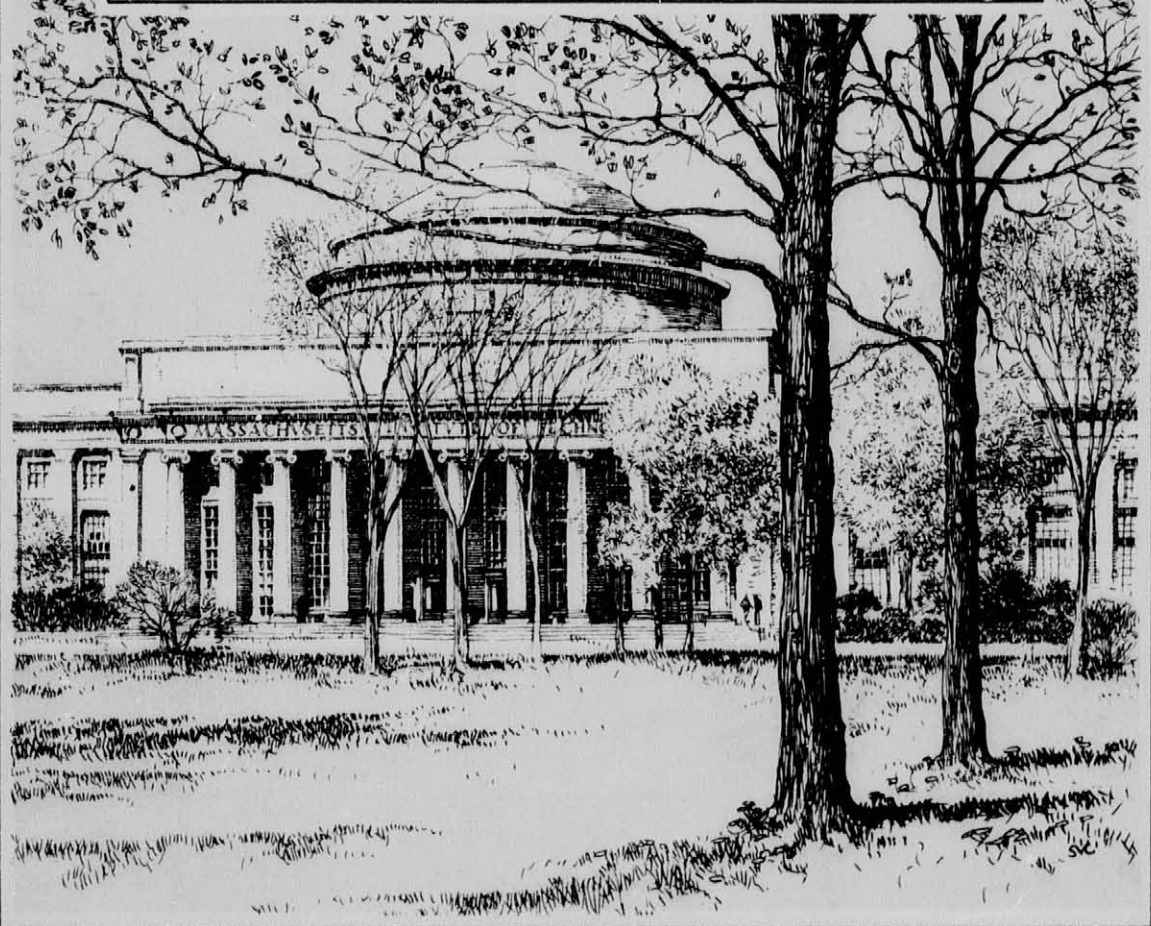
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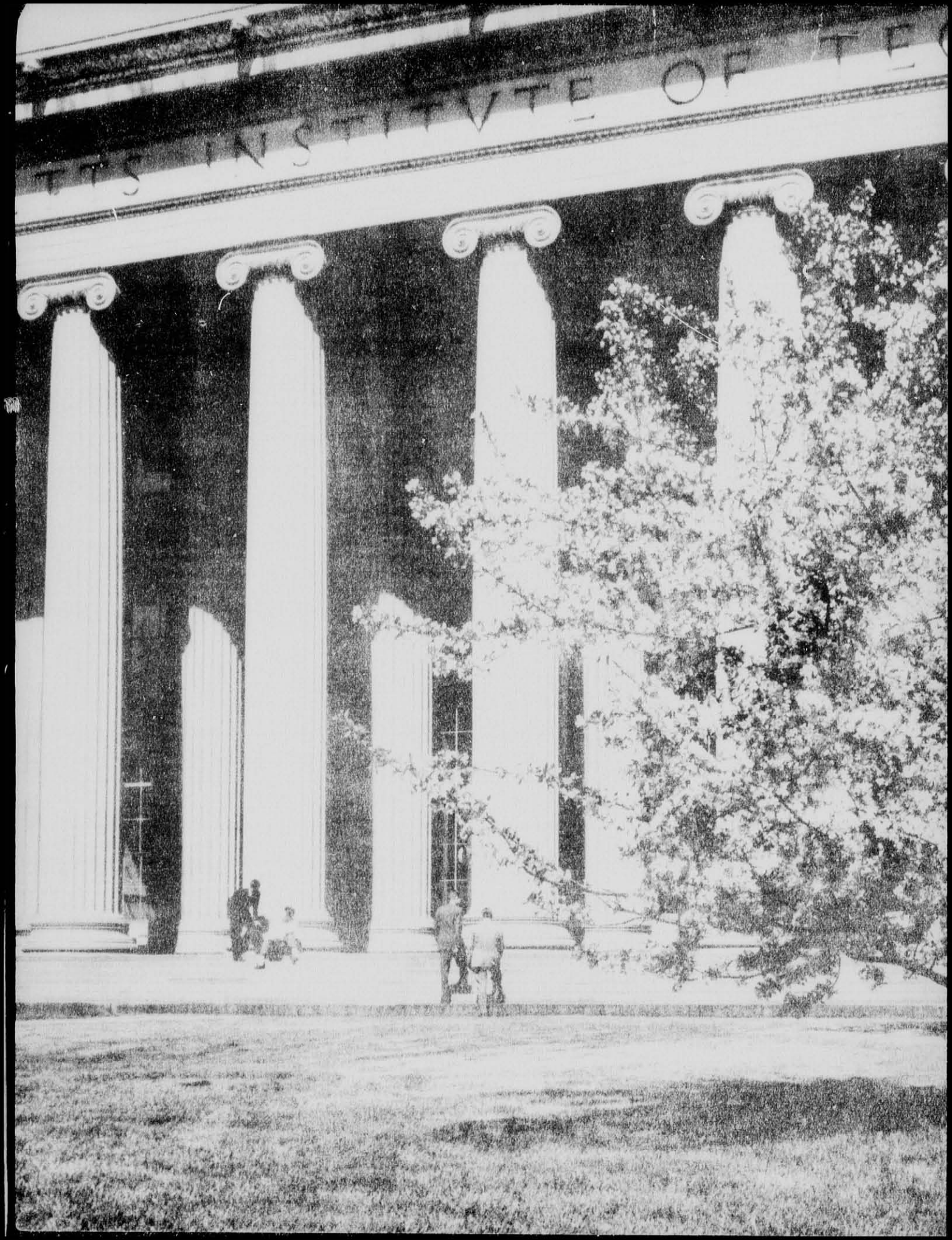
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The Institute reserves the right to make changes in the regulations and courses announced in this Bulletin

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CAMBRIDGE, MASS., U.S.A.


INSTITUTE OF

MASSACHUSETTS INSTITUTE OF TECHNOLOGY BULLETIN

CATALOGUE ISSUE
1945

A Bulletin of Information
About the Institute, its Government, Staff, Regulations,
Requirements for Admission, Facilities, and Courses of Instruction,
both Undergraduate and Graduate, Including Provision for Veterans

VOLUME 80 NUMBER 4



PUBLISHED BY THE INSTITUTE
CAMBRIDGE

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CALENDAR

CALENDAR 1945–1946

FALL TERM 1945–46

	1945	
Fall Term Begins	Nov. 5	
Armistice Day (*Holiday*)	Nov. 11	
(*Exercises omitted Monday, Nov. 12*)		
Thanksgiving Day (*Holiday*)	Nov. 22	
Christmas Vacation	Dec. 22 through	Dec. 30
	1946	
Last Exercises, Fall Term	Feb. 15	
Examination Period	Feb. 16 through	Feb. 21
Commencement Day	Feb. 25	

SPRING TERM 1946

1946	
Spring Term Begins	Mar. 4
Patriot's Day (*Holiday*)	April 19
Memorial Day (*Holiday*)	May 30
Last Exercises, Spring Term	June 7

SUMMER SESSION 1946

(*Optional Attendance*)

Summer Session Begins	June 17
Independence Day (*Holiday*)	July 4
Labor Day (*Holiday*)	Sept. 2
Last Exercises, Summer Session	Sept. 20

FALL TERM 1946–47

Fall Term Begins	Sept. 30

1945

JANUARY							FEBRUARY							MARCH						
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1946

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OCTOBER							NOVEMBER							DECEMBER						
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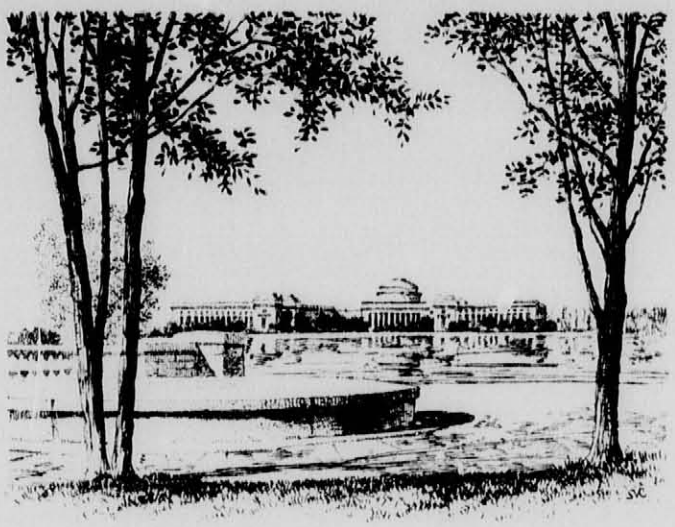


TABLE OF CONTENTS

	Page
Calendar	2
Table of Contents	3
Objectives and Policies of the Institute	5
Members of Corporation	7
Officers of Administration	8
Officers of Instruction and Instructing Staff	10
Faculty Committees	22
Committees on Joint Projects	22
Other Committees and Boards	23
General Information	
Location	24
Government and Administration	24
Degrees Granted	25
Coöperative Arrangements with Liberal Arts Colleges	25
General Regulations	25
Fees, Deposits, Payments, Expenses	27
Loans, Scholarships, Fellowships, Prizes	27
Placement	28
Educational Buildings	28
Society of Arts	29
Student Housing	29
Recreational Facilities	29
Undergraduate Activities	30
Lowell Institute School	31
Information for Veterans	
General Policy	32
Former Institute Students Returning	32
Other Veterans	32
Adjustment of Credits	32
Postwar Calendar	33

UNDERGRADUATE COURSES

Requirements for Admission	
Admission Calendar	34
Admission from Secondary Schools	34
Admission with Advanced Standing	35
Special Students	36
Foreign Students	36
Undergraduate Courses of Study	
School of Architecture and Planning	37
School of Engineering	37
School of Science	37
Division of Humanities	37
Professional Summer Schools	38
Requirements for the Bachelor's Degree	38
Subject Numbering System	38
Undergraduate Course Schedules	
First Year	38
Civil Engineering (I)	39
Mechanical Engineering (II)	40
Mechanical Engineering, Coöperative (II-A)	41
Metallurgy (III) (Including Mineral Dressing)	42
Architecture (IV)	43
City Planning (IV-B)	44
City Planning Practice (IV-C)	44
Chemistry (V)	45
Electrical Engineering (VI)	45
Electrical Engineering, Coöperative (VI-A)	47
Quantitative Biology (VII)	48
Physical Biology (VII-A)	49
Food Technology (VII-B, VII-C)	50

UNDERGRADUATE COURSES (*Continued*)

	Page
Physics (VIII)	51
General Science (IX-A)	51
General Engineering (IX-B)	52
Chemical Engineering (X)	53
Chemical Engineering Practice (X-B)	54
Geology (XII)	54
Naval Architecture and Marine Engineering (XIII)	55
Marine Transportation (XIII-C)	55
Meteorology (XIV)	56
Business and Engineering Administration (XV-A, XV-B)	57
Aeronautical Engineering (XVI)	59
Building Engineering and Construction (XVII)	60
Mathematics (XVIII)	61
Military Science	62

THE GRADUATE SCHOOL

Administration of the Graduate School	63
Committee on the Graduate School	63
Chairmen of Department Committees	63
General Information	64
Admission	64
The Master's Degrees	65
Degrees of Doctor of Philosophy or of Science	65
Graduate Programs Offered	
Civil and Sanitary Engineering	66
Mechanical Engineering	67
Textile Technology	67
Torpedo Engineering	68
Army Ordnance	68
Metallurgy (Including Mineral Dressing and Ceramics)	68
Architecture	68
City Planning	69
Chemistry	69
Electrical Engineering	70
Biology	72
Food Technology	73
Physics	73
Chemical Engineering	74
Chemical Engineering Practice	74
Geology	75
Naval Architecture	76
Marine Engineering	76
Naval Engineering	76
Naval Construction and Engineering (XIII-A)	76
Naval Construction (XIII-B)	76
Meteorology	77
Business and Engineering Administration	77
Aeronautical Engineering	78
Mathematics	79
Economics and Social Science	79
Group Psychology	80

SUBJECTS OF INSTRUCTION

Description of Subjects	81
Tabulation of Subjects	122

APPENDICES

Student Aid and Prizes	
Technology Loan Fund	143
Freshman Scholarships	143
Undergraduate Scholarship Aid for Upper Classmen	144
Graduate Fellowships and Scholarships	
Assistantships and Teaching Fellowships	148
Fellowships	148
Graduate Scholarships	148
Prizes	150
Directory of Honorary Secretaries	151
Student Housing	154
Index to Subjects of Instruction	158
Alphabetical Index	161

OBJECTIVES AND POLICIES OF THE INSTITUTE

WITH a lively and prophetic vision of the part that science was capable of playing in advancing human welfare, William Barton Rogers (1804–1882), geologist and natural philosopher of the University of Virginia, planned and worked for nearly a decade prior to the Civil War for the establishment of a great institute of technology. He selected Boston as the most advantageous location because, as he said, "ever since I have known something of the knowledge-seeking spirit and the intellectual capabilities of the community in and around Boston, I have felt that it was the one most certain to derive the highest benefits from a polytechnic institution. The occupations and interests of the great mass of the people are immediately connected with the applications of physical science, and their quick intelligence has already impressed them with just ideas of the value of scientific teaching in their daily pursuits."

As stated in its charter, granted by the Commonwealth on April 10, 1861, the Institute was established "for the purpose of instituting and maintaining a society of arts, a museum of arts, and a school of industrial science and aiding generally by suitable means the advancement, development, and practical applications of science in connection with arts, agriculture, manufactures and commerce." As its first President, Rogers, aided by far-sighted colleagues, set the Institute squarely on the course laid down in this charter and engendered among the Staff those high ideals of intellectual leadership and public service that have given continuing vitality to the Institute and that have made it not the local institution originally planned but one of national and international influence.

Motivated by the pioneering spirit of its founder, the Institute proceeded rapidly to make many seminal contributions to education and industry. It pioneered in extending the laboratory methods of instruction as an indispensable educational technique. It virtually created the modern profession of chemical engineering; its courses in electrical and aeronautical engineering, in applied physics, and in biological engineering were probably the first in the world. It was the first technological institution to recognize and provide for the important place of economics in the training of the engineer.

In attaining its present position, the Institute has constantly kept before it three objectives — the education of men, the advancement of knowledge, and the rendering of service to industry and the nation. It aims to give its students such a combination of humanistic, scientific, and professional training as will fit them to take leading positions in a world in which science, engineering, and architecture are of basic importance. This training is especially planned to prepare students, according to their desires and aptitudes, to become practicing engineers or architects, investigators, business executives, or teachers. The useful knowledge and mental discipline gained in this training are, however, so broad and fundamental as to constitute an excellent general preparation for other careers.

Realizing that the Institute trains for life and for citizenship, as well as for a career, its Staff seeks to cultivate in each student a strong character, high ideals, and a worthy purpose, as well as a keen intellect.

Along with his professional work, the student at the Institute devotes a large amount of study to the arts of expression, both written and oral. Since a high standard of accomplishment is

expected, a student planning to attend the Institute should devote special attention to this aspect of his preparation. This emphasis on expression is a part of a broad program in the humanities which is included in all regular undergraduate curricula and which aims to deepen the student's understanding of himself and his environment. There is also a wholesome regard for those extra-curricular activities which tend to broaden a man's outlook and to give him valuable experience in dealing with people, and these have had the cordial support of Faculty and Administration.

To vitalize its educational procedure and to fulfill its objectives, the Institute is placing increasing emphasis on original research in pure and applied science. Experience has demonstrated that teaching of the highest type, especially in science and its applications, thrives best in an atmosphere of steady progress in the understanding of the subject taught. He who is still a student, who is still himself learning, whether it be new relationships of the most fundamental scientific nature, or sounder and more economical ways of applying scientific knowledge for the promotion of industry and the public welfare, can best guide those about to enter upon a professional career.

Advancement in professional understanding is best acquired by intimate association with creative workers who are, through research, extending the boundaries of their professions. The most striking features of research in science and engineering at the Institute are the spirit of coöperative effort in which it is conducted and the extent to which both undergraduate and graduate students participate in it as an integral part of their educational experience.

All this makes the Institute a place where a man may study, in the true atmosphere of a professional school, those aspects of science, architecture, or engineering for which he is qualified, with opportunity to map out his own path with the aid and counsel of the Staff.

Karl T. Compton

PRESIDENT

THE CORPORATION

(As of November 1, 1945)

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HORACE SAYFORD FORD

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Term expires January, 1947
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Term expires January, 1948
PHILLIPS KETCHUM

Term expires January, 1949
GEORGE A. SLOAN

Term expires January, 1950
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JULIUS ERNEST WARREN, *Commissioner of Education*

[1] Address correspondence to Massachusetts Institute of Technology.
* On leave of Absence.

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Electrical Engineering
HAROLD LOCKE HAZEN, Sc.D. (*On Leave*)
CARLTON EVERETT TUCKER, S.B.
Executive Officer

English and History
HOWARD RUSSELL BARTLETT, B. S., A.M.

Food Technology
WILLIAM LYMAN CAMPBELL, A.B.

General Science, General Engineering
RALPH GORTON HUDSON, S.B.

Geology
WARREN JUDSON MEAD, PH.D.

Marine Transportation
LAWRENCE BOYLSTON CHAPMAN, S.B.

Mathematics
HENRY BAYARD PHILLIPS, PH.D.

Mechanical Engineering
JEROME CLARKE HUNSAKER, Sc.D.

Medical
GEORGE W. MORSE, A.B., M.D., F.A.C.S.

Metallurgy
ROBERT SEATON WILLIAMS, PH.D.
CARL FREDERICK FLOE, Sc.D.
Executive Officer

Meteorology
HENRY GARRETT HOUGHTON, JR., S.M.

Military Science and Tactics
JOHN CURTIS DUNBAR, S.B., LIEUTENANT COLONEL, A.U.S.

Modern Languages
WILLIAM NASH LOCKE, PH.D.

Naval Architecture and Marine Engineering
HENRY HIRAM WHEATON KEITH, S.B. (*On Leave*)
LAWRENCE BOYLSTON CHAPMAN, S.B., *Acting Head*

Naval Construction and Engineering
HENRY EASTIN ROSSELL, S.M. (*On Leave*)
GEORGE CHARLES MANNING, S.M.
Executive Officer

Physics
JOHN CLARKE SLATER, PH.D.

