, and also Vermont students doing graduate work, or students who are graduates of or transfer from Middlebury College or Norwich University . . . who shall meet regular scholastic and other requirements."

ANN WHITE VOSE (1896). Bequest from Ann White Vose of $25,000 "plus one half of the remainder of my estate . . . to establish free scholarships in M. I. T. . . . such persons enjoying benefit . . . shall be worthy young men of American origin."

ARTHUR M. WAITT (1925). Bequest of $10,000 from Arthur M. Waitt, for "assisting needy and deserving students in the second-, third-, and fourth-year classes of the Mechanical Engineering Course of said Institute."

GRANT WALKER FUND (1943). Bequest of $50,000 "the income to be used for scholarships for deserving students in said Institute."

JAMES WATT (1942). Bequest of Jennie A. Douglas, to establish "a scholarship in Mechanical Engineering to be known as the James Watt Scholarship."

LOUIS WEISSBEIN (1915). Bequest of $4,000 from Louis Weissbein "to found a scholarship to be awarded each year to a promising student, preference to be given a Jewish boy in making the award."

WESTERN ELECTRIC SCHOLARSHIPS (1956). Established by the Western Electric Company. Two scholarships in engineering, based upon need and ability, with a maximum grant of $800.

FRANCES ERVING WESTON (1912). Bequest of Frances Erving Weston, "to aid a native-born American Protestant girl of Massachusetts."

SAMUEL MARTIN WESTON (1912). Bequest of Frances Erving Weston, to found a scholarship in memory of her husband, Samuel Martin Weston, "to aid a native-born American Protestant boy, preference to be given one from Roxbury."

AMASA J. WHITING (1927). Bequest of $2,000 from Mary W. C. Whiting "to constitute a fund to be known as Amasa I. Whiting Fund . . . the income . . . to pay or help to pay

tuition of deserving students whose means are limited.... Preference shall be given to students coming from the town of Hingham, Massachusetts."

ELIZABETH BABCOCK WILLMANN (1935). Bequest from Elizabeth Babcock Willmann, "to help in paying the tuition of girl students taking the Chemistry Course."

JOHN J. WILSON SCHOLARSHIP FUND (1953). Established by John J. Wilson '29. The income from this fund is to be used to assist a needy senior, first preference being one who has demonstrated interest and ability in the field of instrumentation for measurement and control and the intention of continuing his senior studies in this field. Selection will be made by the Student Financial Aid Committee.

MARY I. WILSON SCHOLARSHIP FUND (1954). Established by J. J. Wilson '29, income to be used to assist worthy undergraduates in defrayment of their tuition obligations. Selection will be made by the Institute's Student Financial Aid Committee.

MORRILL WYMAN (1915). Bequest of Morrill Wyman, the income of which is "applied in aid of deserving and promising students, but without exclusion in regard to rank, upon the understanding that if in after life the person receiving aid shall find it possible, he shall reimburse the said fund for moneys so applied, but there shall be no legal obligation to make such reimbursement."

TECHNOLOGY LOAN FUND

Since its establishment in 1930 over 4,000 M. I. T. students have borrowed more than $3,000,000 from the Technology Loan Fund.

It is the general policy to make a loan only to men who have completed at least one year of residence at the Institute with a good academic record. In *exceptional* cases, applications will be considered after one term of residence and in *very special and unusual* cases from entering students who have met, with high standing, all entrance requirements.

The maximum amount loaned to an individual in a single year may not exceed the tuition fee, with the additional stipulation that the maximum total loans granted to an applicant may not exceed $3,300 during his undergraduate period, or $4,400 during his undergraduate and graduate periods.

To receive favorable consideration an applicant must:

1. Be endorsed as to character and personality by: (*a*) an alumnus of the Institute from the community in which he has resided, or by some other citizen of standing in that community; (*b*) the Principal or Head Master of the high school or preparatory school, or the President or Dean of the college or university he has previously attended, (*c*) his Registration Officer or the Head of his Course.

2. Have passed, with a standing satisfactory to the Board, the physical examination required annually of all Institute students.

3. Submit a statement of his financial needs and such other information as the Board may deem necessary, on the application form supplied by the Board, such application to have the approval of his parent or guardian.

4. Be prepared to furnish such life insurance as collateral as may be required by the Board.

A recipient of a loan will be required to sign promissory notes in $50 units up to the amount of his loan, each note carrying interest at one per cent per annum from the date of its issue to a date not exceeding two years after he leaves the Institute, and at five per cent per annum thereafter. Interest is to be paid semi-annually. Each note shall have a definite maturity, such maturities to be spaced at intervals of six months, beginning on or before the December thirty-first following the recipient's expected date of graduation, but payments may be anticipated.

Upon signing notes, the student will be supplied with copies thereof. After leaving the Institute he will be required to advise the Board annually, or at more frequent intervals, as to his whereabouts, the character of the work in which he is engaged, the remuneration he is receiving and his plans for the repayment of his obligations to this Fund.

OTHER LOAN FUNDS

BOSTON STEIN CLUB FRESHMAN LOAN FUND (1953). Established by M. I. T. Boston Stein Club to assist needy students resident in the Greater Boston area. Open only to first-year students who show good promise. Grants, in general, will be for less than full tuition. Recipients will be required to sign notes to repay, after graduation, amounts granted without interest.

ETHEL I. FRYER SCHOLARSHIP LOAN FUND (1951). Gift of H. Fryer 1911 to establish a loan scholarship for deserving students from the States of Washington, Oregon, and California. Limited to grants of $600 per student and repayable within five years of graduation.

NATHAN R. GEORGE LOAN FUND (1943). Bequest of $29,000 from Professor Nathan R. George of the Department of Mathematics, the "income to be loaned to undergraduates of M. I. T. who are either citizens or who intend to become citizens" and who are members of the third or fourth year classes.

JOHN A. GRIMMONS (1930). In memory of John A. Grimmons of the Class of 1921 through a deed of trust executed by the late C. Lillian Moore, the Institute received a sum of money to be "used in making loans to undergraduates who are preparing to make Electrical Engineering their life work; such loans to be known as given from the John A. Grimmons Perpetual Loan Scholarship; such loans are not to exceed six hundred (600) dollars to any one student in any one year and are to be made on condition that the loans shall bear interest at five per cent, and shall be repaid within ten years, and that repaid loans shall be treated as income to revert into the Perpetual Loan Fund and to be reloaned from time to time; such loans are to be protected by life insurance.... Loans are to be awarded to male, white, native born citizens of the United States, who are loyal to the State and Nation, are of sound physical body and show steadiness of purpose and zeal in educational acquirements."

REBECCA R. JOSLIN FUND (1924–36). Open to undergraduate and graduate students in Chemical Engineering and restricted to those men who are residents of Massachusetts, and who abstain from using tobacco in any form.

LAMSON-VIRGIN LOAN FUND (1946). Bequest of $5,000 from Elizabeth H. Lamson, the income to be used in aiding a worthy student of excellent character who "must have shown not only respect for his parents but also proper consideration for the rights of others." Students thus aided shall repay if and when they find themselves able to do so.

GEORGE J. MEAD FUND (1951). Bequest of George J. Mead '16 for loans to students in Aeronautical and Mechanical Engineering.

M. H. ROGERS FUND (1945). Bequest of Minnie Hempel Rogers '90 for loans to worthy students.

FRANK P. WAKEFIELD FUND (1955). Established from the remaining one-fourth of the income of the fund to be loaned to needy and worthy students majoring in Chemistry, Chemical Engineering and Biology.

PRIZES

AMERICAN SOCIETY OF TOOL ENGINEERS (1945). Gift of the Boston Chapter of the Society. A monetary prize of $100 offered annually for the best graduation thesis on a subject related to the professional field of tool engineering.

ROBERT A. BOIT (1921). Bequest of $5,000 from Robert A. Boit, to provide annual prizes "to stimulate the interest in the best use of the English language." Awards are made to undergraduates on the basis of essays written on topics approved by the Department of English and History.

BORDEN FRESHMAN PRIZES (1956). Prize of $200 established by the Borden Company Foundation for the student who has achieved the highest average grade among all the members of his class for all college work during the freshman year. Award shall be made to the winner during the first semester of the sophomore year.

KARL TAYLOR COMPTON PRIZE FUND (1951). Gifts from members and friends of the Boston Stein Club. Income for prizes and grants in recognition and encouragement of outstanding contributions in promoting high standards of performance and good citizenship within the Institute community.

ELLEN KING PRIZE. Established in 1950, the prize, a collection of books valued at approximately $50, is awarded for the best essay written by a freshman upon any topic suitable for

treatment in literary form. Papers submitted in a regular subject, as well as extra-curricular compositions, will be eligible for the prize. Specific topics must be registered and approved at the headquarters of the Department of English and History.

JAMES MEANS MEMORIAL (1925). A medal and monetary prize of $100 offered annually to a senior for excellence in "Aeronautical Engineering" (16·71, 16·72).

THE PERKIN-ELMER CORPORATION PRIZE AWARD (1956). Gift of the Perkin-Elmer Corporation. A monetary prize of $200 offered annually to an undergraduate student "to encourage students to seek opportunities in the sciences."

SILENT HOIST AND CRANE COMPANY MATERIALS HANDLING AWARD (1950). Gift of the Wunsch Foundation, Inc., to provide annual prizes for the best papers or theses submitted on subjects in the fields of production, materials handling, or machine design related to materials handling equipment. Prizes totaling $200 will be awarded on the basis of a competition held each year.

STRATTON (1930). Established by the late President Samuel W. Stratton. Two yearly awards from the income of the fund are presented to encourage skill in organized debating.

The following annual prizes are offered to students in the Departments indicated:

Aeronautical Engineering

HENRY WEBB SALISBURY MEMORIAL AWARD (1941). Established by the family and friends of Henry Webb Salisbury '33 to provide the award of useful reference books, preferably annually, to a student who has done outstanding work in the Department of Aeronautical Engineering.

Architecture and Planning

ALPHA RHO CHI MEDAL (1932). To the graduating senior of the Department of Architecture who has shown an ability for leadership, performed willing service for his school and department, and given promise of real professional merit through his attitude and personality.

CHAMBERLIN (1913). Gift of Boston Society of Architects. Prize of $25 to a student in the graduate class in Architecture. Awarded in alternate years.

F. W. CHANDLER (1906). Gift of Boston Society of Architects in memory of Professor Chandler. Five prizes of $5 each awarded for sketch problems in the fourth, fifth, and graduate years.

CLASS OF 1904 (1925). Gift of the Class of 1904. A prize awarded to a student in the third-year class in Architecture for a sketch problem.

WILLIAM EMERSON (1940). Gift of the Alumni and Staff. Five prizes of $10 each awarded in the first, second, third, fourth and fifth years of Course IV-A, and one prize of $10 awarded in Course IV-B.

ROTCH (1895). Gift of Arthur Rotch. Two prizes awarded at the end of the fifth year to the regular and the special student having the best general records. The special student must have spent at least two years in residence to be eligible.

STUDENT MEDAL OF THE AMERICAN INSTITUTE OF ARCHITECTS (1914). Awarded on the recommendation of the Department to the member of the fifth-year class whose record for the Course is the best.

BOSTON SOCIETY OF ARCHITECTS (1923). Gift of the Society. Prizes totalling $50 for week-end conjunctive problems with Harvard and the Boston Architectural Club.

WILLIAM R. WARE (1923). Given by M. I. T. in memory of the founder of the School, prizes totalling $50 for week-end conjunctive problems with Harvard.

H. LANGFORD WARREN (1923). Given by Harvard in memory of Professor Warren, prizes totalling $50 for week-end conjunctive problems with Harvard.

Building Engineering and Construction

TUCKER-VOSS (1953). Gift of the alumni and friends of Course XVII, this prize is awarded annually to an undergraduate or a graduate student with high scholastic standing, leadership, and professional promise in the building field.

Chemical Engineering

HUNNEMAN (1927). Established by William Cooper Hunneman in memory of his son, Roger DeFriez Hunneman, A.B. Harvard 1917, S.M. M. I. T. 1923. Award of $40 to the most meritorious senior who has shown outstanding originality in his work in the regular Course in Chemical Engineering.

Naval Architecture and Marine Engineering

AMERICAN BUREAU OF SHIPPING (1924). Award of $100 by the Bureau to the American citizen in the graduating class who attains the highest average in scholarship for the last two years in the Course.

GRADUATE SCHOLARSHIPS AND FELLOWSHIPS

A FELLOWSHIP is an award of a cash stipend, with or without a credit against tuition fees, based on academic performance and promise of professional competence to aid the recipient in his pursuit of advanced study and research. This award recognizes the recipient as having demonstrated the promise of unusual attainments in science or engineering.

A SCHOLARSHIP is an award of a financial credit toward tuition fees, made to a graduate student of academic promise, to aid and encourage his graduate study toward an advanced degree.

Fellowships and Scholarships are awarded by the Committee on Graduate School Policy only to graduate students who are not also staff members. Tuition credits to whole-time or part-time staff appointees are arranged by the departments recommending staff appointments from funds other than those designated for graduate students.

GRADUATE STUDENT FELLOWSHIPS are available to certain graduate students proceeding toward advanced degrees: ADVANCED RESEARCH FELLOWSHIPS are available to certain holders of advanced degrees who are not enrolled as graduate students (*e.g.*, Postdoctoral Fellowships). The recipient of a Fellowship is designated as a Fellow for the period of time specified in his award. He pays full tuition, has full student status, and no services are required of him in respect to his Fellowship.

APPLICATIONS

Applications for Fellowships or Scholarships must be filed on the form "Application for Scholarship Aid" obtainable from the Admissions Office and should be returned to appropriate department officers. Applications will be acted upon by the Committee on Graduate School Policy at stated times.

For each regular academic year beginning with a Fall term, Applications for Scholarship Aid must be in hand on the previous March 1. Notices of award will be mailed on April 1, and awards not accepted by April 15 will be cancelled.

Applications received at other dates will be considered from time to time if funds are available.

Applications from students applying for admission to the Graduate School must be accompanied by full credentials required with the admission application. Only applicants with highest credentials may expect favorable consideration from the Scholarship Committee previous to at least one term of residence as a graduate student and any award to a new student will usually not exceed tuition.

Each award will be terminated following a term record of less than 3.5 unless mitigating circumstances in explanation of low grades are accepted by the Committee on Graduate School Policy.

The recipient of scholarship aid is expected to complete the period of study for which an award is made, and discontinuance of his work before the end of such period imposes upon him the obligation to refund to the Bursar all portions of the award which have been used unless a waiver is granted by the Committee on Graduate School Policy.

Correspondence concerning scholarships should be addressed to the Chairman of the appropriate Departmental Committee on Graduate Students (see page 89).

ASSISTANTSHIPS

Subfaculty academic staff appointments as teaching or research assistant are made upon recommendation of heads of departments. Request for consideration for such appointment should be addressed to the head of the appropriate department, and will be considered only when receipt of the "Application for Admission to the Graduate School" has been recorded by the Admissions Office.

Graduate students, whether or not they are also on the staff, may apply for financial assistance to the Technology Loan Fund Board.

THE GOODWIN MEDAL. The Goodwin Medal together with a cash prize may be awarded in any year (but not necessarily in every year) to a graduate student who is also a member of the academic staff of the Massachusetts Institute of Technology, in recognition of conspicuously effective teaching. Candidates for this award are nominated through departmental channels or by the Student-Faculty Committee to the Dean of the Graduate School.

THE GOODWIN PREMIUM. In any year in which there is no qualified candidate for the Medal, a cash award not to exceed $500 may be granted to any graduate student in recognition of originality, ingenuity, thoroughness, and a scholarly written presentation of research embodied in a thesis of conspicuously unusual merit. As in the case of the Medal, nominations but not applications are receivable by the Dean of the Graduate School.

GRADUATE FELLOWSHIPS

The capitalized name in each case is that of the donor of funds which support the Fellowship, or the name of the person memorialized by it. All awards are for the academic year beginning September 17, 1956, unless otherwise specified. In most cases, Fellowships are made available to individual Departments (see below); a limited number of Fellowships are also available to several Departments or fields (see page 209).

Aeronautical Engineering

AMERICAN BOSCH ARMA CORPORATION, for a Master's (or under certain conditions for a Doctoral) candidate in the Instrumentation Laboratory; tuition plus $1,600 single (or married but without dependents) or tuition plus $2,100 married and having dependents, status determined as of date of award.

AC SPARK PLUG, for a graduate student in instrumentation, tuition plus $2,100.

AVIATION WEEK, for a male U. S. citizen enrolled for an advanced degree, renewable as long as satisfactory academic rating is maintained, tuition plus $1,600.

DOUGLAS AIRCRAFT COMPANY, for a highly recommended graduate student, tuition plus $900.

RICHARD C. DU PONT, memorial fellowship in aeronautical engineering, for a graduate student in any year of his work toward an advanced degree, tuition plus $1,200 single, $1,800 married.

LESTER D. GARDNER, for a graduate student, $2,000.

GOODYEAR TIRE AND RUBBER COMPANY AND GOODYEAR AIRCRAFT CORPORATION, for an American citizen graduate student, tuition plus $1,600.

LOCKHEED LEADERSHIP FUND, for a graduate student in the field of aerodynamics, tuition plus $1,400.

REEVES INSTRUMENT CORPORATION, for a highly recommended graduate student in the field of instrumentation and automatic control, tuition plus $1,600.

SPERRY GYROSCOPE COMPANY, two fellowships, each for a graduate student in Aeronautical Engineering, tuition plus $1,600.

Architecture

GRUNSFELD FUND, for a distinguished advanced French student of the Ecole des Beaux Arts, for a year's study at M. I. T. and travel in the United States, to be selected from nominations presented to M. I. T. by the Ecole des Beaux Arts; tuition plus $1,500.

VOORHEES, WALKER, SMITH, AND SMITH, tuition plus $1,600.

Biochemistry

KARL TAYLOR COMPTON FELLOWSHIPS OF THE NUTRITION FOUNDATION, two fellowships for graduate work in the field of biochemistry, each tuition plus $1,600.

GENERAL FOODS CORPORATION, for an entering graduate student in biochemistry, whose research will be in the area of enzymology; tuition plus $1,600, renewable for each of two succeeding years.

Chemical Engineering

ALLIED CHEMICAL AND DYE CORPORATION, for a U. S. citizen in final year of graduate study, tuition plus $1,500 single, $2,000 married.

AMERICAN CYANAMIDE COMPANY, for a graduate student during his final academic year of residence in work toward the doctorate, tuition plus $1,500.

AMERICAN OIL COMPANY, for a student who attends either the School of Chemical Engineering Practice or the Engineering Practice School at Oak Ridge, for two terms, tuition plus $1,400.

AMERICAN VISCOSE CORPORATION, for two students to attend the School of Chemical Engineering Practice for one term, tuition plus $750 single, tuition plus $1,050 married.

CARBIDE AND CARBON CHEMICALS COMPANY, for a graduate student in Chemical Engineering, tuition plus $1,500 single or $2,100 married, for normal academic year or (at M. I. T.'s discretion) for calendar year.

CARBIDE AND CARBON CHEMICALS COMPANY, for a student who attends either the School of Chemical Engineering Practice or the Engineering Practice School at Oak Ridge, for one, two or three terms, tuition plus $1,400 single, $2,100 married, per twelve-month period.

R. M. CARPENTER, tuition plus $1,400.

R. S. CRAWFORD GRADUATE RESEARCH, for a graduate student whose work is in the field of elastic colloids, tuition plus $1,200.

DOW CHEMICAL COMPANY, for a graduate student whose research is in the field of high pressure chemical reactions, for two terms plus a regular summer session, tuition plus $1,200 single, $1,800 married.

E. I. DU PONT DE NEMOURS AND COMPANY, for a graduate student in any year of work toward a Doctorate, tuition plus $1,200 for first-year graduate student or $1,500 for later year if single, corresponding stipends if married $1,800 or $2,100.

GENERAL DYNAMICS CORPORATION, for a graduate student in nuclear engineering, tuition plus $1,800 single, $2,200 married.