ADMINISTRATIVE COUNCIL

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Dean of Science
Dean of Architecture and Planning
Dean of Humanities
Dean of the Graduate School
Dean of Students
Director of Libraries
Director of the Division of Industrial Coöperation
Chairman of the Faculty
Bursar
President of the Alumni Association

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Dean of Science
Dean of Architecture and Planning
Dean of Humanities
Dean of the Graduate School
Dean of Students
Chairman of Committee on Undergraduate Courses
Director of Division of Industrial Coöperation
Chairman of Faculty
Secretary of Faculty
Director of Libraries
Registrar
Heads of Departments and Professional Courses

OFFICERS OF INSTRUCTION AND INSTRUCTING STAFF

(As of November 1, 1945)

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GEORGE W. SWETT, S.B., *Secretary of the Faculty*
JOSEPH C. MACKINNON, S.B., *Assistant Secretary of the Faculty*

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ROBERT M. KIMBALL, *Assistant Director of Admissions*
JOHN E. BURCHARD, *Director of Libraries*
WILLIAM N. SEAVER, *Librarian*

AERONAUTICAL ENGINEERING

JEROME CLARKE HUNSAKER, Sc.D.
Professor in charge of the Department
RICHARD HARBERT SMITH, PH.D. (*Absent*)
Professor of Aeronautical Engineering
CHARLES STARK DRAPER, Sc.D.
Professor of Aeronautical Engineering
OTTO CARL KOPPEN, S.B.
Professor of Aeronautical Engineering
JOSEPH SHIPLEY NEWELL, S.B.
Professor of Aeronautical Structural Engineering
EDWARD STORY TAYLOR, S.B.
Professor of Aircraft Engines
SHATSWELL OBER, S.B.
Associate Professor of Aeronautical Engineering
JOHN RAYMOND MARKHAM
Associate Professor of Aeronautical Engineering
WALTER MCKAY, S.M.
Associate Professor of Aeronautical Engineering
MANFRED RAUSCHER, Sc.D.
Associate Professor of Aeronautical Engineering
AUGUSTUS RUDOLPH ROGOWSKI, S.M.
Associate Professor of Aeronautical Engineering
JOHN DEZENDORF TRIMMER, PH.D. (*Absent*)
Assistant Professor of Aeronautical Engineering
DELBAR POULEUR KEILY, S.B.
Assistant Professor of Aeronautical Engineering
JOSEPH BICKNELL, S.M.
Assistant Professor of Aeronautical Engineering
RENÉ HARCOURT MILLER, B.A.
Assistant Professor of Aeronautical Engineering
PEI-MOO KU, D.I.C.
Assistant Professor of Aeronautical Engineering
ROBERT CHANNING SEAMANS, JR., S.M.
Assistant Professor of Aeronautical Engineering

Instructors

HOMER RAY OLDFIELD, JR., S.M. (*Absent*)
JOHN FREDERICK HUTZENLAUB, PH.D.
CYRUS HISAYOSHI KANO, S.M. (*Absent*)

Research Assistants

LAWRENCE BERNBAUM, S.B.
JAMES BURGE MCMILLIN, B.S.
FREDERIC WHITNEY WATRISS, S.B.
MICHAEL WITUNSKI, S.B.

Assistants

WILLIAM JAMES GAUGH, S.M.
LEONARD WALTER WEIS, S.B.

ARCHITECTURE AND PLANNING

(Including City and Regional Planning)

WILLIAM WILSON WURSTER, A.B.
Dean of Architecture and Planning; Professor of Architecture; in charge of the Department
WALTER ROY MACCORNACK, Sc.D.
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HENRY LATIMER SEAVER, A.M. *Professor of History*
ALVAR AALTO
Research Professor of Architecture
LAWRENCE BERNHART ANDERSON, M.ARCH.
Professor of Architectural Design
HERBERT LYNES BECKWITH, M.ARCH.
Associate Professor of Architectural Design
JOHN LYON REID, M.A., M.ARCH. (*Absent*)
Associate Professor of Architecture
ERNEST NAPOLEON GELOTTE, S.B.
Associate Professor of Construction
EDWARD MELVILLE BRIDGE, S.B.
Assistant Professor of Architectural Design
WILLIAM HOSKINS BROWN, M.ARCH. (*Absent*)
Assistant Professor of Architecture

Lecturers

SAMUEL CHAMBERLAIN (*Absent*)
Expressions of Graphic Art
CHARLES-EDWARD AMORY WINSLOW, DR.PH.

Instructors

JOHAN SELMER-LARSEN
ROBERT CHARLES DEAN, M. ARCH. (*Absent*)
ROBERT WOODS KENNEDY

Assistant

FLORENCE WARD STILES, S.B., *Librarian; Adviser to Women Students*

City and Regional Planning

Frederick Johnstone Adams, B.Arch.
Professor of City Planning; in charge of the Course

Flavel Shurtleff, A.B., LL.B.
Associate Professor of Legislation and Administration

Homer Hoyt, Ph.D.
Associate Professor of Land Economics

Dravea[illegible] Bender, B.Arch., M.C.P.
Assistant Professor of City Planning

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Burnham Kelly, A.B., LL.B., M.C.P.

BIOLOGY

Francis Otto Schmitt, Ph.D.
Professor of Biology; in charge of the Department

John Robert Loofbourow, Sc.D.
Professor of Biophysics

Charles Henry Blake, Ph.D.
Associate Professor of Zoölogy

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

Marshall Walker Jennison, Ph.D.
Associate Professor of Bacteriology

Richard Scott Bear, Ph.D.
Associate Professor of Biophysical Chemistry

Irwin Whiting Sizer, Ph.D.
Associate Professor of Physiology

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

David Floyd Waugh, Ph.D.
Assistant Professor of Physical Biology

Kurt Siegfried Lion, D.Eng.
Assistant Professor of Applied Biophysics

Ernest Earl Lockhart, Ph.D.
Assistant Professor of Nutritional Biochemistry

Henry Stanley B[illegible]ett, M.D.
Assistant Professor of Cytology

Research Associates
Cecil Edwin Hall, B.Sc., M.A.
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Anne Frances Knott, S.B.
Elma Dagmar Logemann, B.S.
Hugo Logemann, Jr., B.S.
Gertrude Nightingale, A.B.
Mary Kitfield Nutter, S.B.
Janette Robinson, A.B.
Virginia May Schulman, B.S.

Assistants
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Francis Alfred Giori
Henry Sherman, A.B.

BUILDING ENGINEERING AND CONSTRUCTION

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Professor of Building Construction; in charge of the Department

Dean Peabody, Jr., S.M.
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Howard Raymond Staley, S.M.
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Albert George Henry Dietz, Sc.D.
Assistant Professor of Structural Engineering

Assistant
Albert Joseph O'Neill, S.B.

BUSINESS AND ENGINEERING ADMINISTRATION

Erwin Haskell Schell, S.B.
Professor of Business Management; in charge of the Department

Charles Huntington Porter, A.B., S.B.
Professor of Accounting, Emeritus; Lecturer

Karl Dickson Fernstrom, S.B. (*Absent*)
Professor of Business Management

Wyman Parkhurst Fiske, M.B.A., LL.B., Litt.D. (*Absent*)
Professor of Accounting; Director of Sponsored Fellowship Program

Albert Adams Schaefer, A.B., LL.B.
Professor of Law and Government; Director of Puerto Rican Fellowship Program

Ronald Herbert Robnett, B.S., M.B.A.
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Ross McDuffee Cunningham, M.B.A., D.C.S.
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Gerald Bruce Tallman, M.B.A., Ph.D.
Assistant Professor of Marketing

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

Edwin Arthur Boyan, S.M.
Assistant Professor of Business Management

Lecturers
Franklin Simpson Atwater, S.B.
Arthur Warren Hanson, M.B.A., LL.B., Litt.D.

Assistants
Olive Barnard
William Ellsworth Ritchie, S.B.

CHEMICAL ENGINEERING

(Including the School of Chemical Engineering Practice)

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Professor of Chemical Engineering; in charge of the Department; Director of the School of Chemical Engineering Practice

WARREN KENDALL LEWIS, PH.D., D.SC.
Professor of Chemical Engineering

WILLIAM HENRY MCADAMS, D.SC.
Professor of Chemical Engineering

HOYT CLARKE HOTTEL, B.A., S.M.
Professor of Fuel Engineering; Director of Fuels Research Laboratory

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Professor of Chemical Engineering

HAROLD CHRISTIAN WEBER, D.SC.
Professor of Chemical Engineering

EDWIN RICHARD GILLILAND, SC.D.
Professor of Chemical Engineering; Deputy Dean of Engineering

CLARK SHOVE ROBINSON, S.M. (*Absent*)
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ERNST ALFRED HAUSER, PH.D.
Associate Professor of Chemical Engineering

HERMAN PAUL MEISSNER., D.SC.
Associate Professor of Chemical Engineering

JOHNSON EDWARD VIVIAN, SC.D.
Assistant Professor of Chemical Engineering; Acting Director of School of Chemical Engineering Practice

SCOTT WELLS WALKER, SC.D.
Assistant Professor of Chemical Engineering

GLENN CARBER WILLIAMS, SC.D.
Assistant Professor of Chemical Engineering

Instructors

BERNARD CHERTOW, M.S.
JACK BERNARD POHLENZ, B.SC.
EDWARD WILSON MERRILL, A.B.

Technical Instructor

HENRY CHASEN

Research Associates

RÉE VILMA LE BEAU, PH.D. (*Absent*)
JOSEPH ALBERT POLACK, S.M.
WILBURN HOFFMAN, B.S.
HERBERT STANFORD ISBIN, M.S.
HAROLD SOMERS MICKLEY, M.S.
CHARLES CLEVELAND NEAS, B.S.
CHARLES NELSON SATTERFIELD, S.M.

Assistants

RAYMOND CHUNG, M.CH.E.
CURTIS HOMER ELLIOTT, JR., S.B.
FREDERICK WILLIAM FOLTS, B.CH.E.
ROBERT LEROY JACKS, B.E.
SHELTON MORRIS JOHNSON, JR., M.CH.E.
JAMES ALLISON LUKER, B.S.
ROBERT WALTER MAYER, B.S.
PRESTON PARR, JR., M.S.
DONALD QUON, S.M.
MICHAEL SIVETZ, B.CH.E.

CHEMISTRY

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

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

FREDERICK GEORGE KEYES, PH.D., SC.D.
Professor of Physical Chemistry

MILES STANDISH SHERRILL, PH.D.
Professor of Physical Chemistry, Emeritus; Lecturer

EARL BOWMAN MILLARD, PH.D.
Professor of Physical Chemistry

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

GEORGE SCATCHARD, PH.D.
Professor of Physical Chemistry

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

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

ERNEST HAMLIN HUNTRESS, PH.D
Professor of Organic Chemistry

WILLIS RODNEY WHITNEY, PH.D., SC.D., CH.D.
Non-Resident Professor of Chemical Research

LOUIS HARRIS, PH.D.
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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

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

GERHARD DIETRICHSON, PH.D.
Associate Professor of Physical Chemistry

ROBERT CASAD HOCKETT, PH.D. (*Absent*)
Associate Professor of Organic Chemistry

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

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

ISADORE AMDUR, PH.D.
Associate Professor of Physical Chemistry

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

GEORGE GLOVER MARVIN, PH.D.
Associate Professor of Analytical Chemistry

LAWRENCE JOSEPH HEIDT, PH.D.
Assistant Professor of Chemistry

CLARK CONKLING STEPHENSON, PH.D.
Assistant Professor of Chemistry

ALBERTO FREDERIC THOMPSON, JR., PH.D. (*Absent*)
Assistant Professor of Chemistry

THOMAS ROBINSON PIRIE GIBB, JR., PH.D.
Assistant Professor of Chemistry

JOHN WITHERS IRVINE, JR., PH.D.
Assistant Professor of Chemistry

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

WILLIAM MONTGOMERY HEARON, PH.D. (*Absent*)
Assistant Professor of Chemistry

Instructors

Thomas Palm Pitré, B.A.
Robert Moody Sherman, S.B.

Hewitt Grenville Fletcher, Jr., Ph.D. (*Absent*)
Sheppard Young Tyree, Jr., S.B.

John George Schudel, Jr., S.B.
Robert Reynold Marshall, S.B.

Research Associates

Eugene Rabinowitch, Ph.D. (*Absent*)
Morris Zief, Ph.D.
Allen Scattergood, Ph.D.

Louis Long, Jr., Ph.D.
Sinclair Howard Armstrong, Jr., M.D.

Elizabeth Lee Sheffield, Ph.D.
Franklin Elwood Morris, Ph.D.
Herbert Fessenden Wright, Ph.D.

Library Fellow

James Whitney Perry, S.M.

Research Assistants

James Bradford Ames, S.B.
Margaret Anne Campbell, A.B.
Muriel Ethel Turner Holden, M.A.
Ruth Elizabeth Klabe, S.B.
Robert Ellsworth Miller, Sc.B.

Louis Oliver Mitchell
Harold Russ Nace, B.S.
Hugh Edwin Ramsden, S.B.
Leslie Merrill Redman, B.A.

Rebecca Elaine Emily Spencer, B.A.
Milton Arthur Taves, B.S.
Jean Davidson Tvrzicky, M.A.
Richard Parke Welcher, A.B., S.B.
Alfred Edwards Winslow, B.S.

Teaching Fellows

Erling Grovenstein, Jr., B.S.
Telford Grant Maple, B.S.
Frank Dennis Marsh, B.S., M.A.
Engel Woerne Nelius, Jr.,B.S.

Hellmut Philip Penner, S.B.
Siegfried Edmund Penner, S.B.

Phyllis Louise Pollock, B.S.
Mildred Elizabeth Sackmann, B.A.
Mary Agnes Sullivan, M.S.
Frances Grace Wilmoth, A.B.

Assistants

Elaine Mildred Bickford, S.B.
Carolyn Klein Fitz, Ph.D.

Anne Louise Lyons, S.B.

Maynard Elliott Smith, S.B.
Barbara Frances Van Tassel, A.B.

CIVIL AND SANITARY ENGINEERING

John Benson Wilbur, Sc.D.
Professor of Structural Engineering; Acting in charge of the Department

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

George Edmond Russell, S.B.
Professor of Hydraulics, Emeritus; Lecturer

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

Murray Philip Horwood, Ph.D.
Professor of Sanitary Science

William Edward Stanley, C.E.
Professor of Sanitary Engineering

Walter Maxwell Fife, S.M.
Associate Professor of Structural Engineering

Eugene Mirabelli, S.B.
Associate Professor of Structural Design

John Donald Mitsch, S.B.
Associate Professor of Structural Engineering

Donald Wood Taylor, S.M.
Associate Professor of Soil Mechanics

Alexander Jamieson Bone, S.M.
Associate Professor of Highway Engineering

Clair Nathan Sawyer, Ph.D.
Associate Professor of Sanitary Chemistry

Arthur Thomas Ippen, Ph. D.
Associate Professor of Hydraulics

Arthur Claude Ruge, Sc.D.
Assistant Professor of Engineering Seismology

Allan Thurston Gifford, S.B.
Assistant Professor of Hydraulic Engineering

Charles Head Norris, Sc.D.
Assistant Professor of Structural Engineering

Herman James Shea, S.M.
Assistant Professor of Surveying

Instructors

Charles Franklin Peck, Jr., S.M.
Thomas William Lambe, S.M.

Assistants

Stewart Garrison Green, B.S.
Donald Robert Fergusson Harleman, B.S.
Milton Martin Platt, S.B.

ECONOMICS AND SOCIAL SCIENCE

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

Donald Skeele Tucker, Ph.D.
Professor of Economics

William Rupert Maclaurin, M.B.A., D.C.S.
Professor of Economics

Douglass Vincent Brown, Ph.D.
Professor of Industrial Relations

Norman Judson Padelford, Ph.D.
Professor of International Relations

Kurt Lewin, Ph.D.
Professor of Psychology; Director of Research Center for Group Dynamics

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

F. Alexander Magoun, S.M.
Associate Professor of Human Relations

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

Richard Mervin Bissell, Jr., Ph.D. (*Absent*)
Associate Professor of Economics

Douglas Murray McGregor, Ph.D.
Associate Professor of Psychology

Harold Adolph Freeman, S.B.
Associate Professor of Statistics

Paul Anthony Samuelson, Ph.D.
Associate Professor of Economics

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

Irving Knickerbocker, Ph.D.
Assistant Professor of Psychology

Dorwin Philip Cartwright, Ph.D.
Assistant Professor of Psychology

Ronald Lippitt, Ph.D. (*Absent*)
Assistant Professor of Psychology

INSTRUCTING STAFF

Instructors

ROBERT LYLE BISHOP, A.M.
FINN THEODORE MALM, B.S.
ALEX BAVELAS, B.S., M.A.
GUY HENDERSON ORCUTT, PH.D.
MARIAN JEANETTE RADKE, PH.D.
LEON FESTINGER, PH.D.

Research Associates

JOHN ARSENIAN, PH.D.
CHARLES ERIC HENDRY, M.A. (*Absent*)

Research Assistants

DAVID AMOS EMERY, B.S.,M.A.
ROSALINE JOYCE HARMAN, A.B.
SIMON NATHAN HERMAN, LL.B., M.A.
ROBERT KATES, BS., M.A.
BARBARA KLINGENHAGEN, A.B.

Assistant

BEATRICE ALLEN ROGERS, A.B., B.S.

ELECTRICAL ENGINEERING

HAROLD LOCKE HAZEN, Sc.D.
Professor of Electrical Engineering; in charge of the Department

CARLTON EVERETT TUCKER, S.B.
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RALPH RESTIEAUX LAWRENCE, S.B.
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WILLIAM HENRY TIMBIE, A.B.
Professor of Electrical Engineering and Industrial Practice; Chairman of the Faculty

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

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

RALPH GORTON HUDSON, S.B.
Professor of Electrical Engineering; in charge of Course IX

RALPH DECKER BENNETT, PH.D. (*Absent*)
Professor of Electrical Measurements

EDWARD LINDLEY BOWLES, D.Sc. (*Absent*)
Professor of Electrical Communications

MURRAY FRANK GARDNER, S.M.
Professor of Electrical Engineering

ERNST ADOLPH GUILLEMIN, PH.D.
Professor of Electrical Communications

CLIFFORD EARL LANSIL, S.B. (*Absent*)
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RICHARD DUDLEY FAY, A.B., S.B.
Associate Professor of Electrical Communications

LOUIS FRANK WOODRUFF, S.M. (*Absent*)
Associate Professor of Electric Power Transmission

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

JAYSON CLAIR BALSBAUGH, S.M.
Associate Professor of Electric Power Production and Distribution

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

JOSEPH WARREN HORTON, Sc.D.
Associate Professor of Electrical Communications

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

HAROLD EUGENE EDGERTON, Sc.D.
Associate Professor of Electrical Measurements

SAMUEL HAWKS CALDWELL, Sc.D.
Associate Professor of Electrical Engineering

ARTHUR ROBERT VON HIPPEL, PH.D.
Associate Professor of Electrical Engineering

WILMER LANIER BARROW, Sc.D. (*Absent*)
Associate Professor of Electrical Communications

GORDON STANLEY BROWN, Sc.D.
Associate Professor of Electrical Engineering

JOHN GEORGE TRUMP, Sc.D.
Associate Professor of Electrical Engineering

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

ARTHUR EUGENE FITZGERALD, Sc.D.
Associate Professor of Electrical Engineering

WILLIAM HENRY RADFORD, S.M.
Associate Professor of Electrical Communications

HAROLD IRWIN TARPLEY, M.S.
Associate Professor of Electrical Engineering (Visiting)

IVAN ALEXANDER GETTING, D.PHIL.
Associate Professor of Electrical Engineering

WILLIAM MOTT HALL, Sc.D. (*Absent*)
Assistant Professor of Electrical Communications

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

MALCOLM STRONG MCILROY, E.E.
Assistant Professor of Electrical Engineering

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

JAMES EDWARD MULLIGAN, S.M. (*Absent*)
Assistant Professor of Electric Power Production

LAWRENCE BAKER ARGUIMBAU, S.B.
Assistant Professor of Electrical Communications

JAMES ALBERT WOOD, JR., PH.D.
Assistant Professor of Electrical Engineering

ALBERT CARRUTHERS HALL, Sc.D.
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RICHARD TAYLOR, S.M.
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GODFREY THOMAS COATE, M.S.
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Instructors

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JAMES NORTON THURSTON, S.M.
CHARLES EDGAR DOLBERG, B.S. (*Non-Resident*)
LEROY WESTON EVANS, B.S.
MARTIN WHITE ESSIGMANN, B.S.