GENERAL MOTORS CORPORATION (Research Laboratories Division), for a graduate student, renewable, tuition plus $1,200 single, $1,800 married.

GULF RESEARCH AND DEVELOPMENT COMPANY, for a graduate student in Chemical Engineering, preferably but not necessarily to a doctoral candidate beyond his first year of graduate study, for two regular terms, tuition plus $2,000.

HUMBLE OIL AND REFINING COMPANY, for a student enrolled for S.M. or a Doctorate, tuition plus $1,600.

KIMBERLY-CLARK CORPORATION, for a graduate student whose research is in a subject of interest to the paper and pulp industry; for two regular and one summer term, tuition plus $1,600.

ARTHUR D. LITTLE, memorial Fellowship for a candidate for a Doctorate, for two regular and one summer term, tuition plus $2,100.

MONSANTO CHEMICAL COMPANY, for a graduate student, preferably in his last year of a doctoral program, for two terms, tuition plus $1,750.

PITTSBURGH CONSOLIDATION COAL COMPANY, for a graduate student, candidate for a Doctorate, for three terms, tuition plus $1,800.

PROCTER AND GAMBLE COMPANY, two fellowships, each for a student in his first year of graduate study; for two terms, tuition plus $1,500.

STANDARD OIL FOUNDATION, for a graduate student whose thesis subject is in the field of basic research in Chemical Engineering, tuition plus $1,200.

Chemistry

AMERICAN CHICLE COMPANY, to a male graduate student, preferably a U. S. citizen in final year of doctoral study, tuition plus $1,600.

CONSUMERS UNION, for a graduate student in Chemistry in the field of physical chemistry of surfaces, tuition plus $1,000.

EASTMAN KODAK COMPANY, for a graduate student in Chemistry, tuition plus $1,400 single, $2,100 married and having dependent children.

ETHYL CORPORATION, for an American citizen graduate student in Chemistry engaged in research; tuition plus $1,500.

GENERAL ELECTRIC COMPANY, for a graduate student in Chemistry, tuition plus $1,750 single, $2,100 married with no dependent children, $2,500 married with one or more dependent children; such status to be as of September 30, 1956.

ARTHUR D. LITTLE, memorial Fellowship for a candidate for a Doctorate in Chemistry, tuition plus $1,400.

MONSANTO CHEMICAL COMPANY, for a graduate student, preferably in his last year of a doctoral program, for two terms, tuition plus $1,750.

FORRIS JEWETT MOORE MEMORIAL, for graduate study at M. I. T. or elsewhere, preference being given to the field of organic chemistry, tuition plus $1,400.

JAMES FLACK NORRIS MEMORIAL, for a candidate for a Doctorate, $2,500.

UNION CARBIDE AND CARBON, for a graduate student in his final year of predoctoral study, tuition plus $1,500 single, $2,100 married.

UNITED STATES RUBBER COMPANY, for a male candidate for a Doctorate, tuition plus $1,400 single, $2,100 married.

VISKING, for a graduate student in the final year of a doctoral program, tuition plus $1,500.

City Planning

F. W. CHANDLER, awarded upon recommendation of Head of Department to a candidate for the M.C.P., $1,200.

Civil Engineering

McCLINTOCK ENDOWMENT, for a graduate student in Civil Engineering, tuition plus $1,300.

Economics

ECONOMIC DEVELOPMENT, for a graduate student in the Department of Economics, tuition plus $1,400.

GOODYEAR TIRE AND RUBBER COMPANY, for a graduate student in the field of industrial economics or industrial relations, $2,500.

CLARENCE J. HICKS MEMORIAL, for a graduate of not more than 5 years (exclusive of military service) since his Baccalaureate from a college or university in the U. S. or Canada, who is a candidate for a Doctorate at M. I. T. in the field of Industrial Relations, up to $900.

INDUSTRIAL ECONOMICS AND INDUSTRIAL RELATIONS, for candidates for the Doctorate in these fields, several, up to $1,500.

WESTINGHOUSE FELLOWSHIP IN INDUSTRIAL RELATIONS, for a graduate student in this field, $2,500.

Electrical Engineering

GENERAL DYNAMICS CORPORATION, for a graduate student in the field of electronics, tuition plus $1,800 single, $2,200 married.

INTERNATIONAL BUSINESS MACHINES CORPORATION, for a graduate student in Electrical Engineering; tuition plus $1,500 single or married but without children, $2,500 married but with one child or more.

MELPAR, INCORPORATED, for a graduate student in electronics and communications, tuition plus $1,400.

MINNEAPOLIS HONEYWELL, for graduate work in feedback control, tuition plus $1,400.

SCHLUMBERGER FOUNDATION, for a graduate student in Electrical Engineering, tuition plus $1,500.

Food Technology

AMERICAN CHICLE COMPANY, tuition plus $1,600.

THE COFFEE BREWING INSTITUTE, tuition plus $1,600.

GERBER PRODUCTS COMPANY, tuition plus $1,600.

PROCTER AND GAMBLE, for a graduate student in Food Technology, tuition plus $1,600–$2,200.

ROCHE ANNIVERSARY FOUNDATION, tuition plus $1,600.

Geology and Geophysics

STANDARD OIL COMPANY OF CALIFORNIA, for a graduate student in the field of earth science, tuition plus $1,500.

Industrial Management

SCHOOL OF INDUSTRIAL MANAGEMENT, for advanced study and research in Industrial Management, for college graduates whose major studies have been in science, engineering, and engineering administration. Awards may be continued for second year of study if performance justifies. A number of fellowships, tuition plus up to $1,400 single, up to $2,100 married.

SLOAN, for training in executive development, for industrial executives of some experience who are nominated by their employers, a twelve months' program with grants.

Mathematics

MATHEMATICS, for graduate students who are studying in the Department of Mathematics for careers of research or teaching in the various fields, tuition plus $1,300.

Mechanical Engineering

E. I. DU PONT DE NEMOURS AND COMPANY, for a graduate student in any year of work toward a Doctorate; tuition plus $1,200 for first-year graduate student or $1,500 for later year if single, corresponding stipends if married $1,800 or $2,100.

GENERAL MOTORS CORPORATION, for a graduate student in automotive engineering, tuition plus $1,200 single, $1,800 married.

LASALLE STEEL FOUNDATION, to a graduate student working either toward S.M. or Sc.D. in Mechanical Engineering, whose major field of interest including thesis is in the field of metal-cutting; tuition plus $1,400 single, $2,000 married.

PROCTER AND GAMBLE, for a graduate student in Mechanical Engineering; tuition plus $1,400 single, up to $2,100 married.

SHELL, for a graduate student, candidate for the S.M. or Sc.D., preference to be given to doctoral candidate in last year of work, renewable, tuition plus $1,500.

Metallurgy

ALLEGHENY-LUDLUM, two fellowships for graduate students whose thesis research is on topics of interest to the alloy steel industry, tuition plus $1,800–$2,400.

ALUMINUM COMPANY OF AMERICA, three fellowships for graduate students whose thesis research is on topics of interest to the aluminum industry, tuition plus $1,200 to $1,800.

AMERICAN BRAKE SHOE COMPANY, for a graduate student, tuition plus $1,800.

ARMCO FOUNDATION, to a graduate student for research in the general field of metallurgy, tuition plus $1,200–$2,200.

CRANE COMPANY, for a graduate student in the Department of Metallurgy, whose major interest is in the field of foundry research; for two regular and one summer term, tuition plus $1,800.

GENERAL ELECTRIC, for a graduate student in Metallurgy, tuition plus $1,750 single, $2,100 married with no dependent children, $2,500 married with one or more dependent children; such status to be as of September 30, 1956.

HORIZONS, INC., for a graduate student in Metallurgy, for two regular plus one summer term, tuition plus $2,100 for 12 months.

INTERNATIONAL NICKEL COMPANY, for a postgraduate student or postdoctoral fellow for fundamental studies in the field of corrosion; tuition plus $2,100 per calendar year.

KENNECOTT COPPER CORPORATION, for a graduate student in Metallurgy, $2,000 including tuition.

MUCHNIC FOUNDATION, for a graduate student in Metallurgy, for research in foundry, tuition plus $1,800.

NATIONAL STEEL CORPORATION, for a graduate student in Metallurgy, whose research is in the general field of the plastic behavior of steel; tuition plus $1,500 single, $2,100 married.

NELCO METALS, for a graduate student for research on cast iron, tuition plus $2,700 per calendar year of three academic terms.

UNION CARBIDE AND CARBON CORPORATION, for a graduate student in the general field of metallurgy; tuition plus $1,500 single, $2,100 married, for two regular terms.

UNION CARBIDE AND CARBON CORPORATION, for a graduate student in the field of mineral engineering; tuition plus $1,500 single, $2,100 married, for two regular terms.

WEIRTON STEEL COMPANY, for fundamental studies in corrosion, tuition plus $1,200.

Physics

GENERAL ELECTRIC, for a graduate student in Physics, tuition plus $1,750 single, $2,100 married with no dependent children, $2,500 married with one or more dependent children; such status as of September 30, 1956.

INTERNATIONAL BUSINESS MACHINES CORPORATION, for a graduate student in the field of physics; tuition plus $1,500 single or married but without children, $2,500 married but with one child or more.

SHELL, for a graduate student, candidate for the S.M. or Sc.D., preference to be given to doctoral candidate in last year of work, tuition plus $1,500.

Various Fields

BOEING AIRPLANE COMPANY, for a graduate student in engineering or science in a field relating to the aircraft industry; tuition plus $1,400.

WILLIAM SUMNER BOLLES, for graduate work in any Department, $1,200.

COATS AND CLARK, INC., three fellowships, each for a graduate student in a field of textile technology, whose thesis research is in that division, tuition plus $900.

FLUOR FOUNDATION, tuition plus $1,400–$1,900, in engineering fields, with preference for (but not restricted to) chemical and mechanical engineering.

INDUSTRIAL FELLOWSHIPS, for graduate work in electronics, tuition plus $1,600 single, $2,400 married, advanced fellowships up to $3,000. Sponsored by the GABRIEL COMPANY, GENERAL COMMUNICATIONS COMPANY, INTERNATIONAL TELEPHONE AND TELEGRAPH COMPANY, RADIO CORPORATION OF AMERICA, SPERRY GYROSCOPE COMPANY.

INTERNATIONAL BUSINESS MACHINES CORPORATION, for a graduate student in certain areas of chemistry, communication theory, electronics, information theory, mathematics, physics, etc.; tuition plus $1,500 single or married but without children, $2,500 married but with one child or more.

WILLIAM S. KNUDSEN, for a graduate student in any field of science or engineering, tuition plus $1,200 single, $1,800 married.

SOLAR ENERGY, four fellowships for graduate students, candidates for the Doctorate in Chemistry, Physics or Engineering or candidates for Master of Architecture, for study in a field which may lead to improved use of solar energy, tuition plus $1,400 single, $2,100 married, for two terms but renewable.

GERARD SWOPE, for students of exceptional ability and promise, as a mark of highest distinction.

UNITED STATES STEEL FOUNDATION, for a U. S. citizen graduate student in the general area of industrial organization and management; tuition plus $1,500 single, $2,100 married.

GRADUATE SCHOLARSHIPS

Unrestricted

AUSTIN FUND	$30,000
COLLAMORE AND ROGERS FUNDS (for women)	700
SALTONSTALL FUND	600
SAVAGE FUND	600
SWETT FUND	600
UPHAM FUND	50,000
WHITNEY FUND	60,000

In Specified Fields

EASTMAN KODAK COMPANY, for an M.S. candidate (preferably a U. S. citizen) in the Chemical Engineering Practice School, tuition.

Regional Awards

HEBREW INSTITUTE OF TECHNOLOGY, Haifa, Israel, for a staff member, tuition, in conjunction with an award by The Boston Stein Club.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, London, England, tuition.

M. I. T. CLUBS OF MEXICO, for a graduate student nominated by the Alumni of M. I. T. Clubs of Mexico City and Monterrey, tuition.

THEODORE B. PARKER MEMORIAL for graduates of colleges of the Tennessee Valley States, tuition.

VERMONT SCHOLARSHIP, open to a native of Vermont or a graduate of Middlebury College or Norwich University. Undergraduate applications have preference, tuition.

APPENDIX B

STUDENT HOUSING

Including Men's Residences, Women's Residence, and Residences for Married Students

THE UNDERGRADUATE HOUSES

THE student residences at the Massachusetts Institute of Technology have been planned to afford an economical, comfortable place in which to live, an environment conducive to study, and an opportunity to participate in those social and extracurricular activities which properly supplement scholastic work. Faculty Residents occupy quarters in each of the three residential centers. Chosen for their understanding of students and student questions, these men welcome informal friendly discussions with their fellow residents.

The Institute believes that it is to the great advantage of all students who do not live at home to live in Institute Houses or in fraternities. As far as accommodations allow, such residence is required for all freshmen unless other special arrangements are approved by the Associate Dean of Students. Upperclassmen are free to make whatever living arrangements they choose.

The undergraduate Houses are administered as a part of the general plan of student self-government at the Massachusetts Institute of Technology. The student Dormitory Council organizes and supervises all student activities, athletic and social, and co-operates with recognized undergraduate activities at the Institute. A House Tax included in rental is turned over to the Dormitory Council for social and athletic activities.

The success of student self-government depends upon the maturity of each resident and his willingness to co-operate, and therefore upon the responsibility which the group as a whole is willing to assume. Those who are unable or unwilling to live under student government and support its principles in the strictest sense, whether on or off the Institute grounds, are undesirable tenants, and are so recognized by the Dormitory Council and the Institute's Faculty and Administration. The privilege of residence in the undergraduate Houses will therefore be denied to those who do not accept this responsibility.

THE EVERETT MOORE BAKER HOUSE (WEST CAMPUS)

Located on the river front at 362 Memorial Drive, Cambridge, west of Massachusetts Avenue, Baker House accommodates some 350 students in single, double, or triple rooms. All private rooms receive direct sunlight during most of the day, and nearly all have spectacular views across the Charles River Basin. On the north are living rooms with large window areas looking out on the Institute's playing fields. Generous lounge space is provided on each of the floors, with a main lounge adjoining the entrance. On the ground floor is a community area including music, recreation, and social rooms. Baker House has its own dining facilities, where residents are expected to take commons meals. (See Page 211.)

THE ALFRED EDGAR BURTON HOUSE (WEST CAMPUS)

This House is also on the river front at 410–420 Memorial Drive, Cambridge, west of Baker House. It consists of five units accommodating 600 students. There are some single and double rooms but most of the accommodations are suites of rooms designed for congenial groups. Conner Hall, the name of the section of Burton House comprising units 1 and 2 of the 410 section, is operated on the co-operative plan and residents accept responsibility for the care of their own rooms. Units 3, 4, and 5 of the 420 section are not on a co-operative basis and the rooms are cared for by Institute personnel.

Residents of the House who choose to do so may include the fee for commons meals with the rental and will be served in one of the campus dining rooms, where à la carte service is also available. The building has a number of lounge and game rooms, and a bicycle room. A snack bar on the ground floor accommodates all students who live on West Campus; open from 7:30 in the morning to 12:00 midnight, seven days a week, this provides a very pleasant place to meet friends and relax.

THE FACULTY HOUSES: WARE, ATKINSON, RUNKLE, HOLMAN, NICHOLS, AND CRAFTS (EAST CAMPUS)

These six Houses, located on Memorial Drive east of Walker Memorial and adjacent to the President's House, accommodate about 225 students.

Most of the first floor rooms in all the Houses except Crafts and Ware are designed for single occupancy. On the upper floors most of the quarters are suites, composed of a living room, a dressing room with lavatory, and a sleeping room arranged for two students.

THE ALUMNI HOUSES: MUNROE, HAYDEN, WOOD, GOODALE, BEMIS, WALCOTT (EAST CAMPUS)

Situated on the main campus near Walker Memorial, these six houses have accommodations for 430 men. Most of the rooms are designed for single occupancy — with a limited number of double and triple suites. There are lavatory installations in all these rooms, supplemented by adequate toilets and showers on each floor of every house.

Dining facilities for residents of the East Campus Houses are in the Walker Memorial Building. This includes a large cafeteria where both commons meals and à la carte service are provided. A modern social room and soda bar, where light refreshments are served, is located in Pritchett Lounge on the second floor. This room is open during the evening hours, and is equipped with a dance floor and other facilities for entertainment.

Assignment of Rooms

Applications from students who have not been notified of admission to the Institute cannot be considered. Freshmen and college transfer students entering the Institute receive with their notice of admission a form for securing information about the Houses, including an application card. The application should be filed with the Associate Dean of Students, Room 7-102, Massachusetts Institute of Technology, Cambridge 39. In filling out the application, students are requested to indicate first and second choices of Houses and of rooms within a House.

Freshmen should note that single rooms in Baker House and Burton House are generally taken up by upperclassmen when assignments for the following fall are made each spring to students already in residence. Accommodations reserved for Freshmen vary from year to year but are arranged to care for as many as possible of the first-year students who do not live at home or in a fraternity house. Freshman applications received before August 1 are acted on in early August, and assignments are made as applications are received thereafter. Applicants are notified as assignments are made.

Upperclassmen transferring from other colleges should file application cards with the Associate Dean. Because the demand for accommodations so nearly equals the capacity of the Houses, assignment of rooms to upperclassmen transferring to the Institute is made only after Freshman assignments are completed. Notification is made as promptly as possible. College transfer students who file late applications or who have not received notice of assignment by Registration Day should report to the Associate Dean on arrival in Cambridge.

Occupancy

The period of occupancy begins for entering Freshmen on the Wednesday preceding Registration Day, and for all others on the Saturday preceding Registration Day (see the Calendar in the General Catalogue). It ends at the close of the day following the last day of the scheduled final examination period for all students except those being graduated, who may continue in residence without charge until noon of Commencement Day. Other students desiring to occupy rooms earlier or later than these dates may do so through prior arrangements with the Associate Dean of Students.

On arrival in Cambridge, a student should report to the desk in the lobby of the House to which he has been assigned. At this time he will complete his dormitory registration and obtain a key. Every effort will be made to accommodate students who find it impossible to arrive during the normal business hours; in the event of difficulty in locating the proper dormitory unit, inquire at the Institute's Information Office in the Rogers Lobby at 77 Massachusetts Avenue, which is attended at all times.

A student is not allowed to sublet or transfer his room or his share in a room to any person.

Fraternity Affiliation

Recognized fraternities at the Massachusetts Institute of Technology include twenty-seven chapters situated on private property in Cambridge, Boston, and Brookline. Residence in the undergraduate Houses or fraternities provides very intimate contact with Technology life and activities. Approximately ninety per cent of the fraternity Freshmen are pledged early in the Fall term. Parents who anticipate fraternity affiliation for their sons should, if possible, encourage them to participate in Rush Week and grant them permission to act on their own initiative. The satisfactory and permanent housing of a large group of entering students can be accomplished best through the co-operation of parents, students, fraternities, and Institute housing representatives in making early and prompt decisions so that temporary housing is reduced to a minimum. Freshmen and other new students are therefore requested to withdraw applications for residence promptly if they are certain that such accommodations will not be required.

Commons Meals

Commons meals are required for all students living in Baker House and are available in the Walker Memorial Dining Hall as well. Three meals are served each day Monday through Friday, except during stated vacation periods. On Saturdays and Sundays, and during vacations, the dining facilities of the Institute are available on a cash basis.

The fee for commons meals for the Fall Term, 1956, is $10.75 per week, payable for the full term in advance with tuition. Fees for meals are subject to review and change at the end of each semester. Arrangements for deferred payment may be made through the Bursar before payment is due.

Fees — Refunds

Room Rentals. Rental rates for accommodations in the dormitories vary from $120 to $190 each person each term. The following are the current rates:

East Campus: $165 each student each term, except for: Bemis double rooms 112, 212, 312, 412, and 512; Atkinson single rooms 204A, 304A, 404A, and 204B, 304B, and 404B; and Runkle single rooms 206A, 306A, 406A, 501, 502, 505, 601, 602, 603, 604, 604A, 605, and 605A — all of which are $130 each term each man.

Baker House: $190 each student each term.