Research Associates

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HERBERT EARLE GRIER, S.M.
ROBERT WILLIAM CLOUD, S.M.
RICHARD HUBERT BLYTHE, S.M.
ROBERT LOUIS KYHL, S.B.
JOHN LARS COLE LÖF, S.M.
SHEPARD ROBERTS, S.M.
WILLIAM GORDON TULLER, S.M.
DAVID FERDINAND WINTER, B.S.
PATRICKYOUTZ, A.B., S.M.

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BENJAMIN HARVEY CISCEL, B.S.
MERLIN GEORGE HAUGEN, B.E.E.
ROBERT KELLY, B.S.
SAMUEL JEFFERSON MASON, B.S.
CLARENCE ROLAND MOSTER, E.E.
KENNETH EUGENE SCHREINER, B.S.
BERNARD THOMAS SVIHEL, B.S.
CHARLES JULIUS SWARTWOUT, B.S.
FRANK MATT VERZUH, B.S.
DONALD REEDER YOUNG, B.S.
FRANK PAUL ZAFFARANO, B.S.

Assistants

MANUEL CERILLO, B.S.
JOHN PETER CHISHOLM, S.B.
WEN-TSING CHOW, S.M.
PAUL CHARLES GROSSE, S.B.
DAVID EDWIN HIGGINBOTHAM, S.B.
EARL WILLIAM KELLER, B.E.
ERNEST RUDOLF KRETZMER, B.S.
JOHN GRIMES LINVILL, A.B., S.M.
WILLIAM KIRBY LINVILL, A.B., S.M.
ROBERT PAGE MACK, B.E.
WILLIAM PETER MCNULTY, B.E.
JOHN FERDINAND NICHOLAS, B.S.
MARTIN MICHAEL SANTA, B.E.E.

ENGLISH AND HISTORY

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FOOD TECHNOLOGY

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CHARLES ARTHUR BULFINCH
RALPH JOHN BOWLEY
CLARENCE WILLIAM CHRISTIANSEN
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GAYLORD PALMER COON, M.Sc., M.D.
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*Solar Energy Conversion Research

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LUCILLE CHARRON, A.B., S.M.
ALBERT NELSON DINGLE, S.M.
CHARLES JOSEPH H[illegible]BBARD, A.B., S.B.

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MAGDALENE HEYMANN
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Assistants

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MILITARY SCIENCE AND TACTICS

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FRANK CRONK, Technical Sergeant, D.E.M.L. *Armorer*
ARNOLD JOSEPH BIANCHI, Sergeant, D.E.M.L.

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NAVAL ARCHITECTURE AND MARINE ENGINEERING

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Professor of Marine Transportation and Marine Engineering; acting in charge of Department; in charge of Course XIII-C

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RONALD HERBERT ROBNETT, B.S., M.B.A.
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Professor of Industrial Biology, Emeritus

ROBERT PAYNE BIGELOW, PH.D.
Professor of Zoölogy and Parasitology, Emeritus

CLAIR ELSMERE TURNER, A.M., DR.P.H., Sc.D.
Professor of Public Health, Emeritus

BUSINESS AND ENGINEERING ADMINISTRATION

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

CHEMISTRY

MILES STANDISH SHERRILL, PH.D.
Professor of Physical Chemistry, Emeritus; Lecturer

ARTHUR ALPHONZO BLANCHARD, PH.D.
Professor of Inorganic Chemistry, Emeritus

TENNEY LOMBARD DAVIS, PH.D.
Professor of Organic Chemistry, Emeritus

ALPHEUS GRANT WOODMAN, S.B.
Associate Professor of Analytical Chemistry, Emeritus

WILLIAM THOMAS HALL, S.B.
Associate Professor of Analytical Chemistry, Emeritus

CIVIL AND SANITARY ENGINEERING

CALVIN FRANCIS ALLEN, ENG.D.
Professor of Railroad Engineering, Emeritus

CHARLES MILTON SPOFFORD, S.B.
Hayward Professor of Civil Engineering, Emeritus

ARTHUR GRAHAM ROBBINS, S.B.
Professor of Topographical Engineering, Emeritus

HAROLD KILBRITH BARROWS, S.B.
Professor of Hydraulic Engineering, Emeritus

GEORGE EDMOND RUSSELL, S.B.
Professor of Hydraulics, Emeritus; Lecturer

ECONOMICS AND SOCIAL SCIENCE

FLOYD ELMER ARMSTRONG, A.M.
Professor of Economics and Finance, Emeritus

ELECTRICAL ENGINEERING

DUGALD CALEB JACKSON, C.E., D.Sc., D.ENG.
Professor of Electric Power Production and Distribution, Emeritus

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

ENGLISH AND HISTORY

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

GEOLOGY

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

MATHEMATICS

FREDERICK SHENSTONE WOODS, PH.D.
Professor of Mathematics, Emeritus

FREDERICK HAROLD BAILEY, A.M.
Professor of Mathematics, Emeritus

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

MECHANICAL ENGINEERING

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

GEORGE BARTHOLOMEW HAVEN, S.B.
Professor of Advanced Machine Design, Emeritus

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

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

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

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

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

JESSE JENNINGS EAMES, S.B.
Associate Professor of Mechanical Engineering, Emeritus

METALLURGY

WILLIAM SPENCER HUTCHINSON, S.B.
Professor of Mining, Emeritus

GEORGE BOOKER WATERHOUSE, PH.D., D.MET.
Professor of Process Metallurgy, Emeritus

CHARLES E LOCKE, S.B.
Professor of Mining Engineering and Ore Dressing, Emeritus

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

EDWARD EVERETT BUGBEE, S.B.
Associate Professor of Mining Engineering, Emeritus

MODERN LANGUAGES

ERNEST FELIX LANGLEY, PH.D.
Professor of French, Emeritus

HERMAN RUDOLPH KURRELMEYER, PH.D.
Professor of German, Emeritus; Lecturer

NAVAL ARCHITECTURE AND MARINE ENGINEERING

WILLIAM HOVGAARD, D.ENG.
Professor of Naval Design and Construction, Emeritus

JAMES ROBERTSON JACK
Professor of Naval Architecture and Marine Engineering, Emeritus

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

CHARLES SHERIDAN JOYCE, Captain, U.S.N., Retired
Professor of Naval Engineering, Emeritus

PHYSICS

HARRY MANLEY GOODWIN, PH.D.
Professor of Physics and Electrochemistry, Emeritus

NEWELL CALDWELL PAGE, S.B.
Professor of Electricity, Emeritus

SECTION OF GRAPHICS

STEPHEN ALEC BREED, S.B.
Associate Professor of Drawing and Descriptive Geometry, Emeritus

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

CHARLES MATTHEW CURL, S.B.
Assistant Professor of Drawing and Descriptive Geometry, Emeritus; Lecturer

ADMINISTRATION

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

INSTRUCTING STAFF

FACULTY COMMITTEES
1945-1946

GRADUATE SCHOOL

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

L. B. Anderson
D. V. Brown
M. J. Buerger
W. M. Fife
W. P. Fiske
M. F. Gardner
H. G. Houghton
E. H. Huntress
R. S. Williams
G. C. Manning
H. B. Phillips
B. F. Proctor
T. K. Sherwood
I. W. Sizer
J. C. Slater
R. H. Smith
G. W. Swett

PETITIONS

Assistant Secretary (*Chairman*)*
Secretary*
Dean of Students*

	Term Expires
C. E. Tucker	1946
B. E. Warren	1947
J. E. Vivian	1948
J. S. Newell	1949

NOMINATING COMMITTEE
1945-1946

B. E. Warren (*Chairman*)
V. O. Homerberg
J. S. Newell
F. J. Adams
T. K. Sherwood

ADMISSIONS

Director of Admissions (*Chairman*)*
Dean of Students*
Registrar*

	Term Expires
J. A. Hrones	1946
C. H. Norris	1946
R. H. Frazier	1947
H. P. Meissner	1947
L. S. Bryant	1948
S. D. Zeldin	1948

COURSE IX

	Term Expires
R. G. Hudson (*Chairman*)*	
F. W. Sears	1946
R. H. Robnett	1947
E. L. Gamble	1948
C. L. Svenson	1949

GENERAL STUDIES

Dean of Humanities (*Chairman*)*	Term Expires
W. C. Greene	1946
H. L. Seaver	1947
W. H. Timbie	1948
W. H. Stockmayer	1949
W. R. Maclaurin	1950

PROVISIONAL STUDENTS AND DISCIPLINE

Dean of Students (*Chairman*)*
Registrar*

	Term Expires
A. A. Schaefer	1946
J. D. Mitsch	1947
H. B. Phillips	1948

UNDERGRADUATE COURSES

	Term Expires
E. B. Millard (*Chairman*)	1946
J. T. Rule	1946
R. H. Robnett	1947
C. E. Tucker	1947
J. A. Hrones	1948
J. B. Wilbur	1948
E. N. Gelotte	1949
F. W. Sears	1949

COMMITTEE ON THE LIBRARY

Executive Board

Librarian (*Secretary*)*
Director of Libraries*

	Term Expires
L. B. Chapman	1946
J. H. Keenan	1947
N. J. Padelford**	1947
E. H. Huntress	1948
D. V. Brown	1949
M. F. Gardner**	1949

UNDERGRADUATE SCHOLARSHIPS

Dean of Students (*Chairman*)*	Term Expires
M. S. McIlroy	1946
H. P. Meissner	1946
G. G. Marvin	1947
A. R. Rogowski	1947
H. J. Shea	1948
G. B. Tallman	1948
C. A. Myers	1949
I. W. Sizer	1949
J. R. Markham	1950
G. P. Wadsworth	1950

COMMITTEES ON JOINT PROJECTS
1945-1946

APPLIED MATHEMATICS

H. B. Phillips (*Chairman*)
S. H. Caldwell
E. A. Guillemin
P. M. Morse
C. R. Soderberg
J. A. Stratton
R. Taylor
H. Wallman
N. Wiener
Dean of Science*

NUCLEAR RESEARCH

G. R. Harrison (*Chairman*)
J. Chipman
A. C. Cope
R. D. Evans
I. A. Getting
W. K. Lewis
F. O. Schmitt
J. C. Slater
C. R. Soderberg

SOLAR ENERGY CONVERSION

H. C. Hottel (*Chairman*)
A. C. Hardy
G. W. Swett
E. H. Huntress
A. R. von Hippel

L. Harris
G. R. Harrison
G. Scatchard
T. K. Sherwood
G. B. Wilkes
Dean of Engineering*

*ex officio
**Appointed by the President

OTHER COMMITTEES AND BOARDS
1945–1946

CONDUCT OF EXAMINATIONS
A. T. Gifford (*Chairman*)
S. G. Simpson
A. Sloane
G. P. Wadsworth
L. M. Dawes
J. A. Hrones
C. H. Norris
E. N. Gelotte
C. Goodman
E. F. Perry

STABILIZATION OF ENROLLMENT
H. E. Lobdell (*Chairman*)
L. F. Hamilton
W. H. McAdams
F. W. Sears
C. R. Soderberg
B. A. Thresher
C. E. Tucker

TECHNOLOGY MUSEUM
A. C. Watson (*Chairman*)
J. R. Jack
Dard Hunter
H. R. Bartlett
H. L. Beckwith
R. D. Douglass
F. K. Morris
F. W. Sears
E. R. Schwarz

COMMENCEMENT
R. G. Hudson (*Chairman*)
H. S. Ford
R. S. Williams
J. W. M. Bunker
J. C. MacKinnon
E. R. Schwarz
C. L. Svenson

STUDENT-FACULTY
R. H. Robnett (*Chairman*)
C. M. Wareham
T. P. Pitré
M. F. Gardner
J. D. Mitsch
H. R. Bartlett
J. Holt

SPECIAL PROGRAMS AND CONFERENCES
R. D. Douglass (*Chairman*)
H. R. Bartlett
A. F. Holmes
W. K. Lewis
J. C. MacKinnon
T. P. Pitré
C. E. Tucker
B. E. Warren

PATENT POLICY
J. W. M. Bunker (*Acting Chairman*)
E. L. Moreland (*Absent*)
A. C. Hardy
F. G. Keyes
H. L. Hazen
T. K. Sherwood
N. McL. Sage

PATENT MANAGEMENT
J. W. M. Bunker (*Acting Chairman*)
E. L. Moreland (*Absent*)
N. McL. Sage
H. S. Ford
J. R. Killian, Jr.

DORMITORY BOARD
L. F. Hamilton (*Chairman*)
H. E. Lobdell
D. L. Rhind
A. A. Ashdown

LOAN BOARD
H. E. Lobdell (*Chairman*)
K. T. Compton
B. A. Thresher
H. S. Ford
D. L. Rhind (*Secretary*)

BOARD OF PUBLICATIONS
J. R. Killian, Jr. (*Chairman*)
G. R. Harrison
E. H. Huntress
R. T. Jope
H. L. Seaver

UNDERGRADUATE BUDGET BOARD
H. S. Ford (*Chairman*)
H. E. Worcester
D. L. Rhind
H. E. Lobdell
R. T. Jope

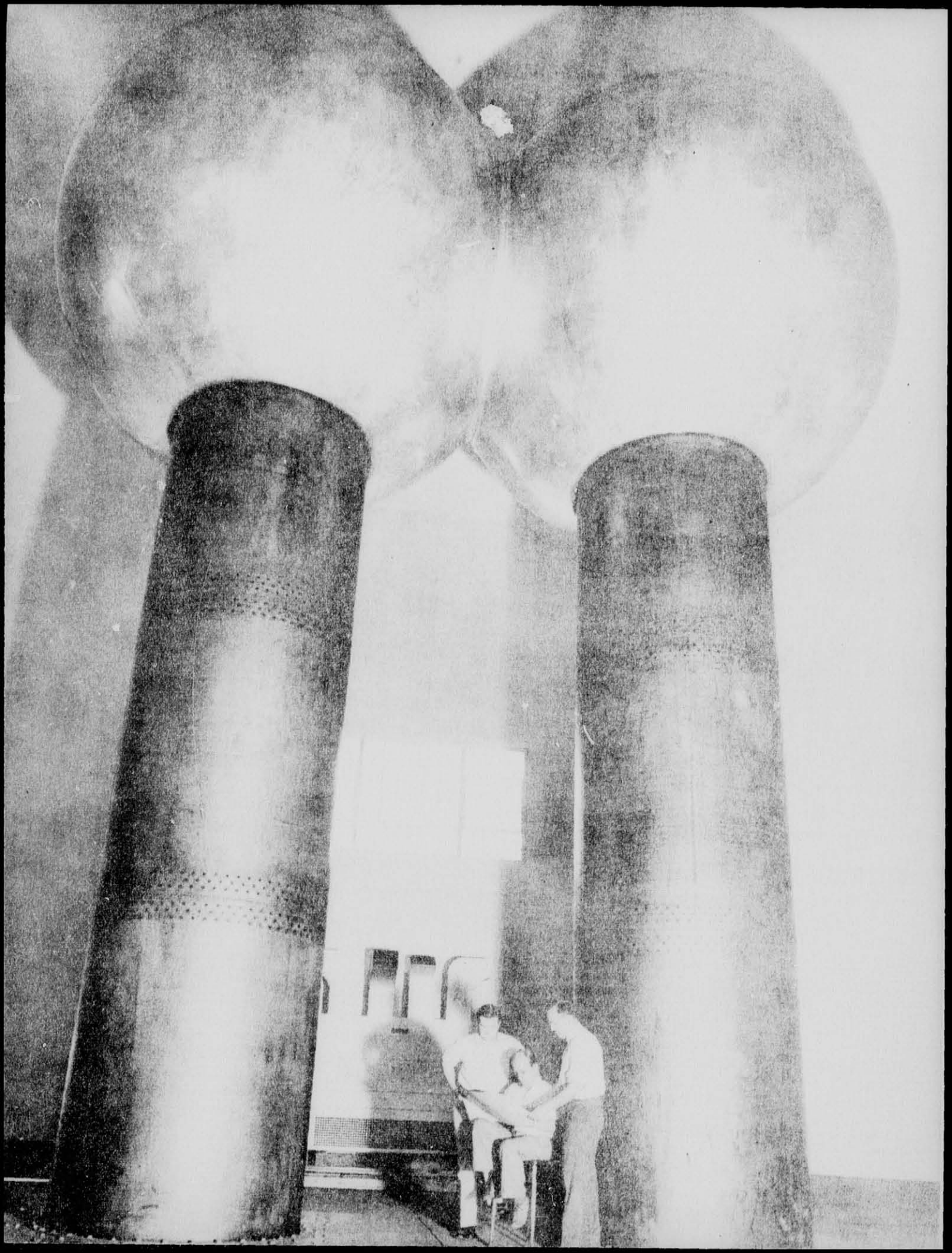
STAFF—ADMINISTRATION
Staff
J. E. Arnold
R. M. Cunningham
P. Franklin
W. C. Greene
H. P. Meissner
C. F. Peck, Jr.
F. W. Sears

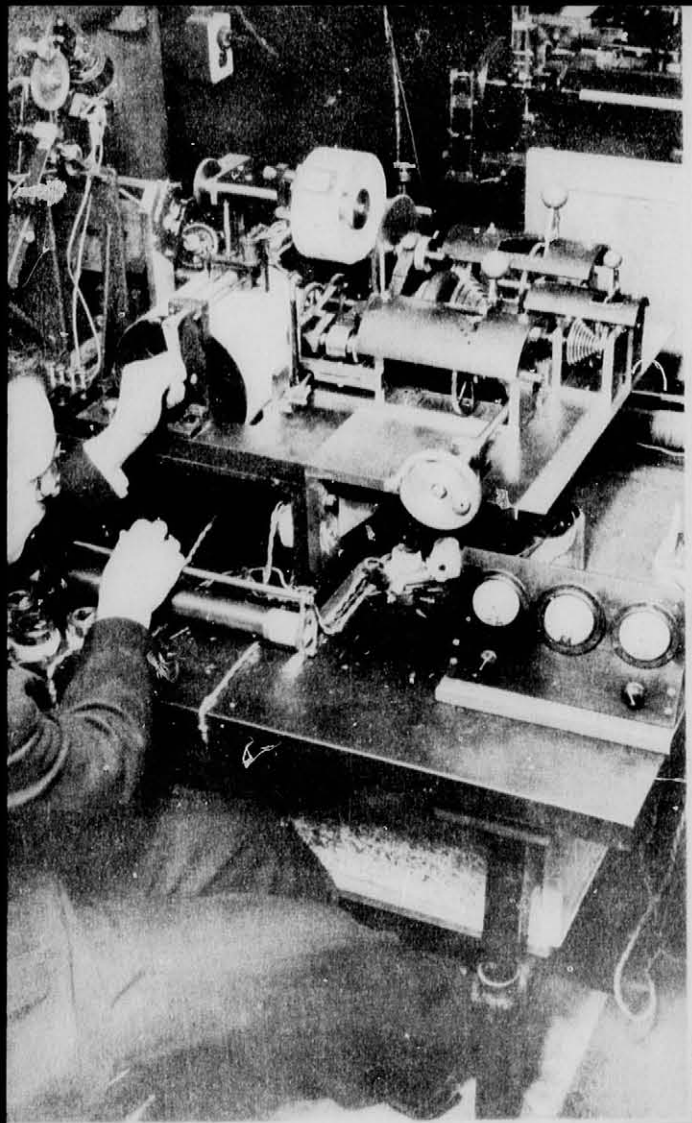
Administration
G. R. Harrison
E. L. Moreland
R. G. Caldwell
H. E. Lobdell
J. C. Hunsaker
H. S. Ford
J. R. Killian, Jr.

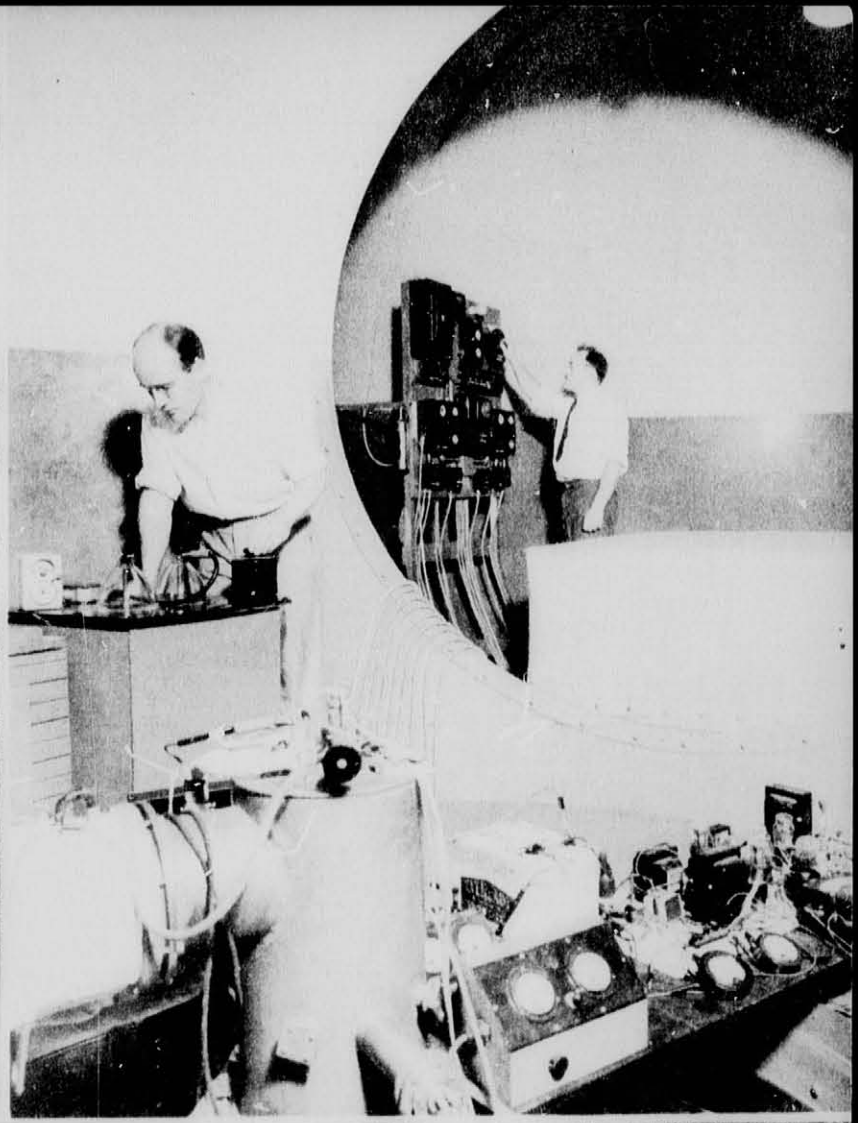
ADVISORY COMMITTEE ON FINE ARTS AND MEMORIALS
H. L. Seaver (*Chairman*)
J. E. Burchard
C. R. Hayward
A. C. Watson
H. B. Richmond

ADVISORY COMMITTEE ON THE BEMIS FOUNDATION
A. C. Bemis
W. W. Wurster
E. L. Moreland
M. L. Colean
A. J. Eken
O. M. W. Sprague
R. E. Zimmerman

ADVISORY COMMITTEE ON THE DIVISION OF INDUSTRIAL COÖPERATION
N. McL. Sage (*Chairman*)
G. R. Harrison
W. K. Lewis
E. B. Millard
R. S. Williams
F. L. Foster (*Secretary*)

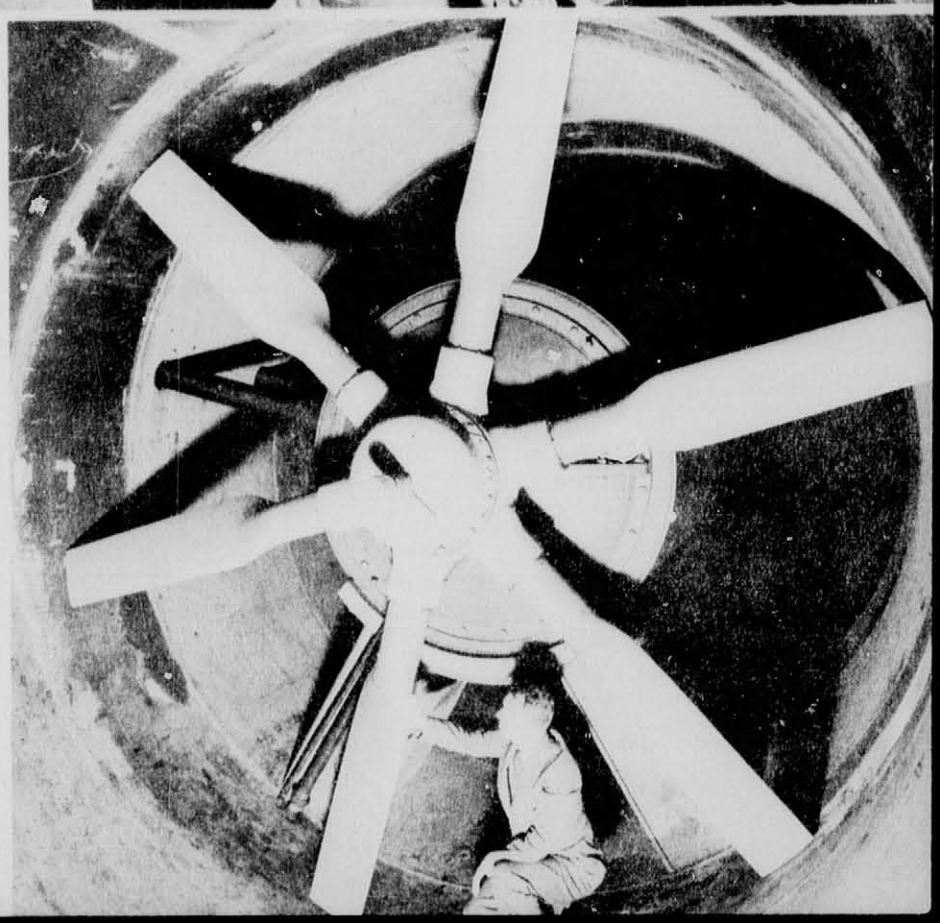






RESEARCH

THE RESEARCH RESOURCES OF THE INSTITUTE ARE NOW DEVOTED TO PROJECTS DESIGNED TO HASTEN VICTORY FOR THE UNITED NATIONS. OUT OF THE ACCELERATED RESEARCHES FOR WAR HAVE COME NEW KNOWLEDGE AND NEW DEVELOPMENTS IN SCIENCE AND ENGINEERING, AND ONE OF THE RICHEST PROMISES OF PEACE IS THE OPPORTUNITY TO APPLY THESE DISCOVERIES FOR THE ADVANCEMENT AND WELL-BEING OF MANKIND.



GENERAL INFORMATION

LOCATION

AFTER occupying for fifty years its site in Boston, the Institute in 1916 moved into a completely new plant located on the Cambridge side of the Charles River Basin. Here, on a tract of eighty acres, extending along the river, are the twenty-five educational buildings and laboratories, infirmary, Walker Memorial (the student union), student houses, and athletic plant, including gymnasium, swimming pool, playing fields, field houses, sailing pavilion, and boat house.

The location of the Institute enables its students to profit from the manifold cultural advantages to be found in Boston and its environs — an area richly provided with great libraries and museums and other foundations devoted to literature, art, music, and science. Proximity to many large industries affords students ample opportunities to supplement their academic work by plant visits and other profitable contacts with industry and commerce.

GOVERNMENT AND ADMINISTRATION

In a legal sense the Institute is a body of trustees known as the Corporation which, as provided in its bylaws, consists "of its Chairman, President, Vice-President, and Treasurer and, if eligible, the President of the Alumni Association *ex officiis*, of the *ex officiis* 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 officiis* 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, January, 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 various departments of the school.

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 and Treasurer there are other duly appointed officers of administration and instruction. Chief among the former are the Deans of Engineering, Science, Architecture, Humanities, the Graduate School, and Students; the Executive Vice-President; the Bursar; and the Director of the Division of Industrial Coöperation. These, together with the Chairman of the Faculty, who is elected by that body, and the President of the Alumni Association, compose the Administrative Council.

The Faculty consists of all Professors, Associate Professors, and Assistant Professors, certain designated Instructors and Research Associates, and the following administrative officers *ex officiis:* the President, Vice-President, Executive Vice-President, Deans, Director of Admissions, Registrar, Librarian, Associate Dean of Students, and Assistant Director of Admissions. 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 the Graduate School, Undergraduate Courses, Admissions, Petitions, Provisional Students and Discipline, Undergraduate Scholarships, the Courses in General Science and General Engineering, General Studies, the Library, and on First-, Second-, Third-, and Fourth-Year Students.

These "Rules and Regulations" also provide for a system of Registration Officers and for a Faculty Council. The Registration Officers, of whom there is one for each year of each Course above the first year, serve as academic advisers and ensure that each student's particular problems will receive individual consideration. The Faculty Council 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.

In order most effectively to administer and to develop the educational and research work of the Institute, and also in order better to coördinate the work of those departments which are naturally similar in outlook, the academic phases of the Institute are divided, as implied above, into the following groups: the Graduate School, the School of Architecture and Planning, the School of Science, the School of Engineering, the Division of Humanities, and the Division of Industrial Coöperation.

In the Schools of Architecture and Planning, Engineering, and Science are grouped those departments of study which lead to degrees and which embody the primary educational objective of the Institute. In the Division of Humanities are grouped the studies through which students may supplement the cultural values inherent in their scientific and engineering subjects with the broadening discipline of the humanities. The Graduate School coördinates the work leading to advanced degrees in all the departments. In the Division of

Industrial Coöperation are centered the organized activities of departments and individual members of the staff which are devoted wholly or in part to the assistance of industry in the solution of its problems or development of new products and methods.

Although the Institute work is thus divided for administrative purposes, the educational policies remain under the control of the Faculty as a whole.

DEGREES GRANTED

The Institute offers both undergraduate and graduate Courses of Study. The former lead to the degrees of Bachelor of Science (S.B.), Bachelor in Architecture (B.Arch.), or Bachelor in City Planning (B.C.P.); the latter, to the degrees of Master of Science (S.M.), Master in Architecture (M.Arch.), Master in City Planning (M.C.P.), 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.

COÖPERATIVE ARRANGEMENTS WITH LIBERAL ARTS COLLEGES

Many prospective students of engineering wish to attend a liberal arts college before undertaking their professional training. Two years are generally required to qualify for the S.B. degree in engineering at M. I. T. after graduation from a liberal arts college. 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 order to facilitate the combination of a liberal arts course with education in science and engineering, the Institute has entered into a coöperative arrangement with a selected group of colleges whose work in the prerequisite fields of science and mathematics is of exceptional merit. Under this arrangement, and by properly planning his studies, a student of high standing may pursue a combined five-years' program in which the first three years are spent at the college and the last two at the Institute, leading to the Bachelor's degree from each institution. Thus one year is saved, and the experience and the degrees of both institutions are secured.

A student who wishes to follow this coöperative program is advised to consult the dean or registrar of the college of his selection in regard to his most advantageous schedule of studies. This plan continues in effect under war time conditions; under the plan of year-round operation prevailing both in the colleges and in the Institute, however, completion of the degree requirements may necessitate a period of residence longer than the four terms normally needed.

The following colleges have united with the Institute in this program: Bowdoin College, Miami University, Middlebury College, Ohio Wesleyan University, Reed College, Ripon College, St. Lawrence University, Washington and Jefferson College, College of William and Mary, Williams College, and the College of Wooster.

GENERAL REGULATIONS

Academic Year. Under normal conditions, the exercises of the Institute begin on the last Monday in September and end early in June, exercises being omitted on the following Massachusetts legal holidays: January 1, February 22, April 19, May 30, July 4, Labor Day, October 12, November 11, Thanksgiving Day and December 25.

The Institute has temporarily adopted a continuous basis of operation with three consecutive terms in a year instead of the regular academic year of two terms. In the undergraduate course schedules the year (first, second, third, fourth, or fifth year) refers to the usual academic year having schedules in the first and second term as shown. Thus a student, on the basis of continuous attendance, would complete the eight terms of a normal four-year schedule in two and two-thirds year. (The Institute will return to a normal calendar in June, 1946. See page 2.)

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.

Provisional Admission. All students admitted to subjects without having fulfilled the usual preparation requirements are considered as provisional students in such subjects. Students whose work is generally low, and students readmitted to the Institute after dismissal, or after withdrawal incident to low standing, are considered as provisional in all subjects. Provisional admission to a subject may be cancelled when it becomes evident that the work of the student is unsatisfactory.

A student taking a dependent subject without a clear record in each required preparatory subject may be required to drop that subject at any time if his work is unsatisfactory.

Attendance. After approval of his registration the student must attend all exercises, including the final examinations, in the subjects for which he is registered. Irregular attendance, habitual tardiness, or inattentiveness may lead to probation. With the exception of an interval of one hour in the middle of the day, students are, in general, expected to devote themselves to the work of the school between the hours of 9 A.M. and 5 P.M. There are usually no exercises on Saturday after 1 P.M. Students who withdraw during the term should give advance notification to the Dean of Students and to the Registrar.

Final Examinations. Final examinations are held at the end of each term.

No member of the Instructing Staff is empowered to grant excuse from a final examination. Absence from any final examination is equivalent to a 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 the ensuing examination in the subject.

Conditions received at the end of a term must be made up by examinations during the succeeding term on Saturday afternoons, the exact dates for these examinations being announced after the term has begun. A student not taking an examination at the time stated forfeits the right to this examination.

The ability of students to continue their subjects is determined in part by means of examinations, but regularity of attendance and faithfulness to daily duties are considered equally essential.

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 two weeks before the day of the first scheduled examination of the examination period. Endorsement by members of the Faculty is not necessary. The privilege of an examination in a subject which involves laboratory instruction, or drawing, must be approved by the Faculty member in charge.

HEALTH OF STUDENTS. The Medical Department is completely organized to protect the health of the students. This work is carried out in the Homberg Memorial Infirmary under the supervision of the Medical Director, Dr. George W. Morse. A staff of nine doctors conducts clinics daily, except Sunday.

A graduate nurse is on clinical duty from 8.30 A.M. to 4.30 P.M. and a staff physician is in attendance from 8.30 A.M. to 5 P.M. (Saturday, 8.30 A.M. to 1 P.M.). Any student may receive medical or surgical treatment in the clinics without charge. In connection with these adequate X-ray, physiotherapy and laboratory facilities are maintained.

In addition to the clinics, the Homberg Memorial Infirmary has a hospital equipped to care for thirty-three bed patients. There are six finely appointed, attractive wards, seven private rooms, and a large solarium. The well-equipped kitchen provides excellent food and dietary service. The hospital is open twenty-four hours daily throughout the year with a staff of graduate nurses and a visiting physician. An ambulance, pulmotor and physician are available for emergencies twenty-four hours a day.

The charges are nominal: food, nursing, and medical care in the wards costing one dollar a day, and the same service in a private room is furnished at two dollars a day. After 5 P.M. on week-days (1 P.M. on Saturday) entrance to the second and third floor hospital must be made through the corridor in the basement, leading past the Photographic Department to the elevator.

Every entering male student, undergraduate or graduate, is required to report to the Medical Department for a complete physical and dental examination within six weeks after his matriculation. All other male undergraduates are required to have a physical re-examination each calendar year, an appointment for which should be arranged with the Medical Department.

CONDUCT. It is assumed that students come to the Institute for a serious purpose, and that they will cheerfully conform to such regulations as may be, from time to time, made by the Faculty or Administration. 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.

Students are expected to behave with decorum, to obey the regulations of the Institute, and to pay due respect to its officers. Conduct inconsistent with general good order, or persistent neglect of work, or failure to respond promptly to official notices, may be followed by dismissal. If the offense be a less serious one, the student may be placed on probation.

It is the aim of the Faculty to administer the discipline of the school so as to maintain the highest standard 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.

PETITIONS. The Committee on Petitions 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.

ADVISERS. The Dean of Students is the general consulting officer for all students, and coöperates with the President in matters of discipline and general student relations. On request to his office, advisers from the Instructing Staff will be assigned to new students. It is not intended that the advisers shall become, in any sense, guardians of the 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.

Each student is assigned to a Registration Officer who is a member of the Faculty having responsibility for, and control of, his academic program. The Associate Dean of Students serves as Registration Officer for all first-year students. However, the Deans of Architecture and Planning, Engineering and Science act as general consultants to first year students who seek advice relating to their choice of professional Courses.

FEES, DEPOSITS, PAYMENTS, EXPENSES

TUITION FEES. For all students pursuing regular courses, undergraduate or graduate, the tuition fee of $300 per academic term (three terms per year) must be paid *in advance*, the date and hour to be specified in the Registration Instructions issued prior to the opening of the particular term. Special students pay, in general, the full fee; but when a few subjects only are pursued, application for reduction may be made to the Bursar.

Members of the teaching or research staff pursuing programs leading to the Master's or Doctor's degree, taking more than one subject or engaged on research, and on full-time Corporation appointment pay $100, on half-time appointment $150, for each term for which they are registered as proceeding toward the degree. The above fees admit members of the staff working for the Master's or Doctor's degree to all subjects, including thesis work, which are approved by their respective department committees. If they are taking but a single subject and not engaged on thesis or research, the tuition is at the rate of $6 per unit credit, with a minimum fee of $15.

A candidate for the Doctor's degree who has been absent from the Institute and who returns for the final examination on his thesis must register for the examination and pay a fee of $25.

OTHER FEES. A charge of $5 is made for each condition or advanced standing examination taken, and $5 for the removal of each deficiency.

LATE REGISTRATION FINE. A fine of $5 is imposed for late registration or late payment of tuition. Students should note that registration is not complete until tuition fees are paid.

DEPOSITS TO COVER CHEMICAL SUPPLIES, MILITARY UNIFORMS, ETC. All first-year students will be required to make a deposit of $25, from which the costs of chemicals and laboratory 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 Division of Chemical Laboratory Supplies will be required to make a deposit of $25 against which the cost of chemicals and laboratory supplies will be charged.

All deposits must be made at the beginning of the 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.

GRADUATE AND UNDERGRADUATE ACTIVITIES. For each civilian student registered, the Institute will appropriate the sum of $3.50 per term to be devoted to the promotion of student life with special reference to the physical and social welfare of the students. No part will be spent for any class function, athletic event, or social entertainment that is not open without charge to every qualified member of the student body in good standing.

These funds will be expended under the general direction of the Institute Committee subject to the approval of the Undergraduate Budget Board appointed by the President.

Subject to modification, funds will be apportioned per term as follows:

Institute Committee	$0.265
Classes	.175
Athletics	2.90
Reserve and Contingent Fund	.16

In addition to the amount made available through the above, the Institute yearly appropriates from its operating budget funds to cover athletic coaching salaries and the maintenance and operation of Walker Memorial, Athletic Fields, the Boat House, Sailing Pavilion, Launches, and Swimming Pool.