Burton House: $120 each student each term in the Co-operative Section; see accompanying floor plan for rates in the 420 section of this House.

Rent for the full term is payable with tuition to W. A. Hokanson, Bursar, except when prior arrangements are made with the Bursar for deferred payments.

Rooms are engaged for the full academic year. Reservations are automatically cancelled and a proportionate refund is allowed upon withdrawal of a student from the Institute or transfer to a co-operative course, or in the event of a leave of absence for military service, or in circumstances approved by the Office of the Dean of Students. Students resident in the undergraduate Houses who desire to move to recognized fraternities after Registration Day and prior to the end of the second week of the Fall term or during the first two weeks of the Spring term, and whose transfer is requested by authorized representatives of the fraternity, will be refunded the rental fee less a pro rata charge for occupancy.

Equipment and Service

All single rooms in the undergraduate Houses have a special bed or couch, mattress, pillow, blankets, mirror, chiffonier or wardrobe, desk and chair, study chair, bookcase, wastebasket, light bulbs, and extra electrical outlets. Interdormitory telephone service is provided. Double and triple suites are furnished in a manner similar to the single rooms. Each occupant is required by the student dormitory government to complete an equipment inventory acknowledgment at the opening of the Fall term, indicating the condition of the room and the furnishings. Bed linen is furnished in all houses. Except for the Co-operative Section of Burton House, the beds are made up with fresh linen once a week by Institute personnel and the rooms are cleaned daily, except on week ends and holidays. In the Co-operative Section of Burton House, each occupant is responsible for the cleaning and care of his own room, drawing fresh bed linen once a week from the supply room. Students in all houses provide their own towels and soap. For maintenance and safety, rooms are inspected regularly during the normal working hours by responsible Institute personnel.

Basic Regulations

In applying for a room in the Houses, a student is understood to agree to abide by the following basic regulations:

1. Only one room application form per student may be filed. Duplicate applications will not be considered.
2. Upperclassmen who are assigned rooms in the Houses in the spring will receive a card which must be signed and returned by August 1, 1956, in order to confirm acceptance of a room assignment. Students from whom no card is received will lose their assignment and be transferred to the bottom of the waiting list. Under special conditions approved by the Associate Dean of Students, students may be relieved of the responsibility for confirmed assignments up to, but not including, September 17, 1956.
3. Room changes within the dormitories will be made in special circumstances only, with the approval of the Associate Dean of Students. Changes requested during the first three weeks of any term will not be effected until the end of the three-week period. Vacancies occurring during the first three weeks of any term will be filled directly from the waiting list, if any. At the end of the three-week period, priority in moves will be given residents as of Registration Day over men assigned rooms after Registration Day.
4. Students engaging dormitory rooms will be expected to live in the dormitories throughout the academic year except if they (1) leave the Institute, (2) move to a fraternity as indicated below, (3) secure a new occupant not in residence to take over the room, (4) present special circumstances to the satisfaction of the Associate Dean of Students. Students so leaving the dormitories will be charged for the period of occupancy pro rata.
5. Students may move from the dormitories to a fraternity only during the first two weeks of the Fall term and during the first two weeks of the Spring term.
6. The Institute reserves the right to move students within the dormitories at its discretion for purposes of consolidation of vacancies, other demands upon dormitory facilities, etc. In these circumstances, students will be allowed to leave the dormitories, instead of moving, with the approval of the Associate Dean of Students.
7. Students who do move from the dormitories for any reason will be responsible for room rent until they have signed out at the office of the Associate Dean of Students, Room 7-102.
8. As a general rule, students may not occupy doubles as singles, triples as doubles, etc. If extra rooms are available, students may so occupy rooms at the Institute's convenience or protect the privilege in any given term by payment of $50.00 each.
9. For reasons of safety and sanitation, no cooking equipment may be used in the Houses.
10. Refrigerators are allowed in students' rooms but must be licensed at a fee of $2.50 per term to cover costs. Refrigerators are subject to inspection for reasons of safety.
11. Damage of Institute property in the dormitories is the responsibility of the residents. Each student is held accountable for any damages in his own room, the entire dormitory, or any part thereof as may be determined by Student Government.
12. All students electing to live in Baker House are required to register for Commons Meals.
13. Open house regulations and regulations for extra-curricular activities in the dormitories are among the responsibilities of Student Government in the Houses. The Faculty and Administration expect all students to abide by the regulations of Student Government.

General Information

Key Deposits. A deposit of $1 is required for a room key, subject to refund in full upon return of the key.

Parking and Automobile Regulations. Because of the acute shortage of on-campus parking space, the Institute cannot provide parking facilities for use of resident students. A limited number of spaces are provided, with the approval of the Associate Dean of Students, for residents with physical handicaps demanding use of an automobile.

Operators of motor vehicles should consult the office of the Dean of Students or the Massachusetts Registry of Motor Vehicles regarding regulations and insurance of out-of-state motor vehicles. The registration and operating licenses of certain states are not honored in Massachusetts after thirty days.

Storage. Space is available in the basements for trunks and baggage during the academic year only and at the owner's risk. The Institute assumes no liability, and articles must be removed when occupancy is terminated. No packing cases or trunks are permitted in the rooms.

Mail, Parcel Post, and Express Service. Each room or suite has a separate combination lock mail box, located in the House office. In addressing mail or packages to a student in the Houses, please specify the House (e.g. East Campus, 3 Ames Street; Burton House, 420 Memorial Drive; or Baker House, 362 Memorial Drive; or the Graduate House), Massachusetts Institute of Technology, Cambridge 39, Massachusetts.

Telephone Service. Local and long distance calls for resident men students should be made by calling UNiversity 4-6900. An inter-dormitory telephone system provides internal service between rooms (corridors in Burton House) of the various men's residence Houses. Telephone pay stations for outgoing telephone calls and telegrams are conveniently located about the Houses.

Laundry and Valet Service. Laundry and valet service by the Institute's authorized suppliers is available at reasonable prices to residents of the Houses for their personal laundry and cleansing on a cash basis. Laundry bags, slips, and tags are available at the office desks.

Opportunities for Student Employment

As stated under "Financial Aids" in the General Catalogue, the Institute provides many opportunities for students to earn a part of their expenses. The operations of the dormitories and the Dining Service lend themselves especially to part-time work; Burton House, for example, is staffed entirely by student personnel. For information, write to Dean T. P. Pitré, Director of Student Aid, at the Institute.

WOMEN'S RESIDENCE

The Women's Dormitory, located at 120 Bay State Road, Boston (telephone CIrcle 7-8646) accommodates 17 students. It is an attractively furnished house where girls may enjoy a homelike atmosphere. A House Mother is in residence. The Dormitory is a fifteen to twenty minute walk to M. I. T. Breakfast and dinner are served to all residents during the academic year in accordance with the schedule planned in advance by the residents of the House. The girls also have the privilege of preparing their lunches with food provided by the House. Application forms as well as further information may be obtained from the Assistant to the Dean of Students.

THE GRADUATE HOUSE (WEST CAMPUS)

The Graduate House, with a capacity of 452 residents, is reserved exclusively for men graduate students. It is located at Memorial Drive and Massachusetts Avenue, Cambridge, directly across the avenue from the main educational buildings. The House was established in the belief that "those contacts which aid in developing qualities of leadership and co-operation would be encouraged by bringing graduate students into one group." In further justifying this new development in student life at the Institute, it was pointed out that "the most natural training comes from free social intercourse between men of different interests but of equivalent intellectual outlook."

On the first floor of the west wing of the House are the public rooms and the dining rooms. In addition to an attractive lounge, the Crafts Living Room and Library, named for James M. Crafts, President of the Institute at the turn of the century, are on the first floor at the end of the west corridor leading towards the Charles River. The Macomber Room, a small lounge, also opens from this corridor, and is used chiefly in connection with the Fabyan Dining Room. The Buttery, containing a soda bar, is located on the lower level of the west wing. The hand ball court, the ping-pong room, the photographic dark room, and a large, modern shower room are in the corresponding east wing basement.

A member of the Faculty who is familiar with the general aims and problems of graduate students is resident House Master. A student House committee, acting with the advice and assistance of the House Master, has charge of the activities program.

A number of general social activities are sponsored by the Graduate House. Informal gatherings are held on Tuesday and Thursday evenings in the Buttery. Sunday afternoon teas are held during the academic year. A series of Graduate House dinners is held on Wednesday evenings from the end of October until the middle of April, and a distinguished guest is invited on each of these occasions to make a brief address. Participation in these different functions is urged for all residents of the Graduate House.

In keeping with the widespread interest in athletics among graduate students, there are organized in the House teams in touch-football, in basketball, in bowling, in soft ball, and in rugby. To take advantage more fully of the facilities for sailing afforded by the Institute, House residents participate in the shore school held by the Nautical Association. Opportunities are available for contests in the game rooms within the House and for tennis and squash on courts maintained by the Institute.

A House Tax, included in the rental, is turned over to the Graduate House Committee for library, athletic, and social activities, and for the maintenance of the dark room, the Buttery hour, and the music room.

The Crafts Living Room is a large, comfortably furnished living room designed for the use of residents and their guests at any time from eight o'clock in the morning until midnight. The Lounge is available for similar purposes. The Crafts Library is a collection of more than two thousand volumes dealing with the history of science, engineering, architecture, economics, philosophy, and the biographies of eminent scientists, engineers, architects, and philosophers. The most useful handbooks for engineering and science together with dictionaries and encyclopedia are provided. The library carries subscriptions to a number of leading magazines.

Applications for Rooms

Applications for rooms in the Graduate House should be made to the Associate Dean of Students, Room 7-102, Massachusetts Institute of Technology, Cambridge 39. Application forms are sent with the notice of admission to new graduate students. Application forms will be distributed to present residents who may file their application with the Superintendent of the Graduate House.

If applying for double or triple suites, the applicant may indicate on the application suggestions of possible roommates. Lacking any suggestions, he will be provided an opportunity for meeting prospective roommates.

Assignment of Rooms

Priority in the assignment of rooms is granted to graduate students already living in the House whose applications are filed in accordance with a circular issued during the Spring Term. Notices of assignments will be forwarded to these applicants as soon as possible. Acceptances must be returned as requested; otherwise, the rooms may be reassigned. The assignment of the remaining rooms by the Associate Dean will be in order of application. The right is reserved to reject any applicant for sufficient reason.

Occupancy

The period of occupancy for an academic year begins on the Wednesday preceding Registration Day (see Calendar in the Catalogue). It ends at the close of the day following the last day of the scheduled final examination period, except for those receiving degrees at Commencement, who may remain in residence until noon of Commencement Day.

Fees — Refunds

Rental rates for the Graduate House for the year 1956–57 are shown on the accompanying plans.

Rent for the full term is payable with tuition to W. A. Hokanson, Bursar, except when prior arrangements are made with the Bursar for deferred payments.

Rooms are engaged for the full academic year. Reservations are automatically cancelled and a proportionate refund is allowed upon withdrawal of a student from the Institute or transfer to a co-operative course, or in the event of a leave of absence for military service.

General Information

Please refer to the undergraduate section on the preceding pages for the Basic Regulations on occupancy and for information on: Equipment and Service, Key Deposits, Storage, Mail, Parcel Post and Express Service, Telephone Service, Laundry and Valet Service, Commons Meals, Opportunities for Student Employment, and Parking and Automobile Regulations.

RESIDENCES FOR MARRIED STUDENTS

"Westgate" and "Westgate West" are housing developments on the campus designed for married students and their families. The 270 families accommodated there are a self-contained and self-governing community, with a well-rounded program of community activities. The governing body is the Westgate Council, elected by the residents, which directs and supervises the affairs of the village; service on the Council is a matter of responsibility and honor, and residents are expected by the Institute to give their support to the Council's activities.

The Westgate project consists of temporary one-story dwellings on the Institute Campus. There are 100 houses in the group, arranged in either single or duplex units. They are similar to small apartments with the privacy of a home and with the additional advantage that each house has its own plot of land.

Fifty of the homes consist of a living room, kitchenette closed off by doors, bath, one bedroom, and closet space. The other 50 have in addition an extra bedroom and a separate kitchen.

Both the small and large units in Westgate are unfurnished except for a refrigerator, stove, and kitchen cabinet, all in one compact unit. All of the units have thermostatically controlled gas heaters and hot water units.

Tenants occupying Westgate units are required to sign a lease under which the rent is $51 and $63 per month for the one-bedroom and two-bedroom units, respectively, including electricity and water. The cost of gas for cooking, heating, and hot water is not included in the monthly rental given above and is estimated to be approximately $10 a month over the calendar year.

Westgate West, with 170 apartments, is adjacent to Westgate. Each two-story building contains 10 apartments; each of these has its own private entrance, and consists of two bedrooms, a living room, kitchen, bath and storage space. Some of the apartments are partially furnished, but tenants are responsible for providing their own furniture. The apartments are equipped with an ice box, gas stove, and thermostatically controlled gas heater and hot water unit. Gas refrigerators are not permitted in either Westgate or Westgate West, but tenants may install their own electric refrigerators in Westgate West.

Tenants occupying Westgate West units are required to sign a lease under which the rental is $37 per month, including water but not electricity or gas. It is estimated that $15 per month should cover the cost of gas and ice, over and above the rental quoted. Electricity is metered and the cost subject to the amount used. Telephone connections are available to residents of both Westgate and Westgate West on application to the telephone company.

Off-highway play areas are provided for the children and a nursery school of limited enrollment is available to Westgate and Westgate West children from the ages of two to five. The nursery school is in operation at stated hours, by age groups, on school days (except Institute holidays) and is in the charge of a trained nursery school teacher who is assisted by two or three apprentice teachers. The school has grown out of the efforts of the Westgate Council. It is subsidized in part by the Technology Christian Association. A Well Baby Clinic is held once a month. A recreation room has been provided for the Westgate Council meetings and special parties. For the convenience of Westgate and Westgate West wives, a community laundry is located on the premises and is easily accessible to the tenants. Limited parking space is available adjacent to the houses for residents.

Eligibility Regulations

1. Eligibility for Residence
   - (*a*) Students must be married. (In case of students planning to be married, leases will be signed on statement of intent.)
   - (*b*) Students must be regular students, candidates for a degree, or full-time special students carrying 36 units or more. (In case of doubt regarding a student's status, the ruling of the Dean of the Graduate School will be final for graduate students, the ruling of the Dean of Students for undergraduate students.)

2. Priority on Moving In
   - (*a*) Priority will be determined by date of application, with all veterans given 4 months' credit on the waiting list.
   - (*b*) Married students with children, or expecting their first child during the first semester of proposed occupancy, will have top priority at any time.

3. Conditions of Continued Residence
   - (*a*) Maintenance of eligibility as defined in 1. except:
     - (1) That a resident may interrupt his studies for one semester per calendar year (both terms of Summer School are considered as one semester).

4. Conditions of Required Termination
   - (*a*) Students becoming ineligible during any term shall be given at least 30 days' notice. Termination shall take effect on either the 15th or last day of the month.
   - (*b*) Students becoming ineligible at the end of a term will be required to meet the following termination dates following ineligibility:
     - (1) End of fall term — February 28 (29)
     - (2) End of spring term — June 30
     - (3) End of summer term — September 30

5. Conditions of Sub-Letting
   - (*a*) Tenants may sub-let apartments for one term a year when they are interrupting their studies and shall take entire responsibility for temporary tenants.
   - (*b*) Sub-let tenants must have official connection with M. I. T., unless other arrangements are approved by the Associate Dean of Students.
   - (*c*) In order to protect legally both the tenant and the Institute, tenants must secure written consent of the Associate Dean of Students before sub-letting.

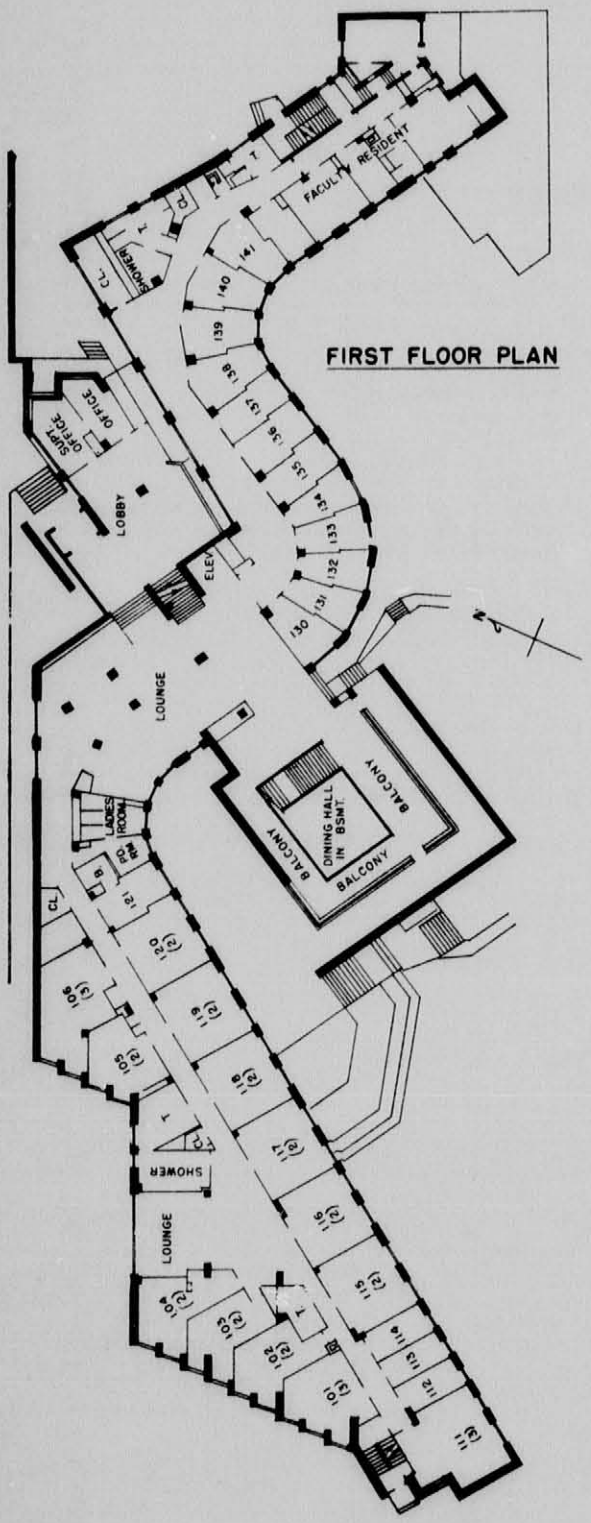
6. Situations not covered by the regulations above may be discussed with the Associate Dean of Students.

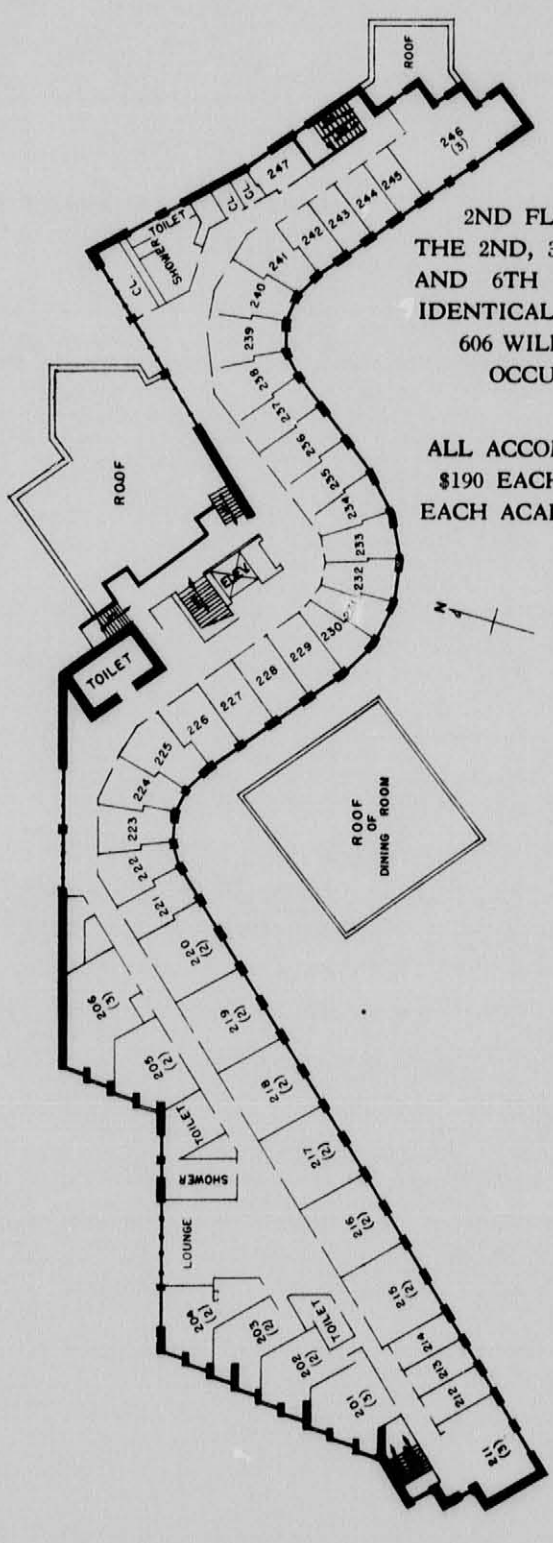
Applications for Westgate and Westgate West should be submitted to the Associate Dean of Students.