PAYMENTS. *No bills are sent.* All payments should be made to D. L. Rhind, Bursar, Massachusetts Institute of Technology, Cambridge 39, Mass. *Students are advised to make their payments by mail.*

ESTIMATED EXPENSES. An estimate of expenses exclusive of personal expenditures such as transportation, clothing, recreation, etc., is given below:

FOR A PERIOD OF ONE TERM

Tuition	$300
Board	160
Room	105
Books and materials	40
	$605

To assist students desiring to help themselves in meeting their expenses, the Student Employment Bureau is maintained by the Technology Christian Association. It is to be understood, however, that the demands of the Institute curriculum are such as to make it impracticable to devote much time to outside employment, and prospective students are advised to have sufficient funds to cover the expenses of the first year at least. Students from foreign lands, in particular, should clearly understand that the opportunities to secure remunerative employment for them are seriously restricted by their unfamiliarity with the English language and American business customs.

LOANS, SCHOLARSHIPS, FELLOWSHIPS AND PRIZES

See Appendix A for Complete Details

Resources for financial aid to students include: the Technology Loan Fund, available for undergraduate and graduate students; Freshman Competitive and other scholarships open to students entering from secondary schools; undergraduate scholarship aid to upperclassmen; fellowships, and graduate scholarships; Teaching Fellowships, and full- and part-time Assistantships to aid students pursuing work leading to the Master's or Doctor's degree; and prizes.

The extent of these resources is indicated by the facts that, since its establishment in 1930, over 2,500 men have borrowed more than $1,880,000 from the Technology Loan Fund; and that approximately $90,000 and $102,000 are annually available for undergraduate and graduate scholarship aid respectively.

PLACEMENT

Without assuming responsibility of finding employment for graduates, the Institute assists them in their placement problems. Senior and graduate students are offered a program of placement training planned to acquaint them with industrial opportunities and to outline the principles to be observed in seeking employment. The placement training program is approached from the long-range point of view rather than in terms of the first position after graduation, and stress is placed upon the importance of each individual's finding the type of opening for which he is best qualified by reason of his special aptitudes and training.

A Placement Bureau is also maintained by the Institute to assist Technology seniors and alumni in securing positions for which they are particularly fitted, and to aid industry in selecting men for positions requiring engineering or scientific education. For this service there is no charge.

EDUCATIONAL BUILDINGS

The characteristic spirit of the Institute finds its material embodiment in its great educational plant in Cambridge. Here all departments of instruction and research are brought together in a group of conjoined buildings containing over one million square feet of floor space.

This unity and coördination of structure permit flexibility in the allotment of space to the departments and promote desirable coöperation among the various disciplines. The several sciences and the humanities, by organization and by common housing, are thus members of a single intellectual family at the Institute, and the objectives which they pursue, both in teaching and in research, are dealt with as coöperative projects, to be studied and solved coöperatively.

LABORATORIES. Another marked characteristic of the Institute from the material point of view is found in its numerous large and well-equipped laboratories. Notable among these are the George Eastman Research Laboratories of Physics and Chemistry, the Spectroscopy Laboratory, the Guggenheim Aeronautical Laboratory, the Wright Brothers Memorial Wind Tunnel, the Pierce Engineering Laboratory, the Sloan Automotive Engine Laboratory, and the Laboratories of Steam and Compressed Air, Refrigeration, Testing Materials, Hydraulics, Gas Engines, Metallurgy, Chemical Engineering, Physical Chemistry, Applied Physics, Electrical Engineering, Biology, and Geology and Mineralogy.

THE LIBRARY. The Institute Library, one of the leading collections in science and engineering in the United States, includes the Central Library and a number of strong branch libraries, containing all together approximately 385,000 volumes. A comprehensive collection of periodicals and society publications, remarkably complete in subjects within the scope of the Institute's programs of study and research, is maintained by the current receipt of over 1,600 periodicals and upwards of 1,900 transactions, yearbooks, and other serials.

The Central Library, on the fifth floor of Building 10 (under the great dome), is easily reached by elevators from the main lobby. Here are located large collections in physics, chemistry, chemical engineering, biology and biological engineering, and mechanical and electrical engineering; also an extensive collection of basic reference books. Especially notable is the Vail Collection in electrical engineering, described more fully under Electrical Engineering in the Graduate School section.

The Central Library is open on week days during term time from 8.45 A.M. to 9 P.M., except on Saturdays when it is closed at four o'clock. Individual reference service, bibliographical aid, and assistance in the use of the card catalogue are given at the Reference desk and the Vail desk in the Central Library and also in the branch libraries. Seniors, graduate students, and others engaged on theses or other research are granted admission to the stack.

Books and periodicals which the Institute does not own can often be obtained from other libraries, or, in lieu of the actual book, it is generally possible to obtain photostats or microfilm reproductions; the latter may be read in the Library's projector.

The following branch libraries, well organized and in charge of competent librarians, are located near the departments which they serve and supplement the service of the Central Library: Aeronautics (including meteorology), Arthur Rotch (architecture, housing, and city planning), Dewey (civil and mechanical engineering, building construction, naval architecture and marine engineering, economics, social science, industrial relations, and business and engineering administration), Eastman (for graduate students and others doing advanced work in physics, mathematics and chemistry), Lindgren (geology, metallurgy, and ceramics), and Walker Memorial. The last-named, primarily a library for recreational reading, contains also the principal collections in history and literature and to some extent serves as a humanities library. The material in all these libraries is listed in the Central Library card catalogue, and telephone interconnection affords a well-integrated service.

A leaflet entitled "A Brief Guide to the Institute Library" is given to all new students; a handbook "How to Use the Institute Library" may be had upon application.

MUSEUMS. The museum of science, engineering and industry is continually expanding within the main group of buildings. Each department has its

own exhibits, along the corridor adjacent to its laboratories and offices; and 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, two of the most significant units have ample quarters of their own: the Dard Hunter Paper Museum, containing the most complete collection of handmade paper and papermaking equipment in the world; and the Francis Russell Hart Nautical Museum, containing a magnificent collection of ship models and prints, and the Allan Forbes and Henry P. Kendall whaling collections.

SUMMER SURVEYING CAMP. (*Summer Camp instruction is temporarily suspended as the Institute is now operating on a continuous basis.*) Camp Technology, an admirably located and amply equipped engineering camp is maintained by the Department of Civil and Sanitary Engineering. During the summer session at this camp, students are given field practice by competent instructors and, incidentally, obtain the healthful experience of approximately two months of outdoor life.

The camp is located on the shore of Gardner Lake about eight miles from East Machias, Maine and, in a direct line, is less than three miles from tidewater.

It comprises about 850 acres of rolling terrain, some of which is wooded, in a region well adapted for carrying out projects in plane, geodetic and route surveying as well as opportunities for hydrographic field work.

Bemis Hall, the headquarters of Camp Technology, has a sightly location on a high bluff overlooking Gardner Lake. In Bemis Hall and other buildings connected with it by covered passages are lounging and dining facilities, lecture, recitation and drafting rooms, office accommodations for the Staff, a store and post office.

Sleeping quarters for students are provided in eight wooden barracks facing the lake. Other structures include a geodetic observatory, extra space for drafting or classroom use and an infirmary which serves as an emergency hospital. A physician is in attendance during the entire camp session.

The Camp is equipped with excellent sanitary facilities, electric light, and a wholesome water supply from driven wells. A baseball field and two tennis courts are located on the Camp property.

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. Beginning in 1917, the Society has set its course by an annual series of Popular Science Lectures. These discourses, always illustrated, are held in Huntington Hall on one week-end in the months of December, January, February and March. On Friday and Saturday afternoons, invitations are sent to the secondary schools, but Sundays find the audience made up of corporation members, the faculty and the public in general. Because they follow the lines of study and research for which the Institute is known, the lecturers explain many present-day developments in science and engineering. During the year 1942–1943 the Society of Arts Lectures were discontinued for the duration of the war.

STUDENT HOUSING

Complete information on housing for graduate and undergraduate students, under present abnormal conditions, giving details regarding applications, allotment of rooms, equipment, rentals, payments and so forth, is presented in Appendix C (Student Housing) of this bulletin. Inquiries and applications should be addressed to Henry K. Dow, Manager of Undergraduate Dormitories, 3 Ames Street, Cambridge 39. As an emergency measure, accommodations for graduate students are available in a reserved section of the Senior House.

RECREATIONAL FACILITIES

Walker Memorial, built in memory of a late president, General Francis Amasa Walker, is the center of the social activities of the Institute. The building was finished in 1917 at a cost exceeding $500,000, contributed in part by alumni.

On the third floor are a gymnasium with a regulation basketball court, lockers and dressing rooms, offices for the various student activities, and rooms for handball. Below are recreation and reading rooms, and an excellent and growing open-shelf library, and, on the first floor, a large dining hall with cafeteria service at low prices. In the grill room soda fountain service is provided, and private rooms are available for class dinners and gatherings of any Technology organization. In the basement are bowling alleys and a lounge room for the "5:15 Club," composed of commuting students.

Adjacent to this building and the dormitories are tennis courts, Technology's swimming pool building completed in 1940, which contains a deep pool for recreational swimming, and a shallow one for use by "beginners," and other facilities for conducting the recreational program of nine sports.

The Barbour Field House, opened in September, 1934, has, in addition to modern shower and locker facilities, special rooms for visiting teams. Connected with the Field House is a Squash Building containing eight courts.

On the land west of Massachusetts Avenue are fields for soccer, lacrosse, and football; additional tennis courts and a quarter-mile cinder track with a 220-yard straightaway completed in 1939. During the winter, an outdoor board track is provided near Briggs Field House.

A boathouse on the Charles River supplied with indoor rowing machines has also a number of singles and wherries available for students, in addition to the opportunities offered to all undergraduates to learn

how to row in an eight-oared shell under competent coaching. 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. All the machines and other tools needed for woodworking, metalworking, and the like, are installed, and equipment for new groups interested in radio, photography, electroplating, and telescope-making, is now being assembled.

UNDERGRADUATE ACTIVITIES

To complement and aid its educational work and to enrich its community life, Technology provides extensive opportunities for students to participate in those extra-curricular pursuits — athletic, literary, 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.

ATHLETICS. The purpose of athletics at the Institute is not to develop highly trained athletes, but rather to encourage all students to participate in some form of physical recreation. Control is vested in 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 secured by undergraduate dues, appropriated by the Institute, but disbursed by the Undergraduate Association. An Advisory Council of Alumni exercises the functions which its name implies.

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. Among the activities are: track and field sports, cross country running, rowing, basketball, golf, lacrosse, rifle, swimming, tennis, squash racquets. Class teams are organized informally in football and baseball.

NAUTICAL ASSOCIATION. The Nautical Association offers every student an opportunity to learn sailing. A fleet of forty dinghies, constituting a special Technology class designed by Technology men, three Class B dinghies, 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 after 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 PUBLIC SPEAKING. The Combined Musical Clubs, consisting of the Glee Club, the Concert and Popular Orchestras, and the Chamber Music Society, provide opportunities for training and expression in instrumental and vocal music. The Dramashop produces plays. Members of the Debating Society participate in intercollegiate debates and exhibition contests.

STUDENT PROFESSIONAL SOCIETIES. The Professional Societies, of which there are twelve, hold meetings for the presentation of scientific papers by students, culminating in the presentation of the Stratton Prizes at Commencement.

There are many other societies and activities which bring students of mutual interest together, and which organize social activities. The Junior Prom and Senior Week committees; the class organizations; and organized groups such as Sigma Xi and Tau Beta Pi for scholarship; Gridiron, the journalism society; Scabbard and Blade, the military society; the 5:15 Club, for commuting students; the Radio Society; and a score of other organizations, social and honorary, furnish important adjuncts to student life.

TECHNOLOGY CHRISTIAN ASSOCIATION. This activity 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, operates the Student Employment Bureau, the Tech Cabin and Freshman Camp, and publishes the Freshman *Handbook*.

THE INSTITUTE COMMITTEE. The activities described above are component parts of the student state — the M. I. T. Undergraduate Association. Over this Association as chief executive presides the Senior Class President who shares with the Institute Committee, a legislative and judicial body representing the four classes and every important student activity, the government of student affairs. Sub-committees of the Institute Committee supervise the finances of undergraduate activities, consider jointly with the Faculty and Administration matters affecting students, administer Walker Memorial, and, by a system of points, control the extent to which any one student may participate in extra-curricular activities.

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, at present, two regular courses — Mechanical Course and Electrical Course each extending over two years; and a number of advanced or supplementary single subjects of varied lengths.

These courses are intended to bring the systematic study of applied science within the reach of young men who are following industrial pursuits and who desire training to fit themselves for higher positions.

Circulars giving detailed information regarding 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.

INFORMATION FOR VETERANS

GENERAL POLICY

The Institute recognizes a prime obligation, as demobilization proceeds, for the education and training of former members of the Armed Forces, as well as of others whose studies have been interrupted by essential war work. To this end, measures have been taken to expand the total enrollment so as to provide accommodations for veterans up to the highest number consistent with the maintenance of Institute standards, and to limit the enrollment of foreign students. Veterans enrolled at the Institute will be eligible for financial aid under the terms of the Servicemen's Readjustment Act and of the special legislation for the rehabilitation of disabled veterans. Under the present interpretation of these laws, the "year" for which tuition is paid is the academic year of two terms, so that additional tuition covering an extra "half-year" is available for a summer term, if desired. The number of veterans already enrolled is increasing with each new term.

It is the policy of the Institute to encourage veterans to enter fully into the normal life and activities of the student body in every respect. There will be no segregation of veterans in a special school. Veterans will thus have every opportunity to make the necessary adjustment to a civilian way of life, while students who have not served in the Armed Forces will find a corresponding opportunity to adjust themselves to an environment in which veterans of this war will long play an important part.

FORMER INSTITUTE STUDENTS RETURNING

Veterans who were regular Institute students in good standing when they were granted leave of absence to enter the service are entitled to resume their courses without further formality. In order that provision may be made to accommodate them, however, they should notify the Registrar as soon as they can indicate the date at which they wish to re-enter. Those who wish to secure advanced credit for subjects studied elsewhere will in general be subject to the general policies as to such credits outlined below. It will not usually be feasible to allow credit for fractions of a term completed at the Institute.

OTHER VETERANS

Definite action on applications cannot be taken until the date of proposed entrance can be specified. Applicants should therefore notify the Director of Admissions as soon as they can indicate the date at which they wish to enter. At that time, final application forms will be issued in accordance with the procedure indicated under Requirements for Admission, or under Admission to the Graduate School.

Members of the Armed Forces contemplating entrance are encouraged to continue their studies, as opportunity permits, by means of the correspondence courses given under the auspices of the United States Armed Forces Institute and the Marine Corps Institute, as well as the classroom courses planned by these organizations for the interval following the cessation of hostilities in the various war theaters. Such courses will provide a useful review, strengthen preparation for later work, and keep alive the habit of study.

ADJUSTMENT OF CREDITS

Many inquiries are being currently received from men in the service requesting exact statements in advance as to the amount of academic credit that will be granted for specified courses such as those referred to above, as well as for courses completed in Army or Navy college training units. Such inquiries can seldom be answered, except in very approximate terms, until full information about the candidate has been assembled. In professional curricula such as those of the Institute, the selection and proper sequence of individual subjects of instruction is of vital importance. It is, accordingly, seldom feasible to grant credit on an arbitrary "semester-hour" basis, without regard to the nature of the subject matter studied. Tests of general educational development such as the Armed Forces Institute has prepared, while of great value for certain purposes, do not measure progress in professional training.

The exact level at which the returning veteran should begin his studies at the Institute will depend on a number of factors, some of which are likely to be unknown or uncertain at the time when he first makes inquiry. Among these factors are: first, the length of time that will have elapsed since his formal education was interrupted by military service; second, the general quality of his past academic record; and third, the extent to which the courses he has taken correspond in content and quality to those for which he seeks credit; courses given under identical titles may differ widely in substance.

It should further be pointed out that many of the training courses in the Army and Navy deal primarily with operation, maintenance and repair of specific pieces of equipment. Their treatment of underlying theory, while adequate for this purpose,

is not sufficiently extensive or thorough to provide a foundation for professional work in engineering design or scientific research. This is illustrated by the widespread training in the use of electronic equipment which has been given by the Army and Navy. It will frequently happen that men with an excellent practical experience and working knowledge of such equipment will, nevertheless, be obliged to resume their studies at a fairly elementary level if they wish to obtain a thoroughgoing professional training in this field. These considerations emphasize the desirability of postponing any attempt at exact evaluation until all the evidence bearing on the question has been assembled. Every effort will, however, be made to give promptly in response to inquiries at least an approximate estimate of the student's probable status upon admission.

The Institute will endeavor to see that each veteran is started in his studies at a level commensurate with his ability and previous preparation, and that he is given every opportunity to make successfully the adjustment required by his return to academic pursuits. Veterans already enrolled have urged a cautious policy in this respect for others who may enter later, rather than an attempt to maximize credits so as to hasten completion of the course.

In view of these considerations, the policy of the faculty in adjusting veterans' credits will be a conservative one. An effort will be made to place every student as soon as possible in a regularly scheduled program at an appropriate stage without attempting to make "small change" in piecing together all the credits he may have accumulated. Degree requirements will be interpreted in a flexible manner; thus the student may be advised to review some subjects for the sake of gaining proficiency, while being permitted liberal substitution privileges for others. The object throughout will be to insure a thorough training with high standards, rather than to piece together a patchwork of credits to equal a degree. This policy will serve the best interests of veterans by insuring that the stamp of an Institute degree shall continue to stand for a high level of excellence. For the same reasons it is expected that "concessions" will not be made to veterans with regard to entrance requirements. On the contrary, the veterans will be protected from the hazard of undertaking an exacting professional program unless they are found to be capable of it and prepared for it.

POSTWAR CALENDAR

The Institute expects to return in 1946 to the normal academic year of two terms and a summer vacation. Summer session courses will be available, however, so that veterans and other students who prefer to do so, may continue their studies on a year-round basis, with correspondingly earlier completion of their courses.

REQUIREMENTS FOR ADMISSION

ADMISSION CALENDAR

First year students from secondary schools will be admitted only once a year, the next class entering on September 30, 1946. Veterans, however, will be allowed to enter the first year at the beginning of *any* term.

All students entering above the first-year level will be admitted at the beginning of any term, the opening dates for the spring and summer terms being March 4, 1946 and June 17, 1946, respectively.

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 applicants will be considerably in excess of the number that can be accepted, 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 which show promise of their development into useful and forceful citizens.

Applicants for admission to the First Year class are expected to have a conference with the Director of Admissions. Office hours are nine to four, Saturdays nine to twelve; it is not necessary to make an appointment in advance. Applicants outside New England are expected to arrange a conference with an alumnus designated by the Director of Admissions. It is recommended that this be done as early as possible in the applicant's final year of secondary school.

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 for 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 of thorough preparation in English and mathematics. It is presupposed that a candidate's training in English has been such that he can express his ideas clearly in oral or 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)	PHYSICS (1)
ALGEBRA (2)	TRIGONOMETRY (½)
PLANE GEOMETRY (1)	SOLID GEOMETRY (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.

In addition to the above subjects specifically required, the applicant must also have completed seven additional units, or their equivalent, in secondary school studies. No limitations are imposed in the choice of these elective subjects, and 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 years study of history.

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 or both. 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 and Russian, since there is an extensive and important technical literature in each of these languages. Since, however, relatively few public high schools in the United States offer German, and very few schools of any kind offer Russian, the student may find it expedient to take French as a part of his general education, and to postpone until a later stage the study of a language appropriate to his professional specialty.

Application Procedure. Evidence of academic preparation is of two kinds: first, the School Report form mentioned below, and second, an entrance examination in mathematics, which may, however, be waived in certain cases. Examinations in other subjects may also be required of some candidates, at the discretion of the Committee on Admissions.

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 announcements 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 at least four months in advance of the date of entrance, to candidates who have filed Preliminary Application forms. At the same time, 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.

A report of his status with respect to admission will be sent to each applicant as soon as possible after the Committee on Admissions has reviewed his completed application.

Entrance Examinations. A satisfactory record in an examination in secondary school mathematics is required, as noted above. This requirement may, however, be waived for a student graduating in the highest fifth of his class in a school which has qualified for this privilege by sending to the Institute a number of graduates whose records at the Institute have been satisfactory. Applicants, except in the State of New York, take the Comprehensive Mathematics Examination given by the College Entrance Examination Board.

This examination is held in June, September, December and April in the principal cities of the United States and in certain foreign centers. A list of the places and dates of examinations is published each year by the Board. Application for the examination must be made by the applicant on a form to be obtained from the College Entrance Examination Board, P. O. Box 592, Princeton, New Jersey. If the application is received sufficiently early, the examination fee is $6. The Board will report the result of the examination directly to the Institute, but not to the candidate. The Committee on Admissions will decide whether the examination grade, taken in conjunction with the applicant's school record, is satisfactory.

Applicants from schools in the State of New York may offer Regents examinations in Intermediate Algebra, Plane Geometry, Solid Geometry and Trigonometry in place of the Comprehensive Mathematics Examination. Only grades of 85 or better will be accepted. The official report of these examinations will be secured by the Institute from the Board of Regents in Albany.

ADMISSION WITH ADVANCED STANDING

Selection of Students. Students who have completed one or more years 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 without examination. Their eligibility for admission will be determined by the Committee on Admissions after a review of their academic records. They will be expected in every case to have completed the academic preparation required of students entering the Institute from secondary schools.

Acceptance in a particular Course, for a transfer student entering the third or fourth year, may be contingent upon his first term record at the Institute.

Students who plan to attend another college with the intention of later applying for admission to the Institute should note the Coöperative Plan in effect between the Institute and certain colleges. (See page 25.)

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 examination that they are entitled to such credit.

A student in another college contemplating transfer to the Institute should so plan his program of study as to cover the basic subjects of the Course he expects to enter. If in doubt as to the best choice of subjects he should consult the Director of Admissions.

Application Procedure. Early in the last term before his contemplated transfer to the Institute an applicant should submit the following, enclosed in one envelope:

1. Application for Admission with Advanced Standing, indicating all subjects which will have been completed at the time of transfer.
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.

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 the applicant's 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.

SPECIAL STUDENTS

Qualified applicants above the usual age, 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. 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.

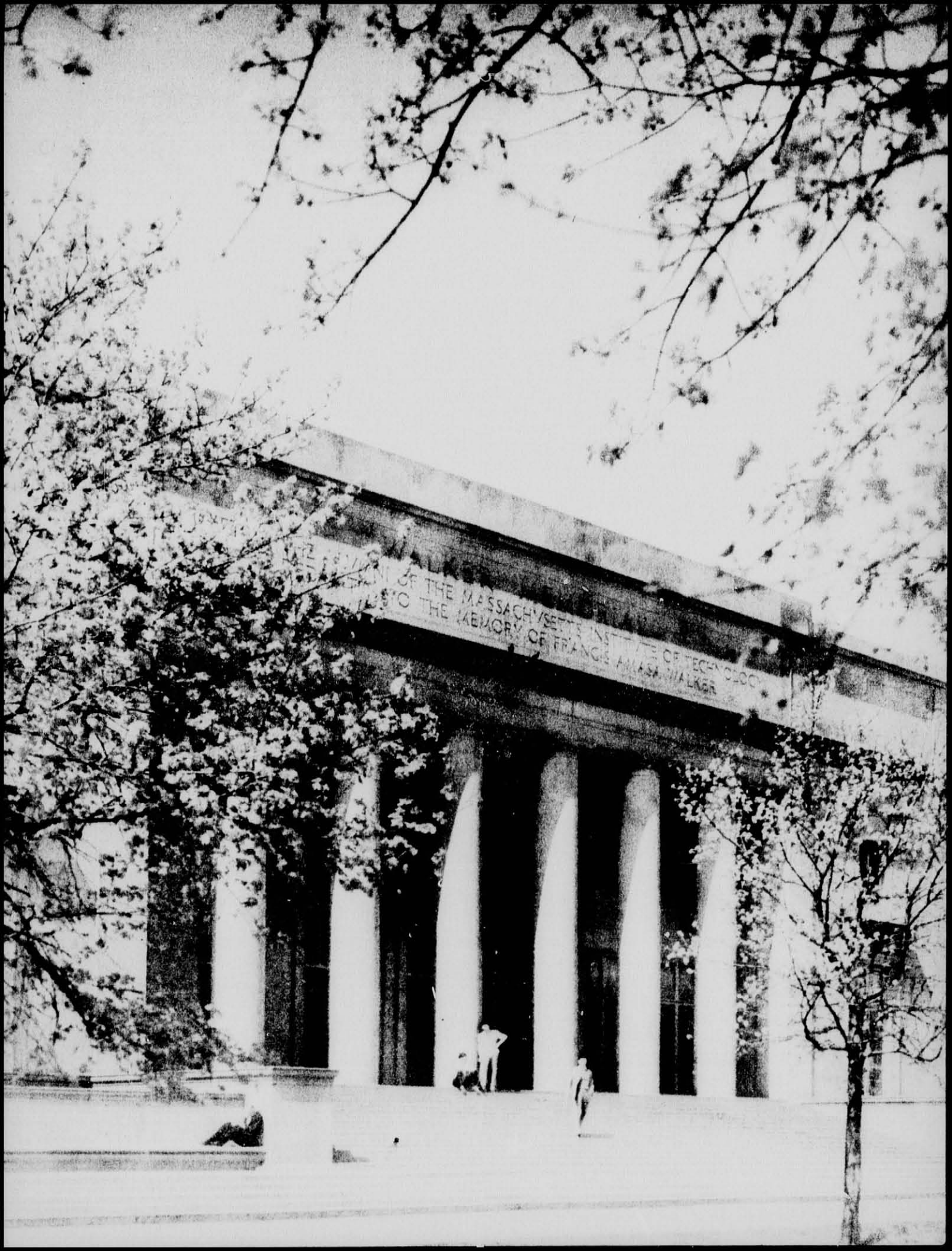
Admission of Special Students in Architecture

Applicants desiring admission as special students in Architecture must be college graduates; or must be at least twenty-one years of age, with not less than three years' experience in an architect's office, or have had equivalent and satisfactory preparation. They must register for those subjects which, in the opinion of the Registration Officer, will best complete the students' educational equipment.

The first week of the course in freehand drawing and the first problem in Design will be considered as test exercises to determine the standing of the student. The arrangement of subjects must be approved by the head of the department and satisfactory records obtained in order to continue architectural subjects.

FOREIGN STUDENTS

Applications from students of foreign citizenship must be completed at least four months prior to the term in which entrance is requested. For example, applications for the July term will be considered on March 1. Those received after March 1 will be held for consideration for the next subsequent entering class. Since competition for places at the Institute is severe, it is possible to take action on admissions only after complete application material has been received. Applications accompanied by incomplete credentials will not be considered.


WALKER
OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY
TO THE MEMORY OF FRANCIS AMASA WALKER

UNDERGRADUATE COURSES OF STUDY

IN the Schools of Architecture and Planning, Engineering, and Science the undergraduate may elect any one of the professional Courses of Study listed below. In most of these Courses leading to the Bachelor's degree, options or electives in professional subjects are available, thereby offering the student wide flexibility in the selection of a schedule of subjects best adapted to his special interests, abilities, and objectives.

In order to qualify for continued attendance at the Institute, students must meet the minimum requirements of the scholastic rating system, a full explanation of which is sent to all new students and their parents. The number of second-year students admitted to certain professional Courses is limited.

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.
CITY PLANNING, Course IV-B.
CITY PLANNING PRACTICE, Course IV-C.

School of Engineering

AERONAUTICAL ENGINEERING, Course XVI.

BUILDING ENGINEERING AND CONSTRUCTION, Course XVII, with options. Heavy Construction (1), Light Construction (2).

BUSINESS AND ENGINEERING ADMINISTRATION. Course XV-A, Based on Physical Sciences and Course XV-B, Based on Chemical Sciences.

CHEMICAL ENGINEERING, Course X, and Chemical Engineering Practice, Course X-B.

CIVIL ENGINEERING, Course I.

ELECTRICAL ENGINEERING, Course VI, with options. Electric Power (1), Illumination Engineering (2), Electrical Communications (3), Electronic Applications (4). Also Coöperative Course in Electrical Engineering, VI-A.

GENERAL ENGINEERING, Course IX-B.

MARINE TRANSPORTATION, Course XIII-C.

MECHANICAL ENGINEERING, Course II, with options. General Mechanical Engineering (1), Engineering Science (2), Automotive Engineering (3). Also Coöperative Course in Mechanical Engineering, II-A.

METALLURGY, Course III, with options. Metallurgy (1), Mineral Dressing (2).

METEOROLOGY, COURSE XIV.

NAVAL ARCHITECTURE AND MARINE ENGINEERING, Course XIII.

School of Science

CHEMISTRY, Course V.

FOOD TECHNOLOGY, Courses VII-B and VII-C.

GENERAL SCIENCE, Course IX-A.

GEOLOGY, Course XII.

MATHEMATICS, Course XVIII, with options. Pure and Applied Mathematics (1), Industrial Statistics (2).

PHYSICS, Course VIII.

QUANTITATIVE BIOLOGY, Course VII. Also Physical Biology, VII-A.

These Courses provide a thorough training in the fundamental sciences and in design. They lay far more stress on the development of power to deal effectively and creatively with new problems than on the acquirement of an extensive knowledge of technical specialties and details. Neither the student nor his professor can possibly foresee what special knowledge or technique the student will be called upon to exercise in his professional career. If, however, his education has emphasized the fundamental principles of science and engineering which underlie all specialties, he will be in a position to attack intelligently the variety of specialized problems which he will meet.

In addition to the above, a five-year course in ECONOMICS AND ENGINEERING or ECONOMICS AND NATURAL SCIENCE is offered which leads to the degree of Bachelor of Science in that one of the above professional Courses in which undergraduate work is taken, together with the degree of Master of Science in Economics and Engineering or Economics and Natural Science. For details see the Graduate School section of this Bulletin.

The first year is devoted to such fundamental subjects as physics, chemistry, mathematics, and English. The student, therefore, may change his course of study at any time before the beginning of the second year.

In the second year, the fundamental subjects of mathematics, physics, and history are required in all curricula. The courses based on chemistry continue this subject, while the other courses begin the study of applied mechanics. In addition, the professional work is begun by each course, the schedule including one or more introductory professional subjects in each term.

Architecture (Course IV) requires five years for the Bachelor's degree. Courses II-A, VI-A, VII-A, and VII-C are of five years' duration, and lead to the degrees of Bachelor of Science and Master of Science. Courses II-A and VI-A are coöperative courses requiring outside work in industry.

Division of Humanities

The four-year program in the humanities and social sciences provides that, in addition to courses in modern languages, students will take one course in this division each year. The work of the first year is devoted to English with emphasis on written and oral expression. Special provisions are made for students who are ready for advanced work in English and for foreign students who require intensive instruction. The emphasis on written and oral expression continues throughout the four years. In the second year all students are given an introductory course in modern history with special reference to the place of the United States in world affairs. On the basis of the preceding courses, especially history in the second year, the third year is devoted to the social sciences, including economics and psychology. Under this program in the second half of the third year students are permitted to choose between a limited number of options in the general field of the social sciences.

In their senior year students are given an opportunity to choose one of four options: (1) music and the fine arts; (2) international relations; (3) the history of science and thought; or (4) western world literature. Each of the four programs is closely coördinated with the objectives and purposes of those given in the preceding three years. All classes are held in small sections and constant opportunity is given for improvement in both written and oral expression. The Program is outlined under the Description of Subjects.

PROFESSIONAL SUMMER SCHOOLS

(Temporarily discontinued as the Institute is now operating on a continuous basis)

REQUIREMENTS FOR THE BACHELOR'S DEGREE

To receive the Degree of Bachelor of Science (S.B.), Bachelor in Architecture (B. Arch.) or Bachelor in City Planning (B.C.P.), 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-year Program, in the Second-year Program excluding professional subjects, and in the Humanities Programs of the third and fourth years including Economic Principles Ec11. 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. For the duration of the war, Fourth-year Professional Subjects or Graduate Subjects may, by petition, be substituted for Thesis.

The ability of the student to perform an original piece of work is considered an important feature of his degree requirements and theses are required in all course schedules. 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.

No degree will be conferred until all dues to the Institute are paid.

SUBJECT NUMBERING SYSTEM

Subjects are grouped and numbered according to the Department under which the instruction is given. A Course is a program of study made up of subjects selected from the several Departments, and leads to a degree in a given field of science or engineering. The arabic numerals for the subjects correspond to the Roman numerals of the Courses in the same Department, except Courses IX and XVIII.

Department	Subject Numbers
Civil and Sanitary Engineering	1·00 to 1·99
Mechanical Engineering	2·00 to 2·99
Metallurgy	3·00 to 3·99
Architecture and Planning	4·00 to 4·99
Chemistry	5·00 to 5·99
Electrical Engineering	6·00 to 6·99
Biology, Food Technology	7·00 to 7·99
Physics	8·00 to 8·99
Chemical Engineering	10·00 to 10·99
Geology	12·00 to 12·99
Naval Architecture and Marine Engineering	13·00 to 13·99
Meteorology	14·00 to 14·99
Business and Engineering Administration	15·00 to 15·99
Aeronautical Engineering	16·00 to 16·99
Building Engineering and Construction	17·00 to 17·99
Graphics	D1 to D99
Economics and Social Science	Ec1 to Ec99
English and History	E1 to E99
General Studies	G1 to G99
Languages	L1 to L99
Mathematics	M1 to M99
Military Science and Tactics	MS1 to MS99

The time given to each subject is expressed in units, one unit representing 15 hours' work. (Units in class are placed first, followed by preparation units.) The units of preparation represent the estimated time for the average student.

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. The division between Recitation or Lecture and Drawing or Laboratory time is shown in the Tabulation of Subjects.

FIRST YEAR FOR ALL COURSES

First Term	5·01	Chemistry, General	7–4
	8·01	Physics	6–5
	D11	Engineering Drawing	6–0
	E11	English Composition	3–5
	M11	Calculus	3–6
	MS11	Military Science	3–0
			28–20

Second Term	5·02	Chemistry, General	7–4
	8·02	Physics	6–5
	D12	Descriptive Geometry	6–0
	E12	English Composition	3–5
	M12	Calculus	3–6
	MS12	Military Science	3–0
			28–20

UNDERGRADUATE COURSE SCHEDULES

I. CIVIL ENGINEERING

CIVIL ENGINEERING is the broadest in scope of the engineering professions, being the stem from which most of the other branches of engineering have developed. Today the Civil Engineer serves and utilizes these other branches as he plans and builds projects such as airports, superhighways, and modern industrial buildings. He develops and adapts new knowledge and new skills as he controls the use of water for power and navigation, and for domestic and industrial purposes. He has at his command new materials of construction as he designs the avenues of transportation, with their bridges, tunnels, and terminal facilities. He is involved in the basic economy and in the organization and execution of major enterprises. Dealing, as he does, with both the forces of nature and with social and economic responsibilities, the Civil Engineer must combine fundamental knowledge of science and engineering with experience and judgment, and with personal characteristics of the highest order.

The objective of the Course in Civil Engineering is to enable students of superior ability to develop their potential qualities for becoming leaders in the field. The curriculum emphasizes the basic principles of mathematics and science and the general application of these principles. Electricity, thermodynamics, and engineering geology are required to broaden the professional base. As the student progresses, the emphasis in application is directed to subjects such as structures, hydraulics, and soil mechanics, which are essential in all branches of the profession. In the fourth year, group elective subjects permit special study in a professional subdivision such as transportation, sanitation, or water power. A limited number of vocational subjects, such as drafting and surveying fieldwork, are included in the curriculum because they afford an excellent opportunity to train a student in proper methods of working, and are helpful in the early stages of his career, but major attention centers on professional subjects.

Throughout the Course constant endeavor is made to aid students in developing their personal potentialities. This development is greatly aided by the period spent at the end of the first year at the Summer Surveying Camp at East Machias, Maine.

The Course leads to the degree of Bachelor of Science in Civil Engineering.

First Year (See page 38)

Required During Summer. At Camp Technology¶		
1·00T	Surveying Fieldwork	13–0
1·01T	Surveying Fieldwork, Adv.	4–0
1·20	Route Surveying Fieldwork	6–0

Second Year

First Term	1·03	Surveying, Adv.	6–6	*Second Term*	1·21	Route and Constr. Surveys	2–4
	2·00	Statics	3–5		1·61	Fluid Mechanics	2–4
	8·03	Physics	5–5		2·01	Dynamics	3–5
	E21	U. S. in World Hist. — Humanities II	3–5		8·04	Physics	5–5
	M21	Calculus	3–6		E22	U. S. in World Hist. — Humanities II	3–5
	MS21	Military Science	3–0		M22	Differential Equations	3–6
			23–27		MS22	Military Science	3–0
							21–29

Third Year

First Term	*1·45	Engineering Materials	3–6	*Second Term*	*1·40T	Structures	6–6
	*1·62	Fluid Mechanics	3–6		*1·43	Reinf. Concrete Design	6–0
	*2·04	Strength of Materials	3–6		2·373	Testing Materials Lab.	5–2
	2·41	Heat Engineering	4–5		2·687	Hydraulic Laboratory	2–2
	§12·321	Engineering Geology	4–4		*6·18	Electrical Eng., Fund.	4–6
	Ec11	Economic Prin. — Humanities III	3–5			†Humanities III	3–5
			20–32				26–21

Fourth Year

(*a*) *Sanitary;* (*b*) *Transportation;* (*c*) *Hydraulic;* (*d*) *General*

First Term	1·271	(*b*) Transportation Engineering	6–6	*Second Term*	1·272	(*b*) Transportation Engineering	6–3
	1·28	(*d*) Highways and Airports	3–3		*1·42	Structures	3–6
	*1·35T	Soil Mech. and Found. Eng.	6–6		‡1·442	Structural Design	6–0
	*1·41	Structures	3–6		1·71	(*c*) Water Power Eng.	6–3
	*1·441	Bridge Design	6–0		1·76	(*a*) Sewerage & Sewage Treatment	6–3
	1·70	(*c*) Hydrol. and Flood Control	6–6		1·77T	(*d*) Water Supply and Sewerage	6–3
	1·72	(*d*) Hydrol. and Water Power Eng.	3–3		*1·92	Engineering Construction	3–3
	1·75	(*a*) Water Supply and Purification	6–6			*Thesis	9
	*1·91	Professional Problems	2–4			†Humanities IV	3–5
		†Humanities IV	3–5				47
			26–27				

* See Requirements for Bachelor's Degree, page 38. † See page 117 for list of subjects.

‡ 1·79 Sanitary Engineering Design 6–0 may be taken as optional substitution by students taking the professional elective in Sanitary Engineering.

§ Students planning to take the professional elective in Sanitary Engineering may substitute 1·78 Sanitary Analysis 6–2.

¶ During the period in which the Summer Surveying Camp is suspended, the following changes will be made: 1·00T, 1·01T, 1·20, 1·03, and one term of the third or fourth year Humanities Program will be omitted; 1·00, 1·01, 1·054, 1·122, and 1·13 will be added.