Married students who cannot be accommodated in Westgate or Westgate West should refer to the Housing Bureau of the Technology Christian Association, Walker Memorial, Massachusetts Institute of Technology, Cambridge 39, for local real estate listings.

UNDERGRADUATE HOUSES

The Baker House (West Campus)





2ND FLOOR PLAN
THE 2ND, 3RD, 4TH, 5TH. AND 6TH FLOORS ARE IDENTICAL EXCEPT ROOM 606 WILL BE FOR 2 OCCUPANTS.

ALL ACCOMMODATIONS $190 EACH OCCUPANT EACH ACADEMIC TERM.

UNDERGRADUATE HOUSES

The Burton House (West Campus)

420 Memorial Drive

First Floor

PARENTHESES INDICATE NUMBER OF OCCUPANTS

UNDERGRADUATE HOUSES

The Burton House (West Campus)

420 Memorial Drive

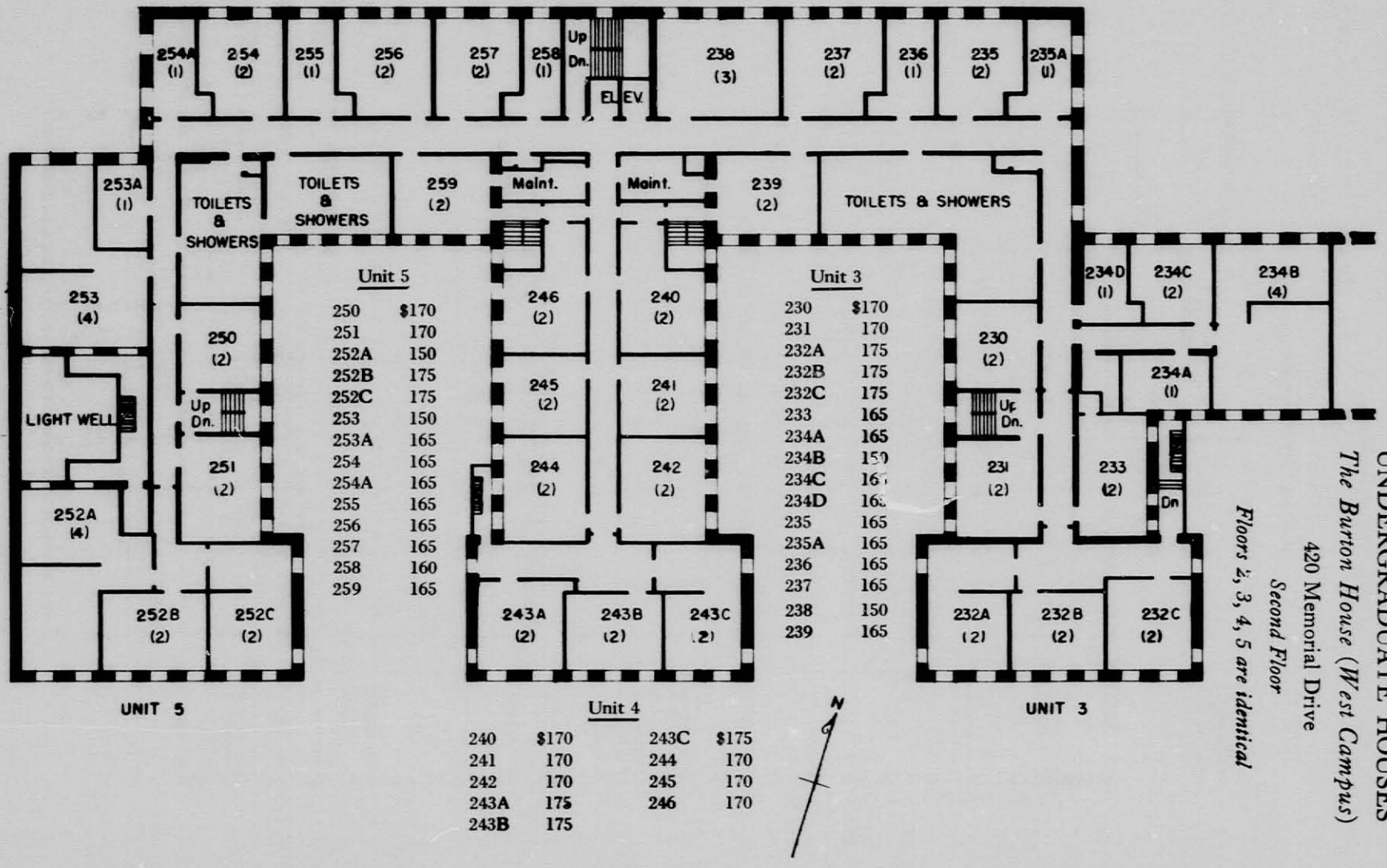
Second Floor

Floors 2, 3, 4, 5 are identical

Rates for Second Floor

(Rates for Floors 3, 4, 5 are the same)

Prices listed are for each occupant each academic term
Parentheses indicate number of occupants



Unit 5

250	$170
251	170
252A	150
252B	175
252C	175
253	150
253A	165
254	165
254A	165
255	165
256	165
257	165
258	160
259	165

Unit 3

230	$170
231	170
232A	175
232B	175
232C	175
233	165
234A	165
234B	150
234C	165
234D	165
235	165
235A	165
236	165
237	165
238	150
239	165

Unit 4

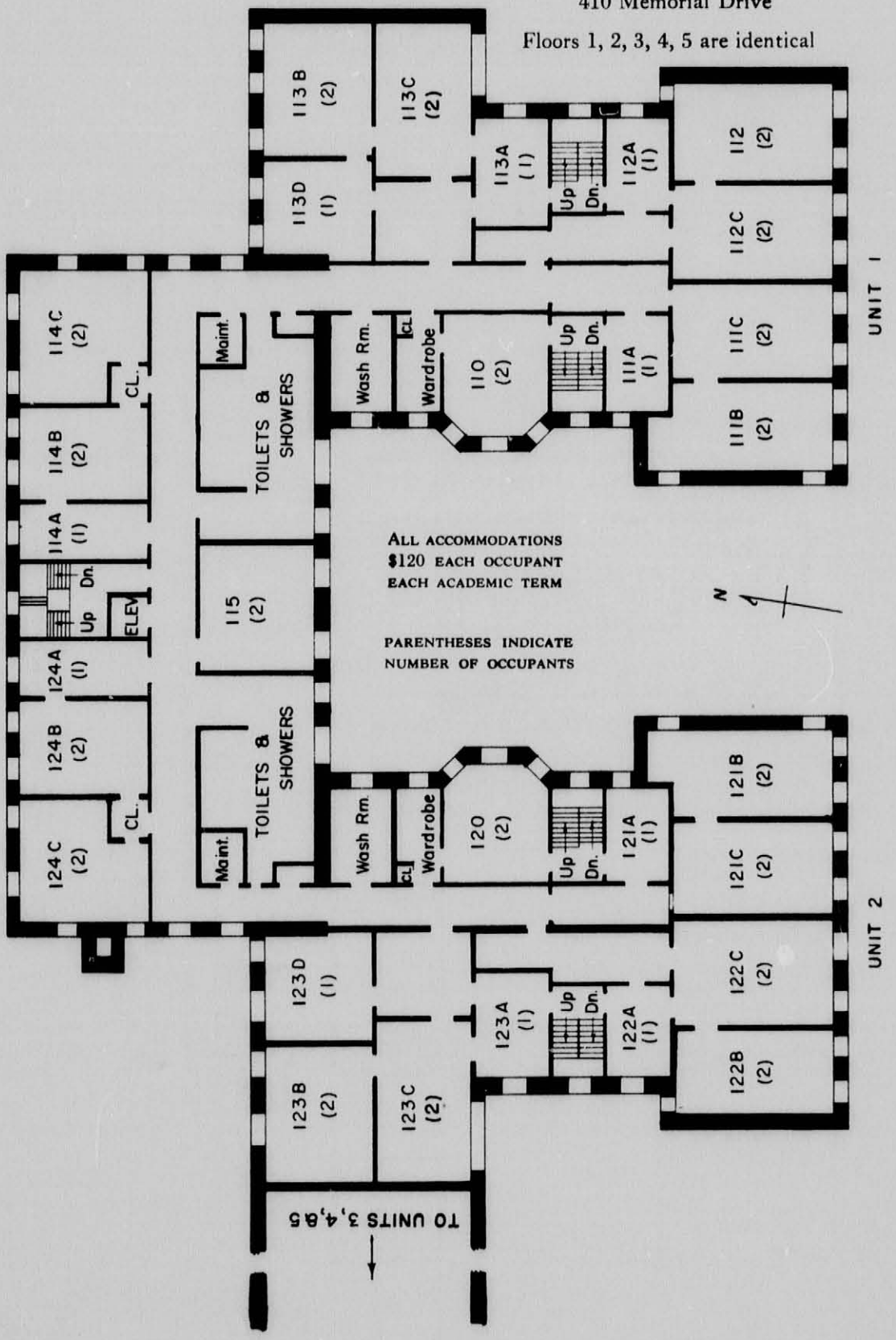
240	$170	243C	$175
241	170	244	170
242	170	245	170
243A	175	246	170
243B	175		

UNDERGRADUATE HOUSES

Conner Hall (West Campus)

410 Memorial Drive

Floors 1, 2, 3, 4, 5 are identical



UNDERGRADUATE HOUSES

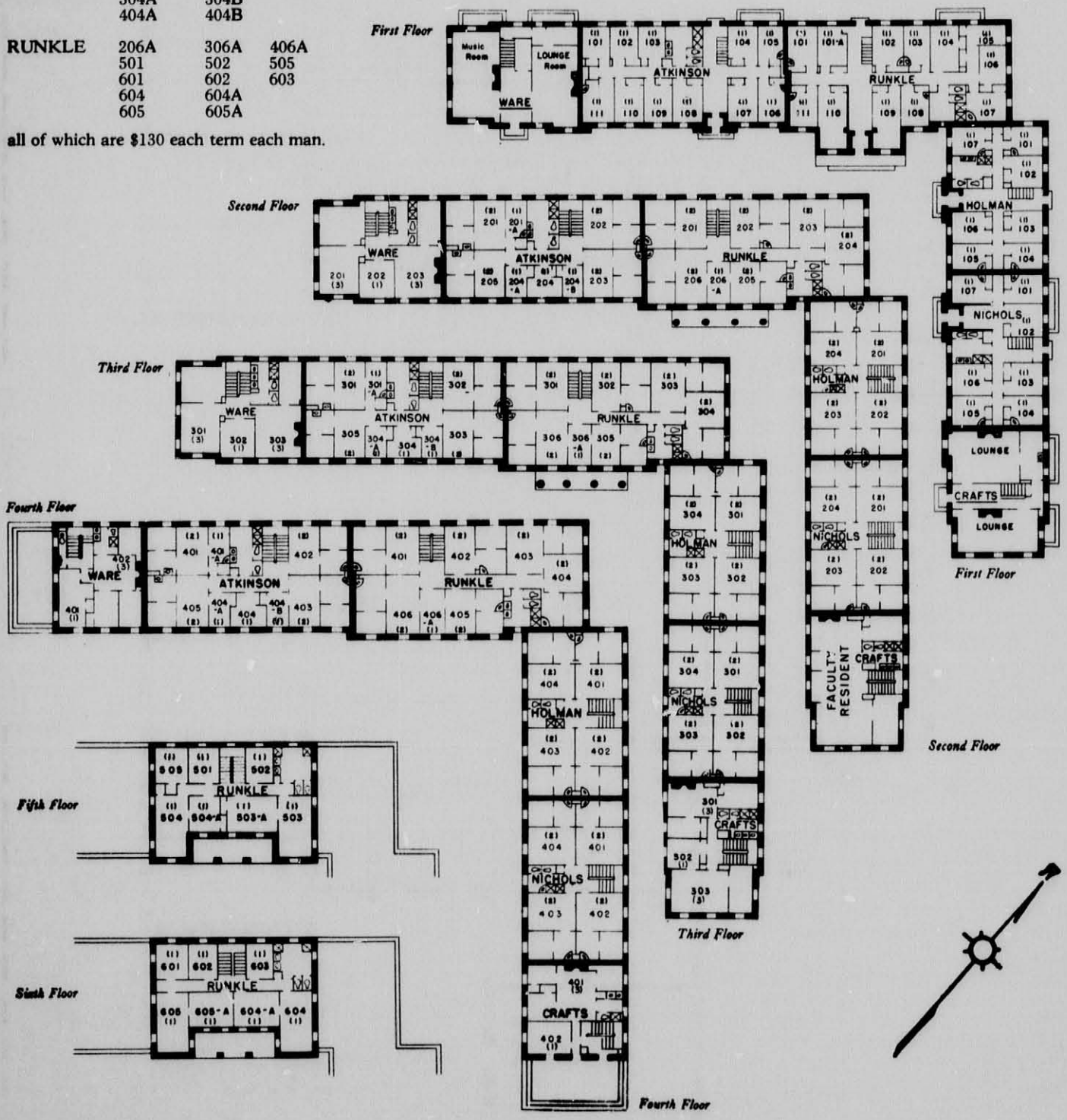
The Faculty Houses (East Campus)

WARE ATKINSON RUNKLE
HOLMAN NICHOLS CRAFTS

All accommodations $165 each occupant each academic term except following rooms:

ATKINSON	204A	204B	
	304A	304B	
	404A	404B	
RUNKLE	206A	306A	406A
	501	502	505
	601	602	603
	604	604A	
	605	605A	

all of which are $130 each term each man.

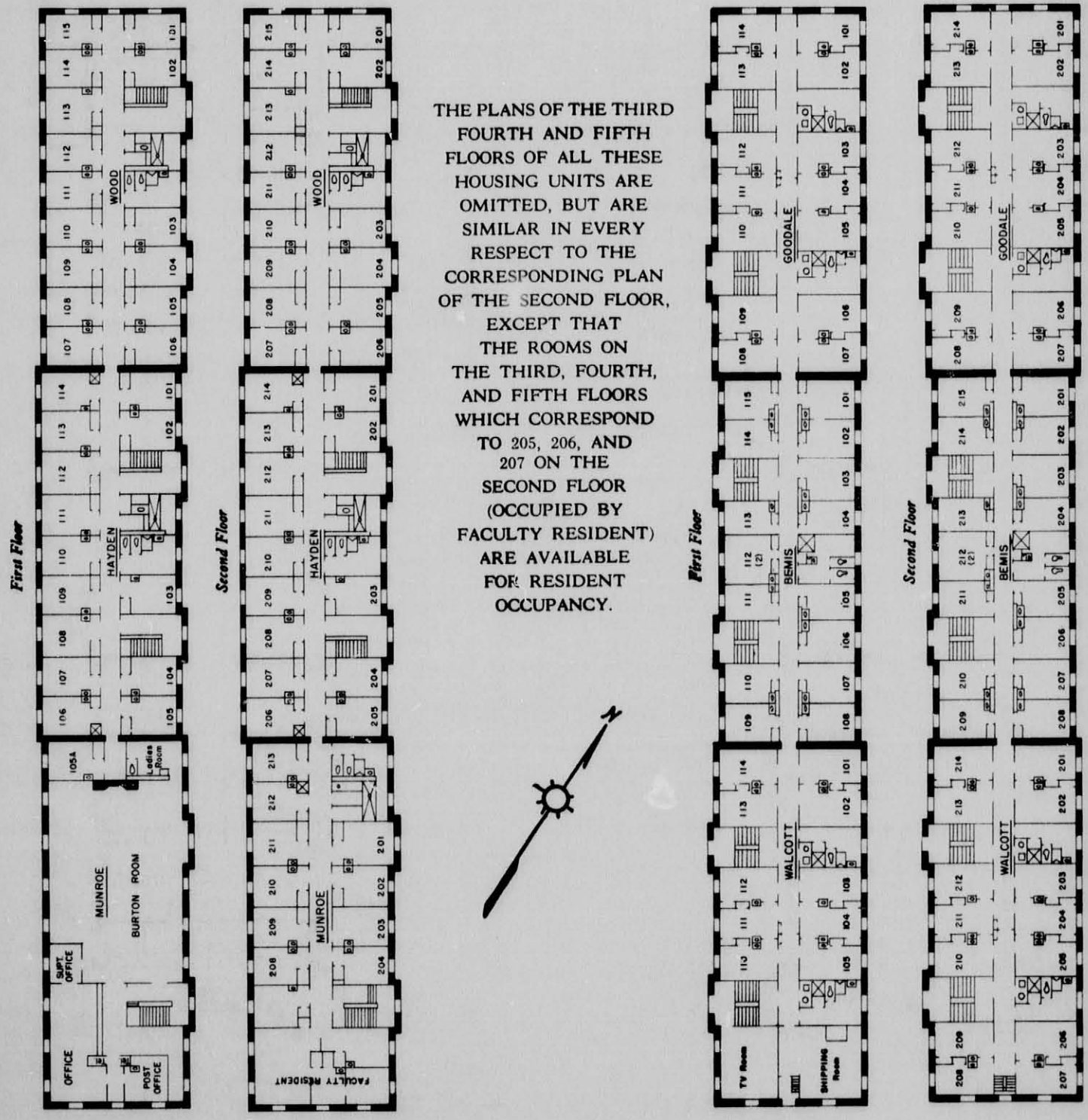


UNDERGRADUATE HOUSES

The Alumni Houses (East Campus)

All accommodations $165 each occupant each academic term except following rooms: BEMIS 112, 212, 312, 412, 512 — all of which are $130 each term each man.