II. MECHANICAL ENGINEERING

THE Course in Mechanical Engineering is planned to provide a sufficient foundation of basic science applied to engineering methods and techniques, to prepare the graduate to enter any industry dealing with heat, power, materials and machinery. The Course does not attempt to teach current commercial practice nor specialized knowledge of the product of any one industry. On the contrary, graduates are expected to obtain their practical experience by direct service in industry.

During the first two years the fundamental subjects which are the basis of the student's later professional work are studied, viz., mathematics, chemistry, physics, and applied mechanics, a thorough knowledge of which is essential in all branches of mechanical engineering. The student is also trained in elements of the more important mechanical processes in order that he may acquire the knowledge of modern machine tools, foundry practice, forging and welding, necessary for the successful designer of machinery.

The professional work of the third and fourth years includes the study of the mechanics of fluids and of rigid and elastic bodies with applications to design. The study of thermodynamics is applied to heat engineering, and to the analysis and design of power plants, turbines, steam and internal combustion engines, and to refrigeration and air conditioning systems. The materials, especially the metals, commonly employed in mechanical engineering, are the subject of lectures and laboratory exercises planned to correlate physical properties with constitution, heat treatment and working.

In general, instruction by lectures is paralleled by laboratory work in which the student is given opportunity, not only to familiarize himself with materials, engines and machinery, but also to develop his ability to apply theory to the analysis of their characteristics.

Three options with professional elective subjects permit a diversification of the student's program in the fourth year.

Under normal conditions a reading knowledge of German or French is required for admission to the Senior year. Due to the war, this requirement has been waived temporarily.

The Course leads to the degree of Bachelor of Science in Mechanical Engineering.

Honors Course

(Admission to the Honors Course is closed for the duration of the war)

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 coördinated schedule of studies through the Senior and Graduate years. A single thesis with a minimum of 30 units will be required in the Graduate year and the time allotted to thesis in the Senior year will be available for advanced mathematics or other subjects preparatory to the program of graduate studies. Before registration for the fifth year, the students selected under this plan must have had at least two months industrial employment satisfactory to the Department. 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 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.

First Year (See page 38)

Second Year

First Term	2·00	Statics	3–5	*Second Term*	2·01	Dynamics	3–5
	2·701	Machine Drawing	6–0		2·30T	Engineering Materials	5–4
	2·851	Machine Tool Lab.	4–0		2·852	Machine Tool Prac.	4–0
	8·03	Physics	5–5		8·04	Physics	5–5
	E21	U. S. in World Hist. — Humanities II	3–5		E22	U. S. in World Hist. — Humanities II	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			27–21				26–25

Third Year

First Term	*2·04	Strength of Materials	3–6	*Second Term*	*2·06	Dynamics	3–6
	*2·251	Fluid Mechanics	3–6		*2·252	Fluid Mechanics	3–6
	*2·40	Heat Engineering	4–5		*2·37	Testing Materials Lab.	4–4
	*2·730	Machine Design	4–2		*2·42	Heat Engineering	3–6
	*6·18	Electrical Eng., Fund.	4–6		*2·731	Machine Design	4–2
	Ec11	Economic Prin. — Humanities III	3–5			†Humanities III	3–5
			21–30				20–29

Fourth Year

Option 1. General Mechanical Engineering

First Term	2·081	Strength of Materials	3–6	*Second Term*	2·56	Mechanical Eng. Prac.	3–6
	2·31T	Engineering Metals	4–4		2·682	Engineering Laboratory	3–3
	2·43	Heat Engineering	3–6			*Thesis	9
	2·681	Engineering Laboratory	3–3			†Humanities IV	3–5
		†Humanities IV	3–5			Prof. Elective Subjects (see next page)	18
		Prof. Elective Subject (see next page)	9				50
			49				

* See Requirements for Bachelor's Degree, page 38.

† See page 117 for list of subjects.

II. Mechanical Engineering Continued

First Term Professional Elective Subjects‡

2·66	Air Conditioning	3–6
2·791	Internal Combustion Eng.	3–6
6·19	Electrical Eng., Fund.	4–6
15·70	Production	3–6

Second Term Professional Elective Subjects‡

2·32T	Engineering Metals	3–6
2·35	Fatigue of Metals	3–6
2·47	Steam Turbine Eng.	3–6
2·48	Gas Turbine Eng.	3–6
2·621T	Refrigeration	3–6
2·622T	Refrigeration, App.	3–6
2·732	Machine Design	5–4
2·78	Hydraulic Machinery, Des.	5–4
2·792	Internal Combustion Eng.	3–6
2·871	Manufacturing Eng.	3–6
15·76	Mass Production Methods	3–6

OPTION 2. ENGINEERING SCIENCE§

First Term	2·081	Strength of Materials	3–6	*Second Term*	2·082 Dynamics 3–6
	2·31T	Engineering Metals	4–4		2·44 Heat Engineering 3–6
	2·43	Heat Engineering	3–6		*Thesis 12
	2·681	Engineering Laboratory	3–3		†Humanities IV 3–5
	6·19	Electrical Eng., Fund.	4–6		Prof. Elective Subject 12
		†Humanities IV	3–5		50
			20–30		

Professional Elective Subjects‡

2·128	Experimental Stress Anal.	8–4
2·322	Engineering Metals	6–6
2·482	Gas Turbine Eng.	6–6
2·562	Mechanical Eng. Prac.	6–6
2·782	Mech. Systems, Des.	6–6

OPTION 3. AUTOMOTIVE ENGINEERING§

First Term	2·081	Strength of Materials	3–6	*Second Term*	2·082 Dynamics 3–6
	2·31T	Engineering Metals	4–4		2·792 Internal Combustion Eng. 3–6
	2·43	Heat Engineering	3–6		2·794 Internal Combust. Eng. Lab. 4–2
	2·681	Engineering Laboratory	3–3		*Thesis 9
	2·791	Internal Combustion Eng.	3–6		†Humanities IV 3–5
		†Humanities IV	3–5		Prof. Elective Subject 9
			19–30		50

Professional Elective Subjects‡

2·126	Experimental Stress Anal.	5–4
2·32T	Engineering Metals	3–6
2·48	Gas Turbine Eng.	3–6
2·796	Internal Combust. Eng. Des.	5–4
15·70	Production	3–6
16·81	General Aeronautics	3–6

II-A. MECHANICAL ENGINEERING

IN COÖPERATION WITH THE GENERAL ELECTRIC COMPANY AND THE BOSTON EDISON COMPANY

(During the war students will take the regular Course II schedule. For typical Course II-A schedule, see Catalogue, June 1942, Volume 77, No. 4, or Summer Session 1942, Volume 77, No. 3.)

THE Coöperative Course in Mechanical Engineering affords training for the technical and executive responsibilities of the manufacturing phases of any representative large industry.

The Course covers a period of five years, of which the first two years are identical with those of Course II. The last three years, including the summers, are spent partly at the Institute and partly at the plants of the coöperating companies.

Instruction in the first four years is essentially the same in content as that given in Course II. No omissions are made in the fundamental and professional subjects, and the subjects omitted from the regular Course II curriculum have their counterparts in the program at the works.

The final year of graduate study and research is to be planned for each student in accordance with the requirements of the Graduate School. Training at the plants is planned and carried out with a view to its educational value and is closely correlated with the instruction at the Institute. During the final term at the works much freedom may be exercised in the assignment of students to the research departments of the companies. This is planned to develop special and individual aptitudes of the various men.

The number of students that can be accommodated is limited and, consequently, registration in the Coöperative Course is restricted to students of marked aptitude who have clear records in the first two years of Course II. Admission to the Course is subject to the approval of the Institute and the coöperating companies. College transfer students may be admitted under equivalent conditions as to adequacy of preparation and aptitude.

It is assumed that students who are admitted to the Course with the approval of the Institute and of the coöperating companies will carry the Course through to

* See Requirements for Bachelor's Degree, page 38. † See page 117 for list of subjects.

‡ Other electives may be chosen with approval of registration officer.

§ Application for admission to this option should be made to the Head of the Department before the end of the third year, since registration is limited.

II-A. Mechanical Engineering Continued

completion, unless exceptional circumstances prevent. Students at the works are subject to the usual regulations of the Company and receive regular compensation, the total of which approximates the tuition charges for the three years of the Coöperative Course.

The 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.

III. METALLURGY

THE Course in Metallurgy provides training in the beneficiation and dressing of ores and minerals, in the production and purification of metals, and in the use of metals and alloys. Although the fields of Metallurgy and Mineral Dressing are differentiated in some industries, it is felt that broad training requires an acquaintance with each branch. As a result the emphasis throughout the four years is laid on the basic sciences of mathematics, physics, chemistry, and economics, and the Junior year is devoted almost exclusively to an application of these sciences to the various branches of Metallurgy.

Two options are offered, one in Metallurgy and the other in Mineral Dressing.

The Metallurgy option covers both process metallurgy, which is concerned primarily with the winning of the metals from ores or concentrates, and the making of steel and other alloys, and physical metallurgy, which stresses the physical properties, structures, testing and uses of metals and alloys. The two subdivisions of Metallurgy are so closely interrelated that a sharp separation is undesirable. A limited amount of specialization in one of the two fields is made possible by the freedom of choice in the selection of electives and of a thesis subject in the fourth year.

The Mineral Dressing option is primarily concerned with the mechanical, physical, and chemical preparation of ores, solid fuels, ceramic raw materials and other non-metallic mineral products. This preparation has as its goal the elimination at low cost of the bulky impurities commonly found in raw mineral products, and the production of the valuable content as concentrate.

Both options lead to the degree of Bachelor of Science in Metallurgy.

CERAMICS. The instruction and research in Ceramics are mainly intended for graduate work leading to a Master's or Doctor's degree. It is advisable for an undergraduate student interested in this subject to register in Course IX-B, General Engineering, and take as electives, subjects bearing on Ceramics. This procedure will also give an excellent foundation for graduate work. The subjects dealing with Ceramics are intended to give a fundamental training in the usual manufacturing processes as well as in the testing of raw materials and finished ware.

FIRST YEAR (See page 38)

SECOND YEAR

First Term	2·011	Statics & Dynamics	3–5	*Second Term*	2·04	Strength of Materials	3–6
	5·11	Qualitative Analysis	7–3		5·12	Quantitative Analysis	7–3
	8·03	Physics	5–5		8·04	Physics	5–5
	E21	U. S. in World Hist. — Humanities II	3–5		E22	U. S. in World Hist. — Humanities II	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			24–24				24–25

REQUIRED DURING SUMMER

2·851 Machine Tool Laboratory 4–0

THIRD YEAR‡

First Term	*3·12	Met.: Iron and Steel	2–4	*Second Term*	2·50	(1) Heat Measurements	3–1
	*3·31	Physical Metallurgy I	5–4		*3·01	Non-Ferrous Metallurgy I	4–4
	*3·81	Mineral Dressing I	6–4		*3·04	Metallurgical Laboratory	4–0
	*5·61	Physical Chemistry I	4–4		3·09T	(1) Metallurgical Calculations	2–4
	*12·011T	Mineralogy	3–1		*3·32	(1) Physical Metallurgy II	5–4
	*12·20	Elem. Crystallography	2–2		*3·41	(1) Industrial Non-Fer. Alloys	2–2
	Ec11	Economic Prin. — Humanities III	3–5		*3·82	(2) Mineral Dressing II	2–4
			25–24		*3·86T	(2) Quant. Mineragraphy	7–2
					*5·62	Physical Chemistry II	4–4
					12·91	(2) Mining, Elements	3–5
						†Humanities III	3–5
							27–24

FOURTH YEAR

OPTION 1. METALLURGY

First Term	2·33	Metal Processing	4–4	*Second Term*	6·19	Electrical Eng., Fund	4–6
	2·371	Testing Materials Lab.	2–2			*Thesis	12
	3·20	Metal. Thermodynamics	4–4			†Humanities IV	3–5
	3·33	Industrial Physical Met.	3–2			Elective Subjects	18
	6·18	Electrical Eng., Fund	4–6				48
		†Humanities IV	3–5				
		Elective Subject	6				
			49				

* See Requirements for Bachelor's Degree, page 38. † See page 117 for list of subjects.

‡ Students planning to take a certain option in the fourth year, take the Group Electives indicated by the corresponding number.

III. Metallurgy Continued

First Term Elective Subjects

3·02	Non-Ferrous Metallurgy II	2–4
3·041	Electric Furnaces	3–2
3·05	Metallurgy, General	4–4
3·40	Cor. & Heat Res. Alloys	2–4
3·50	X-ray Metallography	4–4
3·70	Ceramics	5–4
3·71	Optical Ceramics	6–2
3·83T	Mineral Dressing III	2–4

Second Term Elective Subjects

3·03	Non-Ferrous Metallurgy III	Arr.
3·21	Steelmaking, Prin.	2–4
3·42	Powder Metallurgy	2–4
3·422	Powder Metallurgy Lab.	4–2
3·51	Physics of Metals	2–4
3·65	Theory of the Solid State	3–6
3·82	Mineral Dressing II	2–4

OPTION 2. MINERAL DRESSING

First Term	3·20	Metal. Thermodynamics	4–4
	3·83T	Mineral Dressing III	2–4
	3·87T	Ore Testing	10–0
	5·41	Organic Chemistry I	4–4
	10·31	Chemical Engineering	4–6
		†Humanities IV	3–5
			27–23

Second Term	3·84T	Mineral Dressing IV	2–4
	3·88T	Mineral Dressing Prac.	2–4
	10·32	Chemical Engineering	4–6
	12·24	Theoretical Crystallog.	2–4
		*Thesis	14
		†Humanities IV	3–5
			50

IV. ARCHITECTURE

THE objective of the Course in Architecture is to produce graduates who will be effective and valuable in the planning and execution of all kinds of building projects. The professional contribution includes understanding of the 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, coördination 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 of 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 38)

SECOND YEAR

First Term	2·011	Statics & Dynamics	3–5
	4·721	Architectural Design	9–3
	8·03	Physics	5–5
	E21	U. S. in World Hist. — Humanities II	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
			26–24

Second Term	2·04	Strength of Materials	3–6
	4·07	Shop	4–0
	4·722	Architectural Design	9–3
	17·71	Materials	2–4
	Ec83	Urban Sociology	2–4
	E22	U. S. in World Hist. — Humanities II	3–5
	MS22	Military Science	3–0
			26–22

THIRD YEAR

First Term	*1·771	Sanitation	2–4
	*2·661	Heating & Ventilation	2–4
	*4·031	Freehand Drawing	4–0
	*4·731	Architectural Design	12–6
	*4·811	Structural Analysis	8–0
	Ec11	Economic Prin. — Humanities III	3–5
			31–19

Second Term	*2·662	Heating & Ventilation	2–4
	*4·032	Freehand Drawing	4–0
	*4·732	Architectural Design	12–6
	*4·812	Structural Analysis	8–0
	*17·72	Materials	2–4
		†Humanities III	3–5
			31–19

FOURTH YEAR

First Term	*4·741	Architectural Design	12–6
	*6·16	Electricity	3–6
	8·053	Architectural Acoustics	5–3
	*17·73	Materials	2–4
		†Humanities IV	3–5
			25–24

Second Term	*2·373	Testing Materials Lab.	5–2
	4·042	Freehand & Color	6–0
	*4·641	City Planning, Prin.	2–4
	*4·742	Architectural Design	12–6
	*6·17	Illumination	2–4
		†Humanities IV	3–5
			30–21

* See Requirements for Bachelor's Degree, page 38.

† See page 117 for list of subjects.

IV. Architecture Continued

Fifth Year

First Term	4·051T	Freehand & Color	6–0	*Second Term*	4·052T	Freehand & Color	6–0
	*4·451	History of Architecture	3–6		*4·452	History of Architecture	3–6
	*4·621	Site Plan. & Construction	9–3		Ec88	Building Economics	2–4
	*4·751T	Architectural Design	9–3			*Thesis	21
	Ec85	Land Economics	2–4			Prof. Elective Subject	6
		Prof. Elective Subject	6				48
			51				

IV-B. CITY PLANNING

THE undergraduate Course in City Planning has been developed in response to the need for a curriculum which is oriented to this professional field early in the program and which provides for a synthesis of the economic, sociological, administrative, and engineering aspects of city planning impossible in courses developed from existing curricula in specialized professional fields.

The expansion which has taken place in the social and economic aspects of planning, the development of improved technical procedures, and the rapidity with which planning and zoning legislation has placed new instruments of social control into the hands of local and state governments have greatly increased the scope of professional activity. This fact in its turn has placed a greater responsibility on the planning technician or consultant, who must be well equipped in the methods of social and economic research as well as in the techniques of physical planning.

The curriculum of Course IV-B includes preparatory subjects in engineering and in the natural and social sciences with the object of developing in the student an understanding of basic principles and relationships. The content of the third and fourth years is primarily technical in character with emphasis on the economic and administrative aspects, but with considerable time given to the working out in the drafting room of actual problems in the field of city and regional planning.

A feature of the Course is the close relations maintained between the student group and planning agencies in the Boston metropolitan district, advantage being taken of the many opportunities for evaluating "planning in action." Students develop planning studies in various communities as part of their regular program of instruction, such studies including proposals for zoning, traffic circulation, housing, and rehabilitation, as well as comprehensive plans for future development. While these do not of course take the place of official plans and surveys, the procedure enables a student to carry through a planning project under conditions which approximate those of actual practice.

The Course in City Planning, IV-B, covers four years and leads to the degree of Bachelor in City Planning. Graduates of the Course, 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.

(*The Course in City Planning Practice has been temporarily discontinued due to the war. For typical Course IV-C schedule, see Catalogue, June 1942, Volume 77, No. 4, or Summer Session 1942, Volume 77, No. 3.*)

First Year (See page 38)

Second Year

First Term	1·05	Surveying	3–1	*Second Term*	4·641	City Planning, Prin.	2–4
	8·03	Physics	5–5		4·672	City Planning Design	10–5
	12·321	Engineering Geology	4–4		Ec32	Economic Statistics	3–6
	E21	U. S. in World Hist. — Humanities II	3–5		Ec83	Urban Sociology	2–4
	E35	Reports	2–4		E22	U. S. in World Hist. — Humanities II	3–5
	M21	Calculus	3–6		MS22	Military Science	3–0
	MS21	Military Science	3–0				23–24
			23–25				

Third Year

First Term	1·24	Municipal Engineering	3–3	*Second Term*	4·62	Site Plan. & Const.	9–3
	4·59	Govt. & Public Admin.	2–4		4·652	City Planning, Th. & Prac.	2–4
	4·651	City Planning, Th. & Prac.	2–4		4·682	City & Regional Planning	9–3
	4·681	City & Regional Plan.	12–6		Ec40	Money & Banking	2–4
	Ec11	Economic Prin. — Humanities III	3–5			†Humanities III	3–5
		Prof. Elective Subject	6			Prof. Elective Subject	6
			50				50

Fourth Year

First Term	4·683	City & Regional Plan.	9–3	*Second Term*	4·60	Plan. Legis. & Admin.	2–4
	15·61	Law of Contracts	3–6		Ec86	Land Economics	3–6
	Ec49	Public Finance	2–4		G38	Public Speaking	3–3
	Ec85	Land Economics	2–4			*Thesis	12
		*Thesis	3			†Humanities IV	3–5
		†Humanities IV	3–5			Prof. Elective Subject	6
		Prof. Elective Subject	6				47
			50				

* See Requirements for Bachelor's Degree, page 38. † See page 117 for list of subjects.

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 and 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 a command of the fundamentals in a selected field of science or engineering. Elective time is also available for additional subjects in the humanities.

Elective series are available in advanced inorganic, organic, and physical chemistry, in chemical engineering, ceramics, textiles, economics, metallography, mineralogy and geology, biology and biochemistry, and metallurgy.