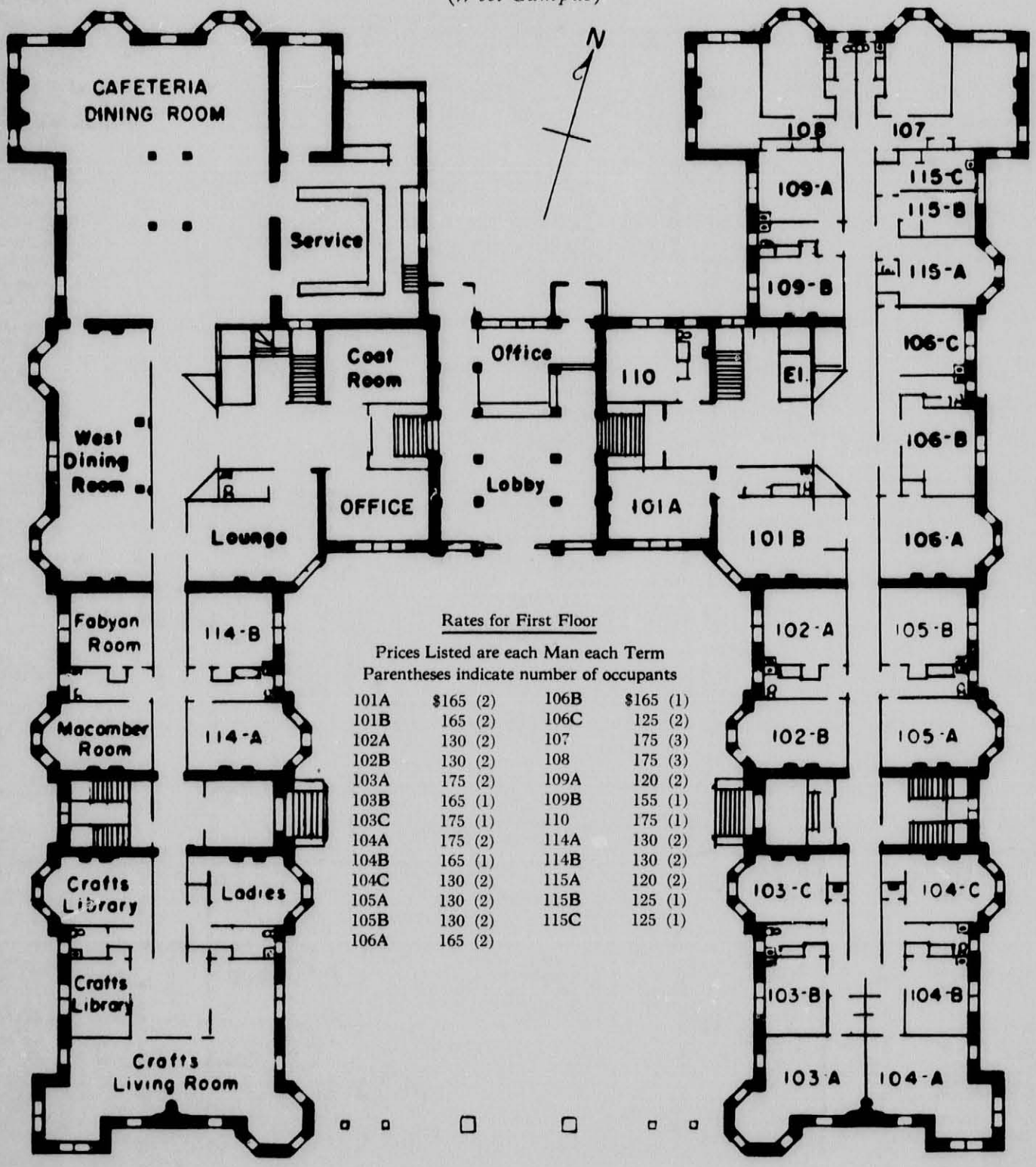
MUNROE HAYDEN WOOD GOODALE BEMIS WALCOTT



THE PLANS OF THE THIRD FOURTH AND FIFTH FLOORS OF ALL THESE HOUSING UNITS ARE OMITTED, BUT ARE SIMILAR IN EVERY RESPECT TO THE CORRESPONDING PLAN OF THE SECOND FLOOR, EXCEPT THAT THE ROOMS ON THE THIRD, FOURTH, AND FIFTH FLOORS WHICH CORRESPOND TO 205, 206, AND 207 ON THE SECOND FLOOR (OCCUPIED BY FACULTY RESIDENT) ARE AVAILABLE FOR RESIDENT OCCUPANCY.

THE GRADUATE HOUSE

(West Campus)



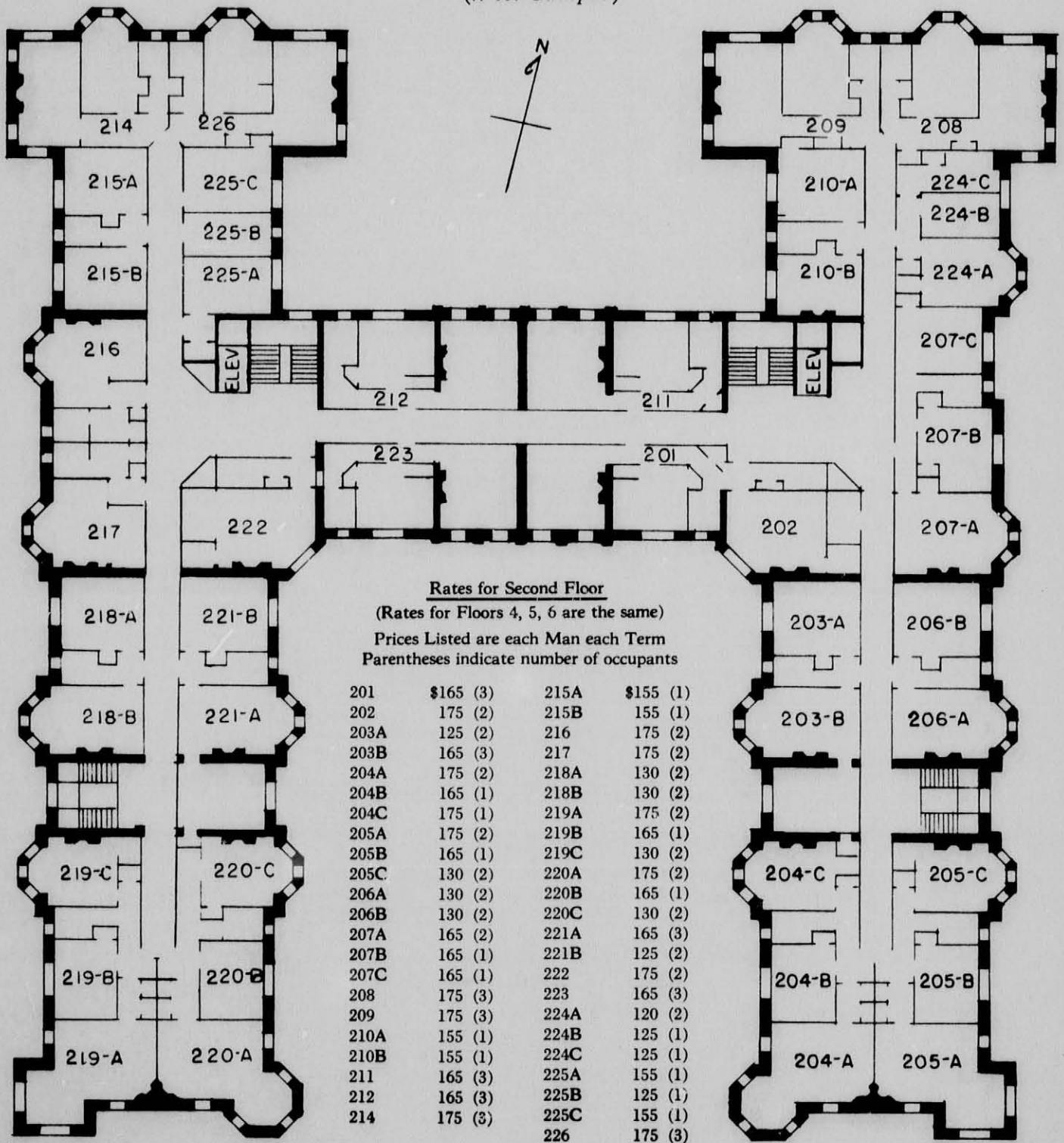
Rates for First Floor

Prices Listed are each Man each Term
Parentheses indicate number of occupants

101A	$165 (2)	106B	$165 (1)
101B	165 (2)	106C	125 (2)
102A	130 (2)	107	175 (3)
102B	130 (2)	108	175 (3)
103A	175 (2)	109A	120 (2)
103B	165 (1)	109B	155 (1)
103C	175 (1)	110	175 (1)
104A	175 (2)	114A	130 (2)
104B	165 (1)	114B	130 (2)
104C	130 (2)	115A	120 (2)
105A	130 (2)	115B	125 (1)
105B	130 (2)	115C	125 (1)
106A	165 (2)		

THE GRADUATE HOUSE

(West Campus)



Rates for Second Floor

(Rates for Floors 4, 5, 6 are the same)

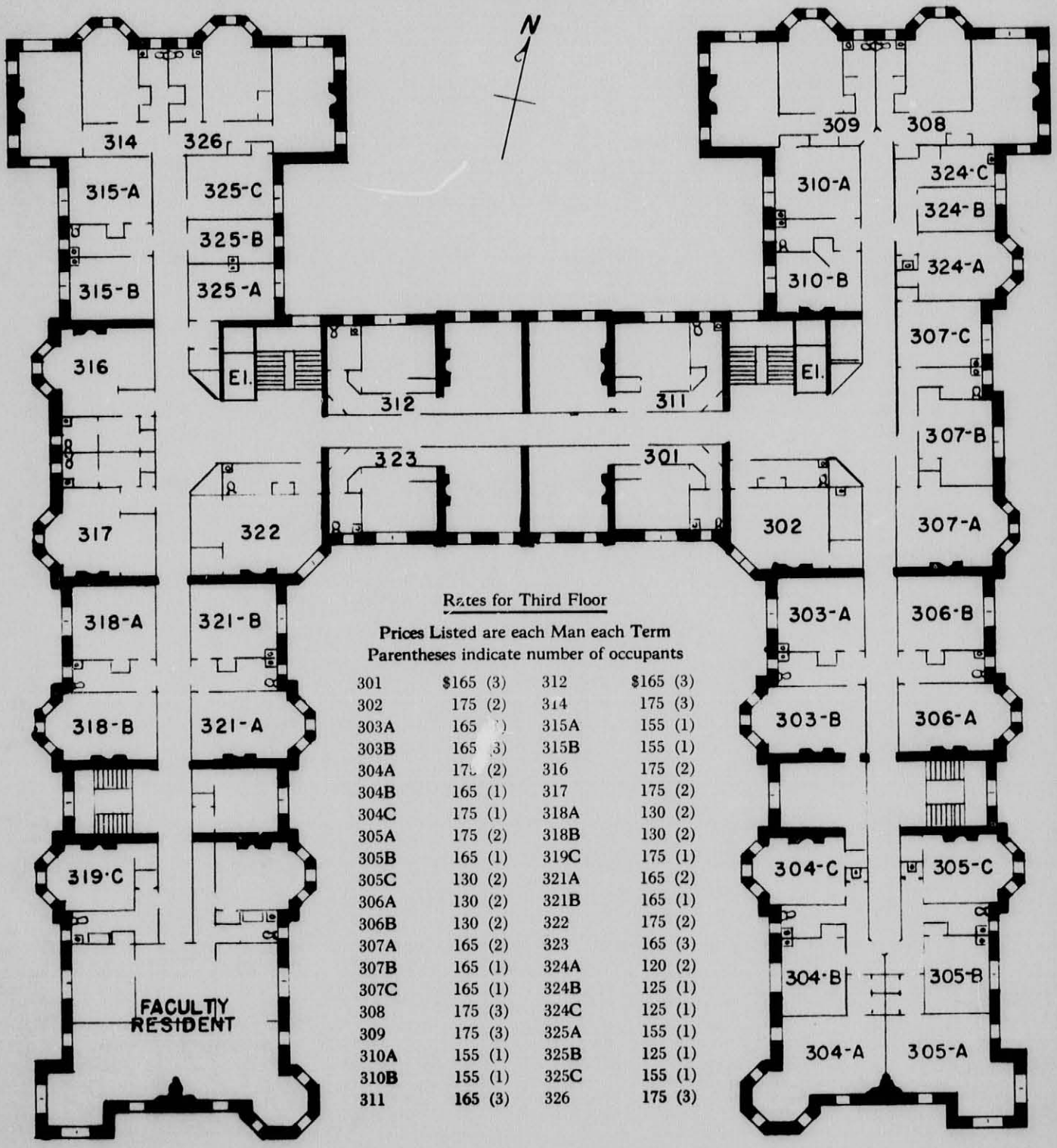
Prices Listed are each Man each Term

Parentheses indicate number of occupants

201	$165 (3)	215A	$155 (1)
202	175 (2)	215B	155 (1)
203A	125 (2)	216	175 (2)
203B	165 (3)	217	175 (2)
204A	175 (2)	218A	130 (2)
204B	165 (1)	218B	130 (2)
204C	175 (1)	219A	175 (2)
205A	175 (2)	219B	165 (1)
205B	165 (1)	219C	130 (2)
205C	130 (2)	220A	175 (2)
206A	130 (2)	220B	165 (1)
206B	130 (2)	220C	130 (2)
207A	165 (2)	221A	165 (3)
207B	165 (1)	221B	125 (2)
207C	165 (1)	222	175 (2)
208	175 (3)	223	165 (3)
209	175 (3)	224A	120 (2)
210A	155 (1)	224B	125 (1)
210B	155 (1)	224C	125 (1)
211	165 (3)	225A	155 (1)
212	165 (3)	225B	125 (1)
214	175 (3)	225C	155 (1)
		226	175 (3)

THE GRADUATE HOUSE

(West Campus)



Rates for Third Floor

Prices Listed are each Man each Term
Parentheses indicate number of occupants

301	$165 (3)	312	$165 (3)
302	175 (2)	314	175 (3)
303A	165 (1)	315A	155 (1)
303B	165 (3)	315B	155 (1)
304A	175 (2)	316	175 (2)
304B	165 (1)	317	175 (2)
304C	175 (1)	318A	130 (2)
305A	175 (2)	318B	130 (2)
305B	165 (1)	319C	175 (1)
305C	130 (2)	321A	165 (2)
306A	130 (2)	321B	165 (1)
306B	130 (2)	322	175 (2)
307A	165 (2)	323	165 (3)
307B	165 (1)	324A	120 (2)
307C	165 (1)	324B	125 (1)
308	175 (3)	324C	125 (1)
309	175 (3)	325A	155 (1)
310A	155 (1)	325B	125 (1)
310B	155 (1)	325C	155 (1)
311	165 (3)	326	175 (3)

INDEX TO SUBJECTS OF INSTRUCTION

(With reference to pages containing description)

Subjects	Page
Absorption, Distillation and	142
Absorption and Extraction	142
Accounting	152
Accounting and Production	151
Accounting, Business and National Income	152
Accounting Control, Problems in	152
Accounting, Industrial	152
Acoustics, Advanced	137
Acoustics, Architectural	129
Acoustics, Architectural, Special Problems in	129
Acoustics, Engineering	134
Acoustics, Engineering, Advanced	137
Acoustics, Fundamentals of	134
Acoustics, Special Problems in	137, 139
Administration, Airport Planning and	115
Administration, Financial, of Industry	152
Administration, Marketing Policy and	153
Administration, Personnel	151
Administration, Personnel, Seminar in	149
Administration, Planning Legislation and	129
Administration, Public, Government and	150–151
Administration, Public Health	119
Administration, Seminar in	154
Administrative Policy	153
Administrative Policy Seminar	153
Administrative Theory and Practice	154
Aerodynamic Laboratory	156
Aerodynamics	154
Aerodynamics, Applied	154
Aerodynamics of Compressible Fluids	154
Aerodynamics, Principles of	154
Aerodynamics — Viscous Fluids	154
Aeroelasticity	156
Aeroelasticity, Advanced	156
Aeroelasticity Laboratory	156
Aeromechanics	154
Aeronautical Engineering	156
Aeronautical Engineering Industrial Practice	156
Aeronautical Engineering Laboratory	156
Aeronautical Problems, Advanced	156
Aeronautical Systems	155
Aeronautics, General	156
Aeronautics Seminar	156
Air Conditioning	123
Air Conditioning, Advanced	123
Air Conditioning Laboratory, Refrigeration and	123
Air Science	160
Air Science, Advanced	160
Aircraft, Advanced Rotating Wing	156
Aircraft, Advanced Stability and Control of	154
Aircraft, Automatic Control Equipment for	155
Aircraft Detail Design	156
Aircraft Propulsion	122, 156
Aircraft, Rotating Wing	156
Aircraft Structural Design	155
Aircraft Structural Theory	155
Aircraft Structures	155
Aircraft Structures, Advanced	155
Aircraft Structures, Dynamics of	156
Airforce Cambridge Research Laboratories	137
Airplane Design, Advanced	156
Airplane Stability and Control	155
Airport Design	115
Airport Pavements, Highway and	115
Airport Planning and Administration	115
Airports, Highways and	115
Algebra	167
Algebra, Abstract	167
Algebra, Modern	167
Algebra, Topics in	167
Algebraic Functions	167
America, Industrial, Political Process in	162
American Character and Institutions	162
American Diplomacy, Principles and Problems of	149
American Economic Development	162
American Economy, The, Business Leadership in	162
American Foreign Policy in Action	162
American Gas and Electric Service Corporation Practice	137
American Industrial Society Seminar	163
American Law, Structure of, and Industrial Change	151
American Literature, Nineteenth-Century	161
American Literature, Twentieth-Century	161
American Political Economy, Problems in	151
American Political System, The	150
American Politics, Contemporary, Issues in: Seminar	150
American Social and Intellectual History	162
American Society, Religious Thought and	162
Analysis	167
Analysis, Functional	167
Analysis, Structural	116, 117, 128
Analytical Chemistry, Advanced	130
Analytical Chemistry, Research Conference in	132
Analytical Chemistry, Seminar in	131
Anatomy, Comparative	138
Antennas	136
Architectural Acoustics	129
Architectural Acoustics, Special Problems in	129
Architectural Design	128
Architectural Design, Special Problems	128
Architecture, History of	129
Architecture, Inside	129
Art and Industrial Civilization	162
Asian Politics and United States Foreign Policy	149
Astronomy	143–144
Atmosphere, Physics of the, Elementary	158
Atmospheric Pollution, Industrial Health Engineering and	119
Atomic and Molecular Structure, Introduction to	131
Atomic and Nuclear Physics	139
Atomic Physics, Experimental	139
Atomic Radiations, Production and Application of	133
Atomic Structure and Atomic Spectra	131
Atoms, Molecules and Nuclei, Physics of	139
Automatic Control Equipment for Aircraft	155
Automatic Control, Principles of	155
Automatic Control, Problems in	124
Automatic Control, Random Processes in	155
Automation	124
Automotive Vehicles	124
Bacteriology	159
Bacteriology of Foods	160
Banking Problems, Monetary and	149
Beam-Type Microwave Tubes	136
Behavior, Analysis of, Seminar	150
Bell Telephone Laboratories	137
Bible, The	161
Biochemical Engineering	160
Biochemistry, Advanced	138
Biochemistry and Physiology, General	138
Biochemistry of Microorganisms	138
Biochemistry and Physiology, General, Laboratory	138
Biochemistry, Sanitary	119
Bioelectric Signals	135
Biological Effects of Nuclear Radiation	169
Biological Systems, Molecular Configuration in	138
Biology, Electrical Instrumentation in	138
Biology, General	137
Biology Laboratory, General	138
Biology, Selected Topics in	138
Biology Seminar	138
Biophysics, Introduction to	138
Biophysics Laboratory	138
Biophysics, Mathematical	138
Biophysics, Methods in	138
Biophysics Seminar	138
Boston Edison Public Utility Practice	137
Building Construction	119, 157
Building Economics	148
Building Management	157
(Building) Specifications	157
Business and National Income Accounting	152
Business Cycles	149
Business Law	152
Business Leadership in the American Economy	162
Calculus	165
Calculus, Advanced, for Engineers	165
Calculus, Tensor	167
Cellular Physiology	138
Cellular Physiology Laboratory	138
Cementitious Materials	157
Cementitious Materials, Research in	157
Ceramic Processes, Fundamentals of	127
Ceramic Products, Advanced	127
Ceramics	127
Ceramics Laboratory	127
Ceramics Laboratory, Advanced	127
Ceramics Seminar	127
Ceramics, Special Problems in	127
Characteristic Value Problems	167
Chemical Bond, Crystal Structure and the	131
Chemical Engineering	141, 142
Chemical Engineering, Analytical Treatment of	142
Chemical Engineering Design	142
Chemical Engineering Food Applications	159
Chemical Engineering Laboratory	141
Chemical Engineering, Nuclear	169
Chemical Engineering Practice, School of — Bangor Station	143
Chemical Engineering Practice, School of — Buffalo Station	143
Chemical Engineering Practice, School of — Parlin Station	143
Chemical Engineering, Seminar in	143
Chemical Engineering Thermodynamics	142
Chemical Industry, Economic Balance in	142
Chemical Kinetics	142
Chemical Kinetics, Applied	143
Chemical Laboratory, Industrial	142
Chemical Reactions, Kinetics of	131
Chemical Thermodynamics	131
Chemistry, Analytical, Advanced	130
Chemistry, Analytical, Research Conference in	132
Chemistry, Analytical, Seminar in	131
Chemistry, Applied Surface	143
Chemistry, Colloid	143
Chemistry, Colloid, of Silicon	143
Chemistry, Colloid, Surface and	131
Chemistry and Technology of Food Supplies	159
Chemistry, General	130
Chemistry, Industrial	141–142, 143
Chemistry and Industrial Waste Treatment	118–119
Chemistry, Inorganic, Advanced	130
Chemistry, Inorganic, Research Conference in	132
Chemistry, Inorganic, Seminar in	131
Chemistry, Inorganic, Special Topics in	130
Chemistry of Nutrition	159
Chemistry of Nutrition Laboratory	159
Chemistry, Organic	130, 131
Chemistry, Organic: Natural Products	131
Chemistry, Organic: Synthesis, Advanced	131
Chemistry, Physical	131
Chemistry, Physical, Laboratory	131
Chemistry, Physical, of Proteins	138
Chemistry, Physical, of Proteins Laboratory	138
Chemistry, Physical Organic, Advanced	131
Chemistry, Physical, Seminar in	132
Chemistry, Sanitary	118
Chemistry, Special Problems in	131
Chemistry, Surface and Colloid	131
Chemistry, Theoretical Inorganic, Topics in	130
Circuit and Field Analogs and Models	133
Circuit, Pulse, Analysis	134
Circuit Theory, Active, Topics in	136
Circuit Theory, Communication and Control	134
Circuit Theory, Elementary Electric	132
Circuit Theory, Introductory	132
Circuits, Electrical, and Electronics, Advanced	137
Circuits, Electrical, and Electronics Laboratory	137
Circuits, Electronic	132
Circuits, Electronic, Laboratory	132
Circuits, Microwave	136
Circuits, Pulse, Principles of	136
Circuits, Switching	135
City, Form of the	129
City Planning Research	129
City Planning Techniques	129
City Planning Theory	129
City and Regional Planning	128
City, Structure of the	128
Civil Engineering Projects	119
Climatology, Applied	158
Climatology, General	158
Collaborative Design	128
Collective Bargaining and Union-Management Cooperation	149–150
Colloid Chemistry	143
Colloid Chemistry of Silicon	143
Colloid Chemistry, Surface and	131
Color, Light and	128
Color Measurements	139
Combustion	124
Combustion, Internal, Engine Laboratory	124
Combustion, Internal, Engines	124
Combustion, Internal, Engines, Advanced	124
Combustion, Internal, Engines, Elementary	124
Combustion, Internal, Engines, Special Problems in	124
Combustion, Principles of	143
Combustion, Research in	124
Combustion, Waves, Shocks and	154
Comic Sensibility	162
Communication and Control Circuit Theory	134
Communication in Groups, Organization and	150
Communication, International, Seminar in	151
Communication, Principles of	134
Communication, Psychology of	150
Communication Research, Methods of	151
Communication, Statistical Theory of	135
Communication System Engineering	134
Communication Systems, Mass Media and	151
Communications, Electrical, Laboratory	137
Communications Laboratory	137
Communications, Wire, Principles of	133–134
Community Planning Design	128
Complex Variables, Functions of	166

Subjects	Page
Concrete	157
Concrete Design	157
Concrete Design, Reinforced	117
Concrete Design, Reinforced, Advanced	117, 157
Conservation of Natural Resources	115
Construction, Building	119, 157
Construction, Dwelling House	119
Construction, Elementary Ship Design and	146
Construction, Engineering	119
Construction Management	119
Construction Management Seminar	157
Construction Problems	157
Continua, Mechanics of, Fundamentals of	166
Continuous Groups	166
Control, Accounting, Problems in	152
Control of Aircraft, Advanced Stability and	155
Control, Airplane Stability and	155
Control, Automatic, Equipment for Aircraft	155
Control, Automatic, Principles of	155
Control, Automatic, Problems in	124
Control, Automatic, Random Processes in	155
Control Circuit Theory, Communication and	134
Control Components, Electromechanical	133
Control, Electronic, and Measurement	133
Control, Electronic Instrumentation and	136
Control, Feedback, Laboratory	136
Control, Feedback, Principles	133
Control, Feedback, System Engineering	136
Control, Feedback, Theory Advanced	136
Control, Fire, Instrument Laboratory	156
Control, Fire, Instruments Laboratory, Advanced	156
Control, Fire, Principles	155
Control, Fire, Special Problems in	156
Control, Fire, Systems	155–156
Control, Fire, Systems, Advanced	156
Control, Instrumentation and, Laboratory	155
Control, Instrumentation and, Principles of	155
Control, Instrumentation and, Special Problems in	155
Control, Instruments for Measurement and	124
Control, Manufacturing, Seminar	153
Control, Process	136
Control, Statistical Quality	148
Control Systems Components	155
Conversion Devices, Electrical Energy	134
Conversion, Electrical Energy	132
Conversion, Electrical Energy, Laboratory	137
Conversion, Electrical Energy, Laboratory, Advanced	137
Conversion, Energy, Components and Systems	133
Corps, Chemical, Advanced	168
Corps of Engineers, Advanced	168
Corps, Ordnance, Advanced	168
Corps, Quartermaster, Advanced	168
Corps, Signal, Advanced	168
Corrosion	126
Cosmic Rays and High Energy Phenomena	141
Creative Engineering	123
Creative Thinking	123
Creative Writing	161
Crystal Physics, Special Problems in	140
Crystal Physics, X-rays and	140
Crystal Structure and the Chemical Bond	131
Crystallographic Research	144
Crystallography	144
Crystallography, Optical	144
Crystallography, Optical, Advanced	144
Cytology, Genetics and	138
Deposits, Mineral	144
Deposits, Mineral, Advanced	144
Deposits, Mineral, Laboratory	144
Design, Aircraft Detail	156
Design, Aircraft Structural	155
Design, Airplane, Advanced	156
Design, Airport	115
Design, Architectural	128
Design, Architectural, Special Problems	128
Design, Chemical Engineering	142
Design, Collaborative	128
Design, Community Planning	128
Design, Concrete	157
Design, Elementary Ship, and Construction	146
Design, Form and	128
Design, Furnace	143
Design, Geometric, Highway Location and	115
Design, Hull Form	146
Design of Hydraulic Structures	118
Design, Machine	123
Design, Marine Engineering	146, 147
Design, Mineral Dressing	127
Design Problems in Heat Engineering	122
Design, Process	142
Design, Product	123
Design, Reinforced Concrete	117
Design, Reinforced Concrete, Advanced	117, 157
Design, Sanitary, Advanced	119
Design, Sanitary Engineering	118
Design, Ship	146
Design, Ship, Advanced	145
Design, Ship, Elementary	146
Design, Ship, Hydromechanics of, Advanced	145–146
Design, Ship Machinery	147
Design, Ship, Principles of	145
Design of Ships, Preliminary	145
Design, Structural	117
Design, Structural, Advanced	117
Design, Structural Steel, Advanced	157
Design, Systems	123–124
Design, Visual, Advanced	128
Design, Warship Basic	146
Design, Warship Electrical System	147
Design, Warship Form	146
Design, Warship General	146
Design, Warship Structure	146
Design of Warships, Preliminary	146
Design, Wood, and Graphical Analysis	157
Differential Equations	165, 166
Differential Equations, Partial	166
Differential Geometry, Elementary	166
Diffraction, X-ray	140
Digital Computer Coding and Logic, Introduction to	134
Diplomacy, American, Principles and Problems of	149
Distillation	142
Distillation and Absorption	142
Drama, English, before Ibsen	161
Drama, Modern, since Ibsen	161
Drawing, Engineering	160
Drawing, Machine	123
Drawing, Ship Structural	146
Dwelling House Construction	119
Dynamic Measurements	155
Dynamics	120
Dynamics of Aircraft Structures	156
Dynamics of Rotating Machine Systems	134
Dynamics, Marine Engineering	146
Dynamics, Statics and	116
Dynamics, Strength of Materials and	120
Earth Dams, Embankments, Highways	116
Earth Science (Geology, Geophysics, Geochemistry)	143
Economic Analysis	148
Economic Balance in Chemical Industry	142
Economic Development, American	162
Economic Development, Political and, Contemporary Ideas on	163
Economic Development, Problems in	163
Economic Development, Research Seminar in	148
Economic Growth, Non-Economic Factors in	148
Economic Growth, Theory of	148
Economic History	148
Economic Principles	147
Economic Problems Seminar	147
Economic Statistics	148
Economic Systems, Political and, Comparative	150
Economic Thought, Schools of	148
Economics and Finance, Principles and Policies	148
Economics, Building	148
Economics of Entrepreneurship and Innovation	148
Economics of the Firm	152
Economics and Industrial Management	148
Economics, Industrial, Problems in	148
Economics, Industrial, Seminar	148
Economics of Innovation Seminar	148
Economics, International	149
Economics of Invention	148
Economics, Labor, and Public Policy	149
Economics, Labor, Problems in	149
Economics, Land	129
Economics, Land, Seminar	129
Economics, Marine Engineering	146
Economics, Mathematical Approach to	148
Economics, Mineral	145
Economics, Mineral, Seminar	145
Economics, Reading Seminar in	148
Economics, Research Seminar in	148
Economics Seminar	148
Economists, Mathematics for	147
Economy, American Political, Problems in	151
Economy, The American, Business Leadership in	162
Elasticity, Theoretical and Applied	167
Elasticity, Theory of	121
Electric and Magnetic Materials	127
Electric Circuit Theory, Elementary	132
Electrical Circuits and Electronics Laboratory	137
Electrical Circuits and Electronics Laboratory, Advanced	137
Electrical Communications Laboratory	137
Electrical Discharges in Gases	140
Electrical Discharges in Gases, Theory of	140
Electrical Energy Conversion	132
Electrical Energy Conversion Devices	134
Electrical Energy Conversion Laboratory	137
Electrical Energy Conversion Laboratory, Advanced	137
Electrical Engineering, Fundamentals of	133
Electrical Engineering, Mathematical Methods in	135
Electrical Engineering, Special Problems in	136
Electrical Engineering, Warship	147
Electrical Engineering, Warship, Advanced	147
Electrical Instrumentation in Biology	138
Electrical System Design, Warship	147
Electricity	132–133
Electrochemistry	126
Electrodynamics, Engineering	133
Electromagnetic Waves	134
Electromechanical Control Components	133
Electromechanical Power Modulators	132
Electron Devices, Thermionic	133
Electron Microscopy	138
Electron Microscopy Laboratory	138
Electronic Circuits	132
Electronic Circuits Laboratory	132
Electronic Computational Laboratory	134
Electronic Control and Measurement	133
Electronic Instrumentation	133
Electronic Instrumentation and Control	136
Electronics	139
Electronics, Applied	132
Electronics, Applied, Laboratory	132
Electronics, Electrical Circuits and, Laboratory	137
Electronics, Electrical Circuits and, Laboratory, Advanced	137
Electronics, Physical	140
Electronics, Physical, Laboratory	140
Electronics, Special Problems in	140
Embankments; Highways; Earth Dams	116
Embryology	138
Energy Conversion Components and Systems	133
Energy Transmission and Radiation	132
Energy Transmission and Radiation Laboratory	132
Engine, Internal Combustion, Laboratory	124
Engineering Acoustics	134
Engineering Acoustics, Advanced	137
Engineering Analysis, Methods of	120
Engineering Applications of Field Theory	135
Engineering Construction	119
Engineering Drawing	160
Engineering Electrodynamics	133
Engineering Equipment	141
Engineering Geology	144
Engineering, History of	162
Engineering Laboratory	123
Engineering Laminates	157
Engineering Metals	126
Engineering Practice School at Oak Ridge	169
Engineering Problems	133
Engineering Properties of Plastics	157
Engineering Thermodynamics, Advanced	122
Engines, Internal Combustion	124
Engines, Internal Combustion, Advanced	124
Engines, Internal Combustion, Elementary	124
Engines, Internal Combustion, Special Problems in	124
Engines, Jet Propulsion	156
English Composition	161
English Drama before Ibsen	161
English for Foreign Students	164
English, Special Readings	162
Enzymology	138
Enzymology Laboratory	138
Enzymology, Seminar in	138
Equations Differential	165, 166
Equations, Differential, Partial	166
Equations, Integral	167
Ethics, Western Politics and, Basic Ideas of	163
Europe, Modern — War, Society and the State	162
Europe — The Expansion of Europe	162
Experiment Planning and Analysis	125
Extraction, Absorption and	142
Fabric Structure, Principles of	125
Feedback Control Laboratory	136
Feedback Control Principles	133
Feedback Control System Engineering	136
Feedback Control Theory, Advanced	136
Field Analogs and Models, Circuit and	133
Field Investigations and Reports (Geology)	144
Field Theory, Engineering Applications of	135
Fields, Energy, and Forces	132
Finance	152
Finance, Economics and: Principles and Policies	148
Finance, Public	148
Financial Administration of Industry	152
Fire Control Instrument Laboratory	156
Fire Control Instrument Laboratory, Advanced	156
Fire Control Principles	155
Fire Control, Special Problems in	156
Fire Control Systems	155–156
Fire Control Systems, Advanced	156
Firm, Economics of the	152
Fiscal Policy	149
Flavor Evaluation	159
Flow, Surface, Free	117–118
Flows, Steady and Unsteady Potential	154
Flows, Viscous	154
Fluid Machinery	121
Fluid Mechanics	117, 121
Fluid Mechanics, Advanced	122
Fluid Mechanics, Advanced Topics in	122
Fluid Mechanics, Compressible	122
Fluid Mechanics Laboratory	117
Fluid Resistance and Turbulent Diffusion	117
Fluids, Compressible, Aerodynamics of	154
Food Acceptance	159
Food Applications, Chemical Engineering	159

Subjects	Page
Food Applications of Ionizing Radiations	160
Food Applications of Ionizing Radiations Laboratory	160
Food Engineering	122
Food Industry Seminar	160
Food, Man's	159
Food Processes, Nutritional Evaluation of	159
Food Production	159
Food Products, Technology of	159
Food Supplies, Chemistry and Technology of	159
Food Technology, Advanced	160
Food Technology, Selected Topics in	160
Food Technology Seminar	160
Foods, Bacteriology of	160
Foreign Policy, American, in Action	162
Foreign Policy, United States, Asian Politics and	149
Foreign Policy, United States, Major Problems in	149
Foreign Policy, United States, Social Science and	149
Form and Design	128
Form of the City	129
Foundation Engineering, Soil Mechanics and	115, 116
Foundations; Lateral Earth Pressure	116
Foundry Engineering: Iron and Steel	126
Fourier Series and Integrals	166
French, Conversational	164
French, Elementary	164
French, Intermediate	164
French Literature, Contemporary	164
French Literature, Great Books and Authors in	164
French Literature of the Third Republic	164
French, Scientific	164
French, Spoken, Introduction to	164
Friction, Lubrication and	121
Frost Action; Seepage through Soil	116
Fuel Engineering	143
Functional Analysis	167
Functions, Algebraic	167
Functions of a Complex Variable	166
Functions of a Real Variable	166
Functions, Theory of	165
Furnace Design	143
Games, Theory of	167
Gas Turbines	120, 122
Gaseous Discharge Phenomena	136
Gases, Electrical Discharges in	140
Gases, Electrical Discharges in, Theory of	140
General Electric Industrial Practice	137
General Radio Industrial Practice	137
Genetics	138
Genetics and Cytology	138
Geochemistry	145
Geography, Strategic and Political	149
Geological Surveying	144
Geology, Engineering	144
Geology, Historical	144
Geology, Isotope	145
Geology, Petroleum	144
Geology, Petroleum, Laboratory	144
Geology, Petroleum, Seminar	144
Geology, Physical	144
Geology, Structural	144
Geology, Theoretical	145
Geometric Design, Highway Location and	115
Geometry, Descriptive	160
Geometry, Differential, Elementary	166
Geometry of Manifolds	166
Geometry, Projective	166
Geophysics, Advanced	145
Geophysics, Elements of	144
Geophysics, Introduction to	145
Geophysics, Seminar	145
German, Elementary	164
German, Intermediate	164
German Literature 1919–33	164
German Literature, Great Books and Authors in	164
German, Scientific	164
German, Spoken	164
Germany, Postwar, Literature of	164
Government and Public Administration	150
Government, Politics, and Technology	150
Government Regulation of Industry	148
Graphic Presentation	128
Graphical Analysis, Wood Design and	157
Graphical Processes	160
Graphical Techniques in Systems Engineering Problems	133
Graphics, Advanced	161
Graphics Laboratory	160
Guided Missiles	155
Guided Missiles and Projectiles, Rockets	156
Gyroscopic Instrument Theory, Vector Kinematics and	155
Harbors, Rivers and	118
Health, Industrial, Engineering and Atmospheric Pollution	119
Health, Public, Administration	119
Health, Public, Engineering	119
Health, Public, Engineering Fieldwork	119
Health, Public, Statistics	119
Hearing, Speech, and Language	137
Heat Engineering	121, 122
Heat Engineering, Design Problems in	122
Heat Measurements	122
Heat Transfer	122, 142
Heat Transfer, Advanced	122
Heat Transmission	142
Heating and Ventilation	123
High Polymer Technology	143
Highway and Airport Pavements	115
Highway Location and Geometric Design	115
Highways and Airports	115
Highways, Embankments, Earth Dams	116
Historical Geology	144
Historical Studies in Innovation	151
History, American Social and Intellectual	162
History and Historians	163
History of Architecture	129
History, Economic	148
History of Engineering	162
History of Mechanics	120
History of Science, The, Topics in	163
History of Warships	146
History, Special Topics in	163
House, Dwelling, Construction	119
Housing Problems	129
Housing Seminar	129
Hull Form Design	146
Human Behavior, Measurements of	152
Human Dimensions of Planning	129
Human Relations and Labor Relations	150
Humanities	162
Hydraulic Engineering	118
Hydraulic Engineering, Hydrology and	118
Hydraulic Machinery	117
Hydraulic Machinery and Controls	124
Hydraulic Structures, Design of	118
Hydrology	118
Hydrology and Hydraulic Engineering	118
Hydromechanics, Applied	117
Hydromechanics, Experimental	118
Hydromechanics of Ship Design, Advanced	145–146
Hydromechanics, Seminar in	118
Hydromechanics, Theoretical	166
Hypersonics and Superaerodynamics	154
Illumination	133
Income, Money and	148
Income, National	148–149
Industrial Accounting	152
Industrial America, Political Process in	162
Industrial Behavior, Laboratory in	152
Industrial Change, Structure of American Law and	151
Industrial Chemical Laboratory	142
Industrial Chemistry	141–142, 143
Industrial Civilization, Art and	162
Industrial Economics, Problems in	148
Industrial Economics Seminar	148
Industrial Health Engineering and Atmospheric Pollution	119
Industrial Location and Regional Development: Principles	129
Industrial Location and Regional Development: Problems	129
Industrial Management	151
Industrial Management, Economics and	148
Industrial Management, Introduction to	151
Industrial Microbiology	160
Industrial Microbiology, Advanced	160
Industrial Organization and Public Policy	147
Industrial Plant Engineering	120
Industrial Practice (Electrical Engineering)	137
Industrial Problems, Quantitative Analysis of	152
Industrial Relations	149
Industrial Relations, Research Seminar in	149
Industrial Society, American, Seminar	163
Industrial Sociology Seminar	150
Industrial Standardization	153
Industrial Waste Treatment, Chemistry and	118–119
Industry, Financial Administration of	152
Industry, Government Regulation of	148
Information, Management, Systems	152
Information, Statistical Theory of	135
Information Theory, Advanced Topics in	135
Innovation, Economics of, Seminar	148
Innovation, Entrepreneurship and, Economics of	148
Innovation, Historical Studies in	151
Inorganic Chemistry, Advanced	130
Inorganic Chemistry, Research Conference in	132
Inorganic Chemistry, Seminar in	131
Inorganic Chemistry, Special Topics in	130
Inorganic Chemistry, Theoretical, Topics in	130
Instrument Laboratory, Fire Control	155–156
Instrument Laboratory, Fire Control, Advanced	156
Instrument Theory, Gyroscopic, Vector Kinematics and	155
Instrumental Analysis	130
Instrumental Analysis Laboratory	130
Instrumentation and Control Laboratory	155
Instrumentation and Control, Principles of	155
Instrumentation and Control, Special Problems in	155
Instrumentation, Electrical, in Biology	138
Instrumentation, Electronic	133
Instrumentation, Electronic, and Control	136
Instrumentation, Micrometeorological	158
Instruments for Measurement and Control	124
Instruments, Meteorological	158
Insulators, Semiconductors, and Metals	136
Integral Equations	167
Integrals, Fourier Series and	166
Internal Combustion Engine Laboratory	124
Internal Combustion Engines	124
Internal Combustion Engines, Advanced	124
Internal Combustion Engines, Elementary	124
Internal Combustion Engines, Special Problems in	124
International Business Machines Corporation Industrial Practice	137
International Communication, Research Seminar in	151
International Economics	149
International Politics, Behavioral Factors in	151
International Politics, Seminar in	149
International Relations	149
International Trade	149
Interpersonal Relations Seminar	152
Invention, Economics of	148
Investments	152
Ion Exchange	142
Ionizing Radiations, Food Applications of	160
Ionizing Radiations, Food Applications of, Laboratory	160
Isotope Geology	144
Jet Propulsion Engines	156
Job Management	157
Job Management, Advanced	157
Kinematics, Vector, and Gyroscopic Instrument Theory	155
Kinetic Theory	131
Kinetics, Chemical	142
Kinetics, Chemical, Applied	143
Kinetics of Chemical Reactions	131
Labor Economics and Public Policy	149
Labor Economics, Problems in	149
Labor Law	152
Labor-Management Relations	152
Labor-Management Relations and Public Policy	149
Labor Relations	149
Labor Relations, Human Relations and	150
Labor Relations, Public Policy on	149
Laminates, Engineering	157
Land-Use Problems in Developing Areas	129
Land Economics	129
Land Economics Seminar	129
Language, Hearing, and Speech	137
Language and Society	164–165
Lateral Earth Pressure, Foundations	116
Law, Business	152
Law, Labor	152
Legal Principles, Fundamental	152
Legislation, Planning and Administration	129
Life Science, Perspectives in	137
Light and Color	128
Line Spectra	140
Linear Operations in Hilbert Space	167
Linear System Analysis	135
Linear Systems, Transients in	135
Linguistic Structure	165
Lipids, Technology of	160
Literary Theory	161
Literature, American, Nineteenth-Century	161
Literature, American, Twentieth-Century	161
Literature, Epic Tradition in	161
Literature, French, Contemporary	164
Literature, French, Great Books and Authors in	164
Literature, French, of the Third Republic	164
Literature, German, 1919–33	164
Literature, German, Great Books and Authors in	164
Literature, Introduction to	161
Literature, Modern Russian, Russia and the West in	161
Literature, Non-Western	161
Literature of Postwar Germany	164
Literature, Philosophy and, Seminar	163
Low Temperature Refrigeration	123
Lubrication and Friction	121
Lubrication, Research in	121
Machine-Aided Analysis	133
Machine Design	123
Machine Drawing	123
Machine Systems, Rotating, Dynamics of	134
Machine Tool Fundamentals	125
Machine Tool Laboratory	124
Machine Tools and Metal Cutting, Research in	124
Machine Tools, Introduction to	124
Machinery Fluid	121
Machinery, Hydraulic	117
Machinery, Hydraulic, and Controls	124
Machinery, Ship, Design	147
Magnetic Materials, Electric and	127
Magnetism, Nuclear, Special Problems in	140
Management, Building	157
Management, Construction	119
Management, Construction, Seminar	157

Subjects	Page
Management, Industrial	151
Management, Industrial, Economics and	148
Management, Industrial, Introduction to	151
Management Information Systems	152
Management, Job	157
Management, Job, Advanced	157
Management Laboratory	153
Management Laboratory, Advanced	153
Management of Research and Development	154
Management Problems	151
Management, Production	152, 153
Management, Research, Seminar in	153
Management, Special Studies in	153
Man's Food	159
Manufacturing Analysis	153
Manufacturing Control Seminar	153
Manufacturing Policy Seminar	153
Manufacturing Technology	124–125
Manufacturing, Textile, Elements of	125
Manufacturing, Textile, Principles of	125
Marine Engineering	146
Marine Engineering Design	146, 147
Marine Engineering Dynamics	146
Marine Engineering Economics	146
Marine Engineering, Naval Architecture and, Special Problems in	146
Marine Propellers	147
Marketing	153
Marketing Policy and Administration	153
Marketing Research	153
Masonry and Metals — Materials	157
Mass Media and Communication Systems	151
Materials, Advanced	116
Materials, Cementitious	157
Materials, Cementitious, Research in	157
Materials, Electric and Magnetic	127
Materials, Mechanical Behavior of	121
Materials, Mechanical Properties of	121
Materials and Mechanics	116
Materials — Masonry and Metals	157
Materials, Nuclear Reactor, Technology of	126
Materials, Organic Structural, Research in	157
Materials, Research in	121
Materials, Strength of	120
Materials, Strength of, and Dynamics	120
Materials, Testing, Laboratory	121
Materials — Wood, Plastics, Fabrics	157
Mathematical Approach to Economics	148
Mathematical Biophysics	138
Mathematical Laboratory	166
Mathematical Logic	166–167
Mathematical Methods in Electrical Engineering	135
Mathematical Reading	167
Mathematics, Applied, Methods of	165–166
Mathematics for Economists	147
Mathematics, Foundations of, Topics in	167
Mathematics, Review of	167
Mathematics, Seminar in	166
Measurement and Control, Instruments for	124
Measurement, Electronic Control and	133
Measurements, Color	139
Measurements, Dynamic	155
Measurements, Heat	122
Measurements of Human Behavior	152
Mechanical Behavior of Materials	121
Mechanical Engineering, Applications of Statistics to	123
Mechanical Engineering Industrial Practice	125
Mechanical Engineering Problems	120
Mechanical Engineering Seminar	125
Mechanical Properties of Materials	121
Mechanical Vibration	147
Mechanics, Advanced	120, 141
Mechanics, Applied	120
Mechanics, Fluid	117, 121
Mechanics, Fluid, Advanced	122
Mechanics, Fluid, Advanced Topics in	122
Mechanics, Fluid, Compressible	122
Mechanics, Fluid, Laboratory	117
Mechanics, History of	120
Mechanics, Materials and	116
Mechanics of Continua, Fundamentals of	166
Mechanics of Soil	116
Mechanics, Quantum, Relativistic	141
Mechanics, Soil	116
Mechanics, Soil, and Foundation Engineering	115, 116
Mechanics, Soil, Laboratory	116
Mechanics, Statistical	122, 131
Mechanics, Statistical, Thermodynamics and	139
Mechanics, Structural, Advanced	117
Meson Physics	141
Metal Cutting, Machine Tools and, Research in	124
Metal Cutting, Principles of	124
Metal Cutting, Theory of	124
Metal Processing	126
Metallic Solutions, Thermodynamics of	126
Metallurgical Engineering	125, 126
Metallurgical Engineering Laboratory	125, 126
Metallurgical Plant Visits	126
Metallurgical Thermodynamics	126
Metallurgy, Experimental Methods in	126
Metallurgy, Extractive	125
Metallurgy, Physical	126
Metallurgy, Physical, Advanced	126
Metallurgy, Powder	126
Metallurgy, Special Problems in	127
Metallurgy, X-ray	127
Metallurgy, X-ray, Advanced	127
Metals at Elevated Temperatures, the Behavior of	126–127
Metals, Engineering	126
Metals and Masonry — Materials	157
Metals, Physics of	127
Metals, Advanced Physics of	127
Metals, Plastic Working of	126
Metals, Properties of	126
Metals, Semiconductors, and Insulators	136
Meteorological Instruments	158
Meteorological Observations	158
Meteorological Seminar	159
Meteorology, Descriptive	158
Meteorology, Dynamic	158
Meteorology, Elementary	158
Meteorology, General	158
Meteorology Laboratory, Introductory	158
Meteorology, Physical	158–159
Meteorology, Radar	158
Meteorology, Special Problems in	159
Meteorology, Synoptic	158
Meteorology, Theoretical, Introduction to	158
Microbiology, Industrial	160
Microbiology, Industrial, Advanced	160
Microbiology, Sanitary	119
Microclimatology	158
Micrometeorological Instrumentation	158
Microorganisms, Biochemistry of	138
Microscopy, Electron	138
Microscopy, Electron, Laboratory	138
Microscopy, Textile	125
Microwave Circuits	136
Microwave Physics	140
Microwave Tubes, Beam-Type	136
Military Science	168
Mineragraphy, Quantitative	127
Mineral Deposits	144
Mineral Deposits and Petrology Seminar	144
Mineral Deposits Laboratory, Advanced	144
Mineral Dressing Design	127
Mineral Dressing Laboratory, Advanced	127
Mineral Economics	145
Mineral Economics Seminar	145
Mineral Engineering	127
Mineral Engineering, Advanced	127
Mineral Property, Valuation of	145
Mineral Valuation Seminar	145
Mineralogical Seminar	144
Mineralogy	144
Mining, Elements of	145
Mining Methods and Practice	145
Modulation, Noise and, Statistical Theory of	135
Modulation Theory	136
Modulators, Electromechanical Power	132
Modulators, Power, Non-Linear Impedances as	134
Molecular Configuration in Biological Systems	138
Molecular Engineering	133
Molecular Spectra and Molecular Structure	131
Molecular Structure, Atomic and, Introduction to	131
Monetary and Banking Problems	149
Money and Income	148
Music Criticism, Principles of	168
Music, Introduction to	168
Music, Seminar in	168
Music, Twentieth-Century	168
Music, Western, from the Middle Ages to the Present	168
National Income	148–149
Nationalism and National Development	163
Naval Architecture	145
Naval Architecture and Marine Engineering, Special Problems in	146
Naval Ordnance Laboratory	137
Network Analysis and Synthesis	135–136
Noise and Modulation, Statistical Theory of	135
Nomography	160–161
Nomography, Elementary	160
Nonlinear and Time-Varying Systems	136
Non-Linear Impedances as Power Modulators	134
Novel, The Modern	162
Nuclear Chemical Engineering	169
Nuclear Engineering Laboratory	169
Nuclear Engineering, Seminar in	169
Nuclear Engineering, Special Problems in	169
Nuclear Magnetism, Special Problems in	140
Nuclear Physics	140
Nuclear Physics, Advanced Topics in	141
Nuclear Physics, Applied, Advanced	140
Nuclear Physics, Atomic and	139
Nuclear Physics for Engineers	140, 141
Nuclear Physics Laboratory	140
Nuclear Physics, Special Problems in	141
Nuclear Radiation, Biological Effects of	169
Nuclear Reactor Engineering	169
Nuclear Reactor Materials, Technology of	126
Nuclear Reactor Theory	169
Nuclear Structure, Theory of	141
Nuclear Technology, Introduction to	169
Number Theory, Elementary	165
Numbers, Theory of, Topics in the	166
Numerical Analysis	166
Numerical Weather Prediction	158
Nutrition, Advanced	159
Nutrition, Applied	159
Nutrition, Chemistry of	159
Nutrition, Chemistry of, Laboratory	159
Nutritional Evaluation of Food Processes	159
Oceanography	158
Office Practice (City Planning)	129
Opera, The	168
Operations Analysis, Probability and	165
Operations Research	165
Optical Crystallography	144
Optical Crystallography, Advanced	144
Optics	139
Optics, Physical, Selected Topics in	139
Optics, Special Problems in	139
Orbital Vehicles	156
Ore Guides	144
Ore Testing	127
Organic Analysis, Qualitative	131
Organic Chemistry	130, 131
Organic Chemistry: Natural Products	131
Organic Chemistry, Physical, Advanced	131
Organic Chemistry: Synthesis, Advanced	131
Organic Preparations	130, 131
Organic Structural Materials, Research in	157
Organization	153
Organization and Communication in Groups	150
Organization, Industrial, and Public Policy	147
Paleontology	144
Paleontology, Advanced	144
Personality and Social Structure	150
Personnel Administration	151
Personnel Administration, Seminar in	149
Perspectives in Life Science	137
Petroleum Geology	144
Petroleum Geology Laboratory	144
Petroleum Geology Seminar	144
Petrology	144
Petrology Laboratory	144
Petrology Laboratory, Advanced	144
Petrology, Mineral Deposits and, Seminar	144
Philco Corporation Industrial Practice	137
Philosophic Problems and Systems	163
Philosophy and Literature Seminar	163
Philosophy and Scientific Methodology	162
Philosophy, Classical	163
Philosophy of Science	163
Philosophy, Science and, from Galileo to the Present	163
Philosophy, Science and, from the Greeks to Copernicus	163
Photoelasticity	120
Photogrammetric Engineering	115
Photography	139
Physical Chemistry	131
Physical Chemistry Laboratory	131
Physical Chemistry of Proteins	138
Physical Chemistry of Proteins Laboratory	138
Physical Chemistry, Seminar in	132
Physical Electronics	140
Physical Electronics Laboratory	140
Physical Geology	144
Physical Metallurgy	126
Physical Metallurgy, Advanced	126
Physical Meteorology	158–159
Physical Optics, Selected Topics in	139
Physical Organic Chemistry, Advanced	131
Physical Processes, Statistical Fluctuations in	141
Physics	139
Physics (College Transfer)	139
Physics (Electricity and Magnetism)	139
Physics (Electromagnetism)	139
Physics (Electromagnetism and Electromagnetic Theory of Light)	139
Physics (Mechanics)	139
Physics (Mechanics: Heat and Kinetic Theory)	139
Physics (Optic and Atomic Physics)	139
Physics, Atomic, Experimental	139
Physics, Atomic and Nuclear	139
Physics, Crystal, Special Problems in	140
Physics, Crystal, X-rays and	140
Physics Experimental	139
Physics, Meson	141
Physics, Microwave	140
Physics, Nuclear	140
Physics, Nuclear, Advanced Topics in	141
Physics, Nuclear, Applied Advanced	140
Physics, Nuclear, for Engineers	140, 141
Physics, Nuclear, Laboratory	140
Physics, Nuclear, Special Problems in	141
Physics of Atoms, Molecules and Nuclei	139

Subjects	Page
Physics of the Atmosphere, Elementary	158
Physics of Metals	127
Physics, Advanced, of Metals	127
Physics of Strength and Plasticity	121
Physics, Solid State, Special Problems in	140
Physics, Theoretical, Applications of Group Theory to	141
Physics, Theoretical, Introduction to (Electromagnetic Theory)	141
Physics, Theoretical, Introduction to (Mechanics)	141
Physics, Theoretical, Methods of	141
Physics, Theoretical, Special Problems in	141
Physiology, Cellular	138
Physiology, Cellular, Laboratory	138
Physiology, General Biochemistry and	138
Physiology Laboratory, General Biochemistry and	138
Planning, Airport, and Administration	115
Planning and Development, Product	153
Planning, City and Regional	128
Planning, City, Research	129
Planning, City, Techniques	129
Planning, City, Theory	129
Planning, Community, Design	128
Planning, Human Dimensions of	129
Planning Legislation and Administration	129
Planning, Regional, Principles of	129
Planning, Regional, Seminar	129
Planning, Transportation	115
Plastic Working of Metals	126
Plasticity	120–121
Plasticity, Seminar in	121
Plasticity, Strength and, Physics of	121
Plastics, Engineering Properties of	157
Plastics, Fabrics, Wood — Materials	157
Plates and Shells	120
Poetry, The Nature of	161
Policy Decisions, Influences on	151
Policy Making, Politics, Society and	151
Political and Economic Development, Contemporary Ideas on	163
Political and Economic Systems, Comparative	150
Political and Social Science, Modern, The Rise of	163
Political Economy, American, Problems in	151
Political Geography, Strategic and	149
Political Process in Industrial America	162
Political Science Seminar	151
Political System, The American	150
Politics and Ethics, Western, Basic Ideas of	163
Politics, and Technology, Government	150
Politics, Asian, and United States Foreign Policy	149
Politics, Contemporary American, Issues in: Seminar	150
Politics, International, Behavioral Factors in	151
Politics, International, Seminar in	149
Politics, Society, and Policy Making	151
Polymer, High, Technology	143
Potential Theory	167
Powder Technology	126
Power Modulators, Electromechanical	132
Power Modulators, Non-Linear Impedances as	134
Power Plant Engineering	122
Power Plants, Advanced	122
Power, Water, Engineering	118
Prices and Production	147
Probability and Operations Analysis	165
Probability, Theory of	167
Process Control	136
Process Design	142
Product Design	123
Product Planning and Development	153
Production, Accounting and	151
Production, Food	159
Production Management	152, 153
Production, Prices and	147
Products, Food, Technology of	159
Professional Problems (Civil Engineering)	119
Propellers, Marine	147
Propulsion, Aircraft	122, 156
Propulsion, Ship	147
Propulsion, Warship	147
Proteins, Physical Chemistry of	138
Proteins, Physical Chemistry of, Laboratory	138
Psychological Theory Seminar	150
Psychology, Experimental	150
Psychology, Introductory	150
Psychology of Communication	150
Psychology of Learning and Motivation	150
Psychology Seminar, Quantitative Methods in	150
Psychology Seminar, Social	150
Psychology, Social	152
Public Administration, Government and	150
Public Finance	148
Public Health Administration	119
Public Health Engineering	119
Public Health Engineering Fieldwork	119
Public Health Statistics	119
Public Opinion and Propaganda	151
Public Policy, Industrial Organization and	147
Public Policy, Labor Economics and	149
Public Policy, Labor-Management Relations and	149
Public Policy on Labor Relations	149
Public Speaking	161
Pulse Circuit Analysis	134
Pulse Circuits, Principles of	136
Pulsed-Data Systems	134
Qualitative Analysis	130
Qualitative Organic Analysis	131
Quantitative Analysis	130
Quantitative Analysis of Industrial Problems	152
Quantitative Methods in Psychology Seminar	150
Quantitative Mineragraphy	127
Quantum Mechanics, Relativistic	141
Quantum Theory, Introduction to	141
Quantum Theory of Matter	140
Quartet, String, The Classic	168
Radar Meteorology	158
Radar System Engineering	134, 136
Radiation, Energy Transmission and	132
Radiation, Energy Transmission and, Laboratory	132
Radiation, Nuclear, Biological Effects of	169
Radiations, Atomic, Production and Application of	133
Radiations, Ionizing, Food Applications of	160
Radiations, Ionizing, Food Applications of, Laboratory	160
Radiochemistry	130
Radiochemistry Laboratory	130
Radiographic Inspection	127
Raytheon Industrial Practice	137
Reading, Mathematical	167
Readings, Special (English)	162
Real Variable, Functions of a	166
Refrigeration	122–123
Refrigeration and Air Conditioning Laboratory	123
Refrigeration, Applied	123
Refrigeration Engineering	123
Refrigeration, Low Temperature	123
Regional Development, Industrial Location and: Principles	129
Regional Development, Industrial Location and: Problems	129
Regional Planning, City and	128
Regional Planning, Principles of	129
Regional Planning Seminar	129
Reinforced Concrete Design	117
Reinforced Concrete Design, Advanced	117, 157
Relations, Human, and Labor Relations	150
Relations, Industrial	149
Relations, Industrial, Research Seminar in	149
Relations, International	149
Relations, Interpersonal, Seminar	150
Relations, Labor	149
Relations, Labor-Management	152
Relations, Labor-Management and Public Policy	149
Relations, Labor, Public Policy on	149
Relations, Union-Management	150
Relativistic Quantum Mechanics	141
Religious Thought and American Society	162
Reports (English)	161
Representation	128
Research (Chemistry)	132
Research Problem, Experimental (Chemical Engineering)	143
Research Problems (Biology)	138
Research Problems (Food Technology)	160
Rivers and Harbors	118
Rockets, Guided Missiles and Projectiles	156
Rotating Machine Systems, Dynamics of	134
Rotating Wing Aircraft	156
Russia and the West in Modern Russian Literature	161
Russian, Elementary	165
Russian, Intermediate	165
Russian Revolution, The, and the Soviet Union	162
Russian, Scientific	165
Sales Promotion: Strategy and Methods	153
Sanitary Biochemistry	119
Sanitary Chemistry	118
Sanitary Design, Advanced	119
Sanitary Engineering	118
Sanitary Engineering, Advanced	118
Sanitary Engineering Design	118
Sanitary Engineering Laboratory	118
Sanitary Engineering Seminar	119
Sanitary Engineering, Special Studies in	119
Sanitary Microbiology	119
Sanitary Science	118
Science and Philosophy from Galileo to the Present	163
Science and Philosophy from the Greeks to Copernicus	163
Science, The History of, Topics in	163
Science, Life, Perspectives in	137
Science, Philosophy of	163
Scientific Methodology, Philosophy and	162
Sedimentation and Stratigraphy	144
Sedimentology	144
Sedimentology, Advanced	144
Sedimentology Seminar	144
Seepage through Soil; Frost Action	116
Seismology, Elements of	145
Semiconductors, Insulators, and Metals	136
Sewerage and Sewage Treatment	118
Sewerage, Water Supply and	118
Shakespeare	161
Shells, Plates and	120
Ship Design	146
Ship Design, Advanced	145
Ship Design, Advanced Hydromechanics of	145–146
Ship Design, Elementary	146
Ship Design, Elementary, and Construction	146
Ship Design, Principles of	145
Ship Machinery Design	147
Ship Propulsion	147
Ship Structural Drawing	146
Ship Structures	146
Ships, Preliminary Design of	145
Social and Intellectual History, American	162
Social Psychology	152
Social Psychology Seminar	150
Social Science and United States Foreign Policy	149
Social Science, Modern Political and, The Rise of	163
Social Science, Reading Seminar in	150
Social Structure, Personality and	150
Society, American Industrial, Seminar	163
Society, American, Religious Thought and	162
Society and the State, War — Modern Europe	162
Society, Language and	164–165
Society, Politics, and Policy Making	151
Sociology, Industrial, Seminar	150
Sociology, Urban	129
Soil Engineering	115, 116
Soil Mechanics	116
Soil Mechanics and Foundation Engineering	115, 116
Soil Mechanics Laboratory	116
Soil, Mechanics of	116
Soil, Seepage through; Frost Action	116
Soil Technology	116
Solid State Physics, Special Problems in	140
Solids, Theory of, Selected Topics in	140
Sound Propagation in Moving Media	139
Sound, Vibration and	139
Special Problems (Geology)	144
Specifications (Building)	157
Spectra, Atomic, Atomic Structure and	131
Spectra, Line	140
Spectra, Molecular, and Molecular Structure	131
Spectrochemical Analysis	145
Spectroscopy, Special Problems in	140
Speech, Language, and Hearing	137
Statically Indeterminate Structures	117
Statics and Dynamics	116
Statistical Fluctuations in Physical Processes	141
Statistical Mechanics	122, 131
Statistical Mechanics, Thermodynamics and	139
Statistical Method	148
Statistical Quality Control	148
Statistical Theory	148
Statistical Theory, Modern	165
Statistical Theory of Communication	135
Statistical Theory of Information	135
Statistical Theory of Noise and Modulation	135
Statistical Thermodynamics	140
Statistics, Applications of, to Mechanical Engineering	123
Statistics, Applied, Seminar	165
Statistics, Economic	148
Statistics, Elementary	148, 165
Statistics, Public Health	119
Steel Design, Structural, Advanced	157
Steelmaking, Principles of	126
Stratigraphy and Sedimentation	144
Strength and Plasticity, Physics of	120
Strength of Materials	120
Strength of Materials and Dynamics	120
Stress Analysis, Experimental	120
Stress Analysis, Experimental, Research in	120
String Quartet, The Classic	168
Structural Analysis	116, 117, 128
Structural Design	117
Structural Design, Advanced	117
Structural Design, Aircraft	155
Structural Drawing, Ship	146
Structural Engineering, Elementary	116–117
Structural Engineering, Seminar	117
Structural Engineering, Special Problems in	117
Structural Geology	144
Structural Laboratory	117
Structural Materials, Organic, Research in	157

Subjects	Page
Structural Mechanics, Advanced	117
Structural Problems in Weapons	156
Structural Steel Design, Advanced	157
Structural Theory, Aircraft	155
Structure, Atomic, and Atomic Spectra	131
Structure, Atomic and Molecular, Introduction to	131
Structure, Crystal, and the Chemical Bond	131
Structure, Fabric, Principles of	125
Structure, Linguistic	165
Structure, Molecular, Molecular Spectra and	131
Structure, Nuclear, Theory of	141
Structure of American Law and Industrial Change	151
Structure of the City	128
Structure, Social, Personality and	150
Structure, Warship Design	146
Structure, Warship, Theory	146
Structures, Aircraft	155
Structures, Aircraft, Advanced	155
Structures, Aircraft, Dynamics of	156
Structures, Hydraulic, Design of	118
Structures Seminar	129
Structures, Ship	146
Structures, Statically Indeterminate	117
Superaerodynamics, Hypersonics and	154
Surface and Colloid Chemistry	131
Surface Chemistry, Applied	143
Surface Flow, Free	117–118
Surveying	115
Surveying, Advanced	115
Surveying, Geological	144
Switching Circuits	135
Synoptic Laboratory	158
Synoptic Meteorology	158
System Design, Warship Electrical	147
Systems Design	123–124
Systems Engineering, Graphical Techniques in	133
Technical Writing, Seminar in	161
Technology, Government, Politics and	150
Tectonic Elements	145
Tectonics Seminar	145
Tensor Calculus	167
Textile Engineering Analysis	125
Textile Manufacturing, Elements of	125
Textile Manufacturing, Principles of	125
Textile Microscopy	125
Textile Research Laboratory	125
Textile Technology Seminar	125
Thermal Effects	154
Thermionic Electron Devices	133
Thermodynamics, Advanced	142
Thermodynamics, Advanced Projects in	122
Thermodynamics and Statistical Mechanics	139
Thermodynamics, Chemical	131
Thermodynamics, Chemical Engineering	142
Thermodynamics, Engineering, Advanced	122
Thermodynamics, Metallurgical	126
Thermodynamics of Metallic Solutions	126
Thermodynamics, Statistical	140
Thesis Reports (Chemical Engineering)	141
Time-Varying Systems, Nonlinear and	135–136
Tissue Ultrastructure	138
Topology	166
Topology, Advanced	166
Trade, International	149
Traffic Engineering	115
Transistors	136
Transmission, Energy and Radiation	132
Transmission, Energy and Radiation, Laboratory	132
Transmission, Heat	142
Transportation Engineering	115
Transportation Engineering, Special Studies in	115
Transportation Planning	115
Turbines, Gas	120, 122
Turbulent Diffusion, Fluid Resistance and	117
Union-Management Cooperation, Collective Bargaining and	149–150
Union-Management Cooperation, Seminar in	150
Union-Management Relations	150
United States Foreign Policy, Asian Politics and	149
United States Foreign Policy, Major Problems in	149
United States Foreign Policy, Social Science and	149
United States, The: Men and Issues	162
Urban Sociology	129
Value Problems, Characteristic	167
Variable, Real, Functions of a	166
Variables, Complex, Functions of	166
Vector Kinematics and Gyroscopic Instrument Theory	155
Vehicles, Automotive	124
Vehicles, Orbital	156
Ventilation, Heating and	123
Vibration and Sound	139
Vibration, Mechanical	147
Vibrations	120
Visual Design, Advanced	123
Warship Basic Design	146
Warship Electrical Engineering	147
Warship Electrical Engineering, Advanced	147
Warship Electrical System Design	147
Warship Form Design	146
Warship General Arrangements	146
Warship General Design	146
Warship Propulsion	147
Warship Structure, Design	146
Warship Structure, Theory	146
Warships, History of	146
Warships, Preliminary Design of	146
Water Power Engineering	118
Water Supply and Purification	118
Water Supply and Sewerage	118
Waves, Electromagnetic	134
Waves, Shocks, and Combustion	154
Weapons, Structural Problems in	156
Weather Forecasting, Long-Range	158
Weather Prediction, Numerical	158
Welding Engineering	125
Western Civilization, Foundations of	162
Western Ideas and Values, Modern	162
Western Music from the Middle Ages to the Present	168
Western Politics and Ethics, Basic Ideas of	163
Wire Communications, Principles of	133–134
Wood, Plastics, Fabrics — Materials	157
Wood Design and Graphical Analysis	157
Writing, Creative	161
Writing, Technical, Seminar in	161
X-ray Diffraction	140
X-ray Metallurgy	127
X-ray Metallurgy, Advanced	127
X-rays and Crystal Physics	140

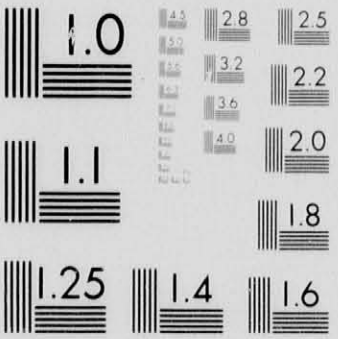
ALPHABETICAL INDEX

	Page
Academic Council	10
Academic Year	4, 36
Administration, Government and	31
Administration, Officers of	6
Administrative Council	10
Admission from Secondary Schools	41
Academic Preparation	41
Application Procedure	42
Choice of Course	41
Entrance Examinations	42
Interviews	42
Selection of Applicants	41
Admission of Foreign Students	44
Admission of Special Students	44
Admission to Graduate School	91
Admission with Advanced Standing	42
Advanced Credit	42
Application Procedure	42
Selection of Students	42
Advisers	37
Aeronautical Engineering:	
Course Schedule	78
Description of Subjects	154
Graduate Study	110
Staff	11
Tabulation of Subjects	189
Aeronautical Engineering, Cooperative	79
Air Science:	
Description of Subjects	160
Reserve Officers' Training Corps	87
Staff	12
Tabulation of Subjects	192
Alumni Association Resident Staff	27
Architecture:	
Course Schedule	58
Description of Subjects	128
Graduate Study	97
Staff	12
Tabulation of Subjects	176
Architecture and Planning, School of	32, 46
Athletic Staff	27
Athletics	39, 45
Attendance	37
Biochemical Engineering:	
Course Schedule	83
Graduate Study	114
Biology:	
Course Schedule	65
Description of Subjects	137
Graduate Study	102
Staff	13
Tabulation of Subjects	181
Board, Cost of	33
Books, etc., Cost of	33
Building Engineering and Construction:	
Course Schedule	80
Description of Subjects	157
Graduate Study	111
Staff	15
Tabulation of Subjects	190
Business and Engineering Administration:	
Course Schedule	76
Description of Subjects	151
Graduate Study in Industrial Management	110
Staff	20
Tabulation of Subjects	188
Calendar	4
Center for International Studies Staff	26
Ceramics (See Metallurgy)	
Chemical Engineering:	
Course Schedule	69
Description of Subjects	141, 169
Graduate Study	104
Staff	13
Tabulation of Subjects	183
Chemical Engineering Practice:	
Course Schedule	70
Graduate Study	105
Chemistry:	
Course Schedule	59
Description of Subjects	130
Graduate Study	98
Staff	14
Tabulation of Subjects	177
City and Regional Planning:	
Course Schedule	59
Description of Subjects	128
Graduate Study	98
Staff	15
Tabulation of Subjects	176

	Page
Civil and Sanitary Engineering:	
Course Schedule	50, 70
Description of Subjects	115
Graduate Study	95, 106
Staff	15
Tabulation of Subjects	170
College Entrance Examination Board:	
Dates of Examinations	42
College Transfer	42
Combined Plan of Study with Liberal Arts Colleges	43
Committees:	
Committees on Interdepartmental Laboratories	30
Committees on Joint Projects	30
Faculty Committees	29
Other Committees and Boards	30
Corporation, Members of	5
Cost of College Year, Estimated	33
Course of Study, Selection of	45
Courses of Study, Modifications in	45
Courses of Study, Undergraduate	45
Credit Unit	45, 170
Credits, System of	45
Degrees:	
Advanced Degrees	92
Degrees Granted	32, 46
Requirements for the Bachelor's Degree	45
Deposits to cover Chemical Supplies, Military Uniforms, etc.	35
Description of Subjects	115
Division of Sponsored Research, Staff	7
Dormitories (See Housing)	
Economics and Engineering:	
Course Schedule	74
Description of Subjects	147
Staff	16
Tabulation of Subjects	186
Economics and Social Science:	
Graduate Study	109
Educational Resources	32
Libraries	32
Museums	33
Electrical Engineering:	
Course Schedule	60
Description of Subjects	132
Graduate Study	100
Staff	16
Tabulation of Subjects	178
Electrical Engineering, Cooperative:	
Course Schedule	61
Employment, Student	34
Engineering Practice School at Oak Ridge	91
Staff	26
Engineering, School of	31, 46
English and History:	
Description of Subjects	161, 162
Staff	19
Tabulation of Subjects	193
Entrance:	
Admission by Examination	42
Examination Subjects	42
Examinations of C. E. E. B.	42
Entrance Dates	41
Examinations:	
Advanced Standing	38
Condition	37
Final	37
Expenses for School Year	33, 34
Faculty and Administrative Officers Emeriti	27
Faculty Committees	29
Faculty Council	10
Faculty Members, Ex-officiis	11
Faculty-Student Relations	37
Fees, Deposits, Payments, Expenses:	
Commons Meals	35
Deposits	35
Dormitory Rentals	34
Fees for Academic Staff	35
Late Registration or Payment Fine	35
Other Fees	35
Refunds	34
Tuition	34
Fellowships	33, 206
Financial Aids	33, 198
First-Year Course Schedule	49
Food Technology:	
Course Schedules	82
Description of Subjects	159
Graduate Study	113
Staff	18
Tabulation of Subjects	191

	Page
Foreign Students, Admission of	44
French (See Modern Languages)	
Fuel Engineering	105
General Engineering:	
Course Schedule	66
General Information	31
General Regulations:	
Academic Year	36
Advisers	37
Attendance	37
Conduct	37
Examinations	37
Examinations for Advanced Standing	38
Faculty-Student Relations	37
Petitions	38
Registration	37
General Science:	
Course Schedule	66
Geology and Geophysics:	
Course Schedule	70
Description of Subjects	143
Graduate Study	107
Staff	19
Tabulation of Subjects	184
German (See Modern Languages)	
Government and Administration	31
Graduate School:	
Administration	89
Admission	91
Chairmen of Department Committees	89
Committee on Graduate School Policy	89
Cooperation with Harvard University	94
Cooperation with Lowell Technological Institute	95
Degrees:	
Doctor of Philosophy or Science	93
Engineering Degrees	93
Master in Architecture	93
Master in City Planning	93
Master of Science	93
General Information	90
Housing	212
Residence	92
Scholarships, Fellowships, Assistantships	206
Undergraduate Preparation for Advanced Degrees	92
Graphics:	
Description of Subjects	160
Tabulation of Subjects	192
Harvard University, Cooperation with	94
Heads of Departments and Professional Courses	9
Health Insurance	36
Health of Students	36
Holidays	36
Homberg Memorial Infirmary	36
Hours of Attendance	37
Housing	33, 210
For Married Students	213
Graduate House	212
Undergraduate Houses	210
Women's Dormitory	212
Humanities and Engineering, Science:	
Course Schedule	84
Staff	19
Humanities and Social Studies, School of	32, 46
Humanities and Social Studies, Undergraduate Program in	46
Humanities, Description of Subjects:	
Economics and Social Science	147, 149
English	161
History	162
International Relations	149
Languages	163
Psychology	150
Sociology, Anthropology, Government	150
Industrial Economics:	
Graduate Study	109
Industrial Management, School of	32, 46
Description of Subjects	151
Graduate Study	110
Staff	20
Tabulation of Subjects	188
Undergraduate Courses in Business and Engineering Administration	76
Institute Committee	38
Instructing Staff	11
Insurance, Health	36
Interdepartmental Laboratories Staff	26

	Page
Library	32
Staff	26
Loan Funds	205
Loans, Scholarships, Fellowships and Prizes	33, 198
Lowell Institute School	40
Lowell Technological Institute, Cooperation with	95
Marine Engineering (See Naval Architecture)	
Mathematics:	
Course Schedule	81
Description of Subjects	165
Graduate Study	112
Staff	21
Tabulation of Subjects	195
Mechanical Engineering:	
Course Schedule	52
Description of Subjects	120
Graduate Study	95
Staff	21
Tabulation of Subjects	172
Mechanical Engineering, Cooperative	55
Medical Department	36
Staff	23
Metallurgy:	
Course Schedule	56
Description of Subjects	125
Graduate Study	97
Staff	23
Tabulation of Subjects	175
Meteorology:	
Course Schedule	81
Description of Subjects	158
Graduate Study	112
Staff	24
Tabulation of Subjects	191
Military Science:	
Description of Subjects	168
Reserve Officers' Training Corps	87
Staff	24
Tabulation of Subjects	196
Mineral Engineering (See Metallurgy)	
Modern Languages:	
Description of Subjects	163
Staff	24
Tabulation of Subjects	194
Museums	33
Staff	26
Music: Description of Subjects	168
Tabulation of Subjects	196
Music, Drama and Debating	39
Nautical Association	39
Naval Architecture and Marine Engineering:	
Course Schedule	72
Description of Subjects	145
Graduate Study	107
Staff	25
Tabulation of Subjects	185
Naval Construction and Engineering	108
Nuclear Engineering:	
Description of Subjects	169
Tabulation of Subjects	197
Officers:	
Administration	6
Instruction	11
Payments	34
Petitions	38
Physical Education Program	45
Physics:	
Course Schedule	65
Description of Subjects	139
Graduate Study	103
Staff	25
Tabulation of Subjects	182
Placement:	
Alumni	40
Student	40
Premedical Students	40
Prizes	205
Professional Societies	39
Professors Emeriti	27
Publications, Student	39
Quantitative Biology:	
Course Schedule	65
Radcliffe College, Cooperation with	94
Recreational Facilities	38
Registration	37
Registration Officers and Advisers	37
Regulations, General	36
Reserve Officers' Training Corps	40, 87
Residence (Graduate)	92
Russian (See Modern Languages)	
Sanitary Engineering:	
Course Schedule	70
Description of Subjects	115
Graduate Study	106
Schedules of Courses	49
Scholarships	33
Assistantships and Graduate Fellowships	206
Freshman	198
Undergraduate	200
Science, School of	32, 46
Science Teaching:	
Course Schedule	67
Semester Hour	170
Shipping and Shipbuilding Management:	
Course Schedule	73
Society of Arts	40
Spanish (See Modern Languages)	
Special Students, Admission of	44
Staff, Instructing	11
Student Aid and Prizes	198
Student Employment	34
Student Housing	210
Student Professional Societies	39
Subjects:	
Index	223
Of Instruction, Description	115
Of Instruction, Tabulated	170
Table of Contents	2
Technology Christian Association	39
Technology Dames	40
Technology Loan Fund	205
Textile Technology (See Mechanical Engineering)	
Transfer, College	42
Tuition Fees	34
Undergraduate Activities:	
Athletics	39, 45
Institute Committee	38
Music, Drama and Debating	39
Nautical Association	39
Professional, Social, Honorary and Service Activities	39
Publications	39
Technology Christian Association	39
Undergraduate Course Schedules	49
Undergraduate Courses of Study	45
Undergraduate Houses	210
Unit Credit	45, 170
Vacations	4
Walker Memorial	38
Women's Dormitory	212
Year, Academic	4, 36



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A