The Course aims to stimulate and develop the research attitude, and the schedule includes the thesis in the fourth year to provide an opportunity for the student to demonstrate his aptitude for creative effort. Fourth-year students who intend to continue with graduate study may register for Graduate Research Conference in inorganic, organic, or physical chemistry as a part of thesis, subject to the approval of the Thesis Supervisor and Registration Officer. Throughout the Course, the student has the benefit of counsel by experienced instructors who assist him in selecting electives and aid him in acquiring the education and training necessary for well-balanced and intelligent living.

The Course leads to the degree of Bachelor of Science in Chemistry.

First Year (See page 38)

Required during Summer

*5·10	Qualitative Analysis	15–3	

Second Year

First Term	5·12	Quantitative Analysis	7–3	*Second Term*	5·13	Quantitative Analysis	7–3
	8·03	Physics	5–5		8·04	Physics	5–5
	E21	U. S. in World Hist. — Humanities II	3–5		E22	U. S. in World Hist. — Humanities II	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
		‡Language	3–5			‡Language	3–5
			24–24				24–24

Third Year

First Term	*5·141	Analytical Chemistry	4–2	*Second Term*	*5·417	Quant. Organic Analysis	4–0
	*5·41	Organic Chemistry I	4–4		*5·42	Organic Chemistry II	4–4
	*5·414	Organic Preparations	9–0		*5·424	Organic Compounds, Ident.	9–0
	*5·61	Physical Chemistry I	4–4		*5·62	Physical Chemistry II	4–4
	*5·611	Physical Chem. Lab. I	4–0		*5·621	Physical Chem. Lab. II	4–0
	Ec11	Economic Prin. — Humanities III	3–5			†Humanities III	3–5
		Elective Subject	6			Elective Subject	6
			49				47

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
	*5·63	Thermodynamics, Int.	2–4		*5·64	Radiation Chem., Int.	2–4
	*5·65	Kinetics & Chem. React.	2–4			or	
		*Thesis	15		*5·66	Surface & Colloid Chem.	2–4
		†Humanities IV	3–5			*Thesis	15
		Elective Subject	6			†Humanities IV	3–5
			53			Elective Subject	6
							47

VI. ELECTRICAL ENGINEERING

THE objective common to all options in Electrical Engineering is to train men for professional, industrial, or commercial careers in progressive applications of present engineering art and in the development of new engineering applications of electrical science. In preparation for such a career, the electrical engineering student must develop a working mastery of the basic sciences of mathematics and physics emphasizing mechanics, thermodynamics and especially electricity and magnetism. On these are built his fundamental professional work in principles of electrical engineering and associated applications. Equally vital to him is the ability to write and speak English effectively. He also needs the elements of chemistry and economics.

Various special features of the Department's work contribute strongly to the development of initiative, judgment, resourcefulness, and responsibility. Emphasis is placed on individual study under staff guidance. Close association among staff and students is considered part of a healthy educational atmosphere. Laboratory work is normally largely of the project type stressing individual experimental investigation under supervision rather than stand-

* See Requirements for Bachelor's Degree, page 38. † See page 117 for list of subjects.

‡ Students credited with Elementary and Intermediate French will take Elementary German. Students credited with Elementary and Intermediate German will take Elementary French. Students credited with Elementary French and Elementary German will take Intermediate German. Students who present neither French nor German on entrance will take Elementary German.

VI. Electrical Engineering Continued

ardized experiments. Small class sections, including students of similar interests and aptitudes, serve to encourage vigorous discussion. The Honors Group Plan requires a large measure of initiative and responsibility in the third and fourth years on the part of accepted candidates. Several Colloquia each year led by outstanding industrial engineers provide case studies in current engineering developments. (The Honors Group Plan and the Colloquia have been suspended for the duration of the war.)

By means of options provision is made for interests in the small-current fields of communications, electronics, measurement, and control, as well as in the large-current or power field. Additional flexibility to meet the needs of the individual student is provided by permitting him to make substitutions in the curriculum with the permission of the head of the department provided these are well considered and directed toward sound objectives.

Course VI provides four options described below.

Option 1. Electric Power. Emphasis is given to electrical machinery, power generation, transmission, and distribution. The student is offered a logical preparation for work with heavy apparatus manufacturers, public power utilities, and users of heavy electrical equipment.

Option 2. Illumination Engineering. Particular attention is given to the scientific basis of vision, color, optical apparatus, and production and good use of illumination. Makers and users of illumination equipment find this rapidly advancing field requires men with such training.

Option 3. Electrical Communications. A study is made of the techniques underlying the translation, transmission, reproduction, and recording of intelligence by electrical means. Circuit theory, electronics, electromagnetic theory, and acoustics are basic professional studies. The field of practical application includes aids to navigation, automatic control, and others in which the same techniques are essential.

Option 4. Electronic Applications. Emphasis is given to the rapidly increasing use of electrical methods of measurement, control, and implementation in all types of industry and engineering, as the emergence of a field of great future importance. Particular attention is paid to electromechanical and electrothermal systems, principles of measurement, and electronic applications.

The purpose of differentiation into options is primarily to provide the incentive to accomplishment which comes from emphasis on that portion of the electrical engineering field which arouses a student's special interest. All of these options lead to the degree of Bachelor of Science in Electrical Engineering.

First Year (See page 38)

Second Year

First Term	2·00	Statics	3–5	*Second Term*	2·01	Dynamics	3–5
	2·851	Machine Tool Laboratory	4–0		6·00T	Electrical Eng., Prin.	4–8
	6·05	Electrical Eng., Prin.	3–5		8·04	Physics	5–5
	8·03	Physics	5–5		E22	U. S. in World Hist. — Humanities II	3–5
	E21	U. S. in World Hist. — Humanities II	3–5		M22	Differential Equations	3–6
	M21	Calculus	3–6		MS22	Military Science	3–0
	MS21	Military Science	3–0				21–29
			24–26				

Third Year‡

First Term	*2·04	(1, 3, 4) Strength of Mat.	3–6	*Second Term*	*2·07	(1, 4) Dynamics	3–6
	*2·40	(1) Heat Engineering	4–5		2·42	(1) Heat Engineering	3–6
	*6·01T	Electrical Eng., Prin.	3–6		*6·02T	Electrical Eng., Prin.	3–6
	*6·75	Electrical Eng. Lab.	4–5		*6·27	(2) Illuminating Eng., Prin.	3–6
	*8·061	(2, 3, 4) Physics, Int.	3–6		*6·30	(3) Electrical Com., Prin.	3–6
	8·161	(2) Optics	3–6		*6·76	Electrical Eng. Lab.	3–3
	Ec11	Economic Prin. — Humanities III	3–5		*6·77	(1, 3, 4) Elec. Eng. Lab.	4–4
	M31	Differential Equations	2–4		8·062	(2, 3, 4) Physics, Int.	3–6
		(1)	19–31		M77	(2) Vector Analysis	3–6
		(2, 3, 4)	18–32			†Humanities III	3–5
						(1, 3, 4)	19–30
						(2)	18–32

Fourth Year

Option 1. Electric Power

First Term	1·64	Hydraulics	3–6	*Second Term*	6·04	Electrical Eng., Prin.	3–6
	2·681	Engineering Lab.	3–3		6·79T	Electrical Eng. Lab.	3–3
	*6.03T	Electrical Eng., Prin.	3–6			*Thesis	9
	*6·78	Electrical Eng. Lab.	4–4			†Humanities IV	3–5
		†Humanities IV	3–5			Prof. Elective Subjects	18
		Prof. Elective Subject	9				50
			49				

Professional Elective Subjects

	6·20	(1, 2, 3) Electronic Control & Meas.	3–6		6·212	App. Electricity to Industry	3–6
	6·211	App. Electricity to Industry	3–6		6·222	Electric Power Generation	3–6
	6·221	Electric Power Generation	3–6		6·23	(1, 2, 3) Electrical Implementation	3–6
	6·251	Electric Machine Design	3–6		6·252	Electric Machine Design	3–6
	6·26	Electric Insulation	3–6		6·27	(1, 3, 4) Illuminating Eng., Prin.	3–6
	6·281	Wire Communications, Prin.	3–6		6·312	Electrical Communications, Prin.	3–6
	6·80	Electrical Eng. Lab.	Time arr.		6·322	Electrical Communications, Prin.	3–6
					6·48	Electrical Equip. Bldgs.	2–4
					6·80	Electrical Eng. Lab.	Time arr.
					8·462	(1, 3, 4) Int. to Theoret. Physics II	4–8
					M77	(1, 3, 4) Vector Analysis	3–6

* See Requirements for Bachelor's Degree, page 38. † See page 117 for list of subjects.

‡ Students planning to take a certain option in the fourth year, take the Group Electives indicated by the corresponding number.

VI. Electrical Engineering Continued

OPTION 2. ILLUMINATION ENGINEERING (Not offered 1945–46)

First Term	*6·03T	Electrical Eng., Prin.	3–6	*Second Term*	*6·272	Illuminating Eng., Prin.	3–6
	*6·271	Illuminating Eng., Prin.	3–6		8·462	Int. Theoret. Physics II	4–8
	8·461	Int. Theoret. Physics I	4–8			*Thesis	9
		†Humanities IV	3–5			†Humanities IV	3–5
		Prof. Elective Subject (See Option 1)	9			Prof. Elective Subject (See Option 1)	9
			47				47

OPTION 3. ELECTRICAL COMMUNICATIONS

First Term	*6·03T	Electrical Eng., Prin.	3–6	*Second Term*	*6·332	Electrical Com. Lab.	4–5
	*6·311	Electrical Com., Prin.	3–6		*6·781	Electrical Eng. Lab.	3–3
	*6·321	Electrical Com., Prin.	3–6			*Thesis	9
	*6·331	Electrical Com. Lab.	3–3			†Humanities IV	3–5
	8·05	Vibration & Sound	3–6			Prof. Elective Subjects (See Option 1)	18
		†Humanities IV	3–5				50
			18–32				

OPTION 4. ELECTRONIC APPLICATIONS

First Term	2·251	Fluid Mechanics	3–6	*Second Term*	*6·23	Elec. Implementation	3–6
	*6·03T	Electrical Eng., Prin.	3–6		*6·781	Electrical Eng. Lab.	3–3
	*6·20	Electronic Control & Meas.	3–6		*6·84	Elec. Implement. Lab.	4–5
	*6·83	Electronic Eng. Lab.	3–3			*Thesis	9
		†Humanities IV	3–5			†Humanities IV	3–5
		Prof. Elective Subject (See Option 1)	9			Prof. Elective Subject (See Option 1)	9
			50				50

VI-A. ELECTRICAL ENGINEERING

COÖPERATIVE COURSE

(*The students in the Coöperative Course follow the program of one of the options of Course VI with four terms of practical experience in place of two professional electives and fourth year thesis. For typical Course VI-A schedule see Catalogue, June 1942, Volume 77, No. 4, or Summer Session 1942, Volume 77, No. 3.*)

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 Coöperative 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 option of Course VI which the student elects. The fifth or final year includes a complete academic year of graduate work subject to the provisions of the Graduate School. 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 five companies coöperate with the Institute by offering practical experience in one or more of the fields represented by the four options of Course VI:

The GENERAL ELECTRIC COMPANY affords practical experience in all four options, emphasis being placed on training for the technical and executive responsibilities incident to the electrical manufacturing industries. The manufacturing practice is taken in plants located in Lynn, Schenectady, Pittsfield, 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 in the power option 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 the repair and maintenance of lines and equipment, the testing of instruments, insulators and transformers, the handling of customer relations, the operation of generating stations, and the solution of transmission and distribution engineering problems.

The AMERICAN TELEPHONE AND TELEGRAPH COMPANY offers experience in the development and manufacture of communications and electronic devices. Students who obtain their experience with the Bell System may go first to an operating company, where they work with installers supplying customer service and in telephone exchanges on the installation and maintenance of central office equipment. The second assignment is to the Western Electric Company at Kearny, N. J., where the students work on problems of plant layout, factory processes, and manufacturing economy. The third assignment is to the Bell Telephone Laboratories, where the students usually confine their attention for the whole term to one specific research or development project. The final assignment may be at one of the Bell-System plants mentioned above or may be with one of the other associated companies, at the discretion of the officials of the American Telephone and Telegraph Company, the coördinating organization of the Bell System.

The GENERAL RADIO COMPANY provides practical experience in the manufacture of communications and electronic apparatus. The first period is spent in the

* See Requirements for Bachelor's Degree, page 38. † See page 117 for list of subjects.

VI-A. Electrical Engineering Continued

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 experience in the development and manufacture of electronic and communication appliances and in television transmission practices. Students obtain experience in production planning, and manufacturing methods, in addition to spending a considerable part of the works periods in the research and development laboratories, including the experimental television broadcasting station.

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 coöperative 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 coöperating companies.

The men when in training at the plants are subject to the usual company regulations. They receive regular compensation for their work, the total of which approximates the tuition charges for the three years of coöperation. During the practice periods classes are held two evenings a week in electrical engineering and other professional studies, in this way maintaining a continuous study of the principles of electrical engineering, whether at the Institute or at the plant.

On account of the limitations of number and the unitary nature of the training, men 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, unless industrial conditions arise which minimize the educational value of the engineering practice.

At the conclusion of the course graduates are not obligated to accept employment with the coöperating company, nor is the company obligated to offer such employment.

A reading knowledge of German or French is required for the Master's degree as stated in detail under the Graduate School.

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 careers in professional biology (teaching and research), for medical training, and for work involving the numerous technical applications, particularly in industries concerned with food and nutrition, biochemicals, and fermentation processes. The term Biological Engineering refers to the broad application of the exact scientific and engineering methods to biological problems, particularly in applied fields in the industries. However, stress is also laid on the application of quantitative, analytical methods in the subjects in 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.

This Course is designed primarily for students looking forward to careers in experimental biology and medicine. While insuring a sound background in the basic sciences of mathematics, physics and chemistry, and the fundamentals of modern biology, provision is made for a wide choice of electives both in the biological sciences and in the humanities. The Course is, therefore, well suited, not only for students wishing to prepare for teaching and research posts in biology, but also for premedical students. Modern medicine is rapidly becoming less empirical and more scientific. It is important, therefore, particularly 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 38)

SECOND YEAR

First Term	5·11	Qualitative Analysis	7–3	*Second Term*	5·12	Quantitative Analysis	7–3
	7·01	General Biology I	6–4		7·02	General Biology II	6–4
	8·03	Physics	5–5		8·04	Physics	5–5
	E21	U. S. in World Hist. — Humanities II	3–5		E22	U. S. in World Hist. — Humanities II	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			27–23				27–23

REQUIRED DURING SUMMER

5·41	Organic Chemistry I	4–4
5·428	Organic Chemistry Lab.	10–0
		14–4

VII. Quantitative Biology Continued

THIRD YEAR

First Term	*5·61	Physical Chemistry I	4–4	*Second Term*	*5·62	Physical Chemistry II	4–4
	*5·611	Physical Chem. Lab. I	4–0		*5·621	Physical Chem. Lab. II	4–0
	*7·14	Comparative Anatomy	8–4		*7·11	Embryology	8–4
	*7·80	Biochemistry	8–4			Language	3–5
	Ec11	Economic Prin. — Humanities III	3–5			†Humanities III	3–5
		Language	3–5			Elective Subject	8
			30–22				48

FOURTH YEAR

First Term	*7·19	General Physiology I	2–4	*Second Term*	*7·03	Genetics	2–4
	*7·211	Gen. Physiol. Lab. I	4–0		*7·20	General Physiology II	2–4
		*Thesis	10		*7·212	Gen. Physiol. Lab. II	4–0
		†Humanities IV	3–5			*Thesis	10
		Elective Subjects	18			†Humanities IV	3–5
			46			Elective Subjects	12
							46

VII-A. PHYSICAL BIOLOGY

THE purpose of this course is to prepare students for work of a research character in experimental and applied biology. In the wide range from pure biology to the applications of Biological Engineering in the industries, attractive opportunities await those who have sound training both in biology and in the exact sciences. Graduates may continue their studies toward the doctorate or may expect to find employment in research laboratories and industries dealing with biochemicals, foods, drugs, medical supplies and instrumentation, textiles, leather, baking, canning, and related fields. It is not only efficient but pedagogically desirable for the student to obtain his training in the separate disciplines simultaneously rather than to study physics, chemistry, and mathematics either before or after specializing in biology. Course VII-A makes possible this combination. Subjects in physics and chemistry are taken in each of the first four years, together with substantially the same amount of work in biology, as is required in Course VII. These aspects of physical biology are correlated in the Biophysics subjects in the graduate year. Electives in the fourth and fifth years permit the selection, subject to approval of the registration officer, of subjects having a bearing on specialized fields of pure or applied biology such as bacteriology, biochemistry, biophysics, general physiology, nutrition, food technology, industrial fermentations, economic entomology, and others. Training in research methods is provided through the solving of a thesis problem which may be selected in a field of pure or applied biology.

Because of the diversified technical courses of study prescribed in this curriculum each applicant for admission to Course VII-A should interview the registration officer for this course to determine if he is qualified to undertake the work.

Course VII-A leads to the degrees of Bachelor of Science in Quantitative Biology and Master of Science in Physical Biology.

Same as Course VII through Third Year.

FOURTH YEAR

First Term	*7·19	General Physiology I	2–4	*Second Term*	*7·03	Genetics	2–4
	*7·211	Gen. Physiol. Lab. I	4–0		*7·20	General Physiology II	2–4
	*7·31	Biology of Bacteria	7–4		*7·212	Gen. Physiol. Lab. II	4–0
	*8·09	Physical Measurements	3–2		*8·311	Atomic Structure	3–6
		†Humanities IV	3–5		*8·312	Atomic Structure Lab.	3–2
		Elective Subjects	12			†Humanities IV	3–5
			46			Elective Subject	8
							46

GRADUATE YEAR

First Term	7·85	Biophysics I	2–2	*Second Term*	7·86	Biophysics II	2–2
	7·881	Biophysics Lab. I	4–0		7·882	Biophysics Lab. II	4–0
	7·91	Instrument. in Biol. I	6–4		7·92	Instrument. in Biol. II	6–4
		Thesis	20			Thesis	20
		Elective Subject	8			Elective Subject	8
			46				46

* See Requirements for Bachelor's Degree, page 38. † See page 117 for list of subjects.

VII-B. 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 especial interests in contiguous fields.

The Course leads to the degree of Bachelor of Science in Food Technology.

First Year (See page 38)

Second Year

First Term	5·11	Qualitative Analysis	7–3	*Second Term*	5·12	Quantitative Analysis	7–3
	7·01	General Biology I	6–4		7·02	General Biology II	6–4
	8·03	Physics	5–5		8·04	Physics	5–5
	E21	U. S. in World Hist. — Humanities II	3–5		E22	U. S. in World Hist. — Humanities II	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			27–23				27–23

Required During Summer

*5·41	Organic Chemistry I	4–4
*5·428	Organic Chemistry Lab.	10–0

Third Year

First Term	*5·141	Analytical Chemistry	4–2	*Second Term*	*5·62	Physical Chemistry II	4–4
	*5·61	Physical Chemistry I	4–4		*5·621	Physical Chem. Lab. II	4–0
	*5·611	Physical Chem. Lab. I	4–0		*7·361	Industrial Microbiology	6–4
	*7·301	Bacteriology	6–2		*7·702	Tech. & Chem. Food Sup.	6–4
	*7·701	Tech. & Chem. Food Sup.	6–2		15·11	Business Management, Int.	3–6
	Ec11	Economic Prin. — Humanities III	3–5			†Humanities III	3–5
		Elective Subject	6				26–23
			48				

Fourth Year

First Term	2·601	Food Engineering	4–2	*Second Term*	2·602	Food Engineering	4–2
	*7·711	Technology Food Products	6–4		7·22	Chemistry of Nutrition	2–2
	*7·80	Biochemistry	8–4		*7·712	Technology Food Products	6–4
	10·28	Chemical Engineering	4–6		10·29	Chemical Engineering	4–6
		*Thesis	4			*Thesis	10
		†Humanities IV	3–5			†Humanities IV	3–5
			50				48

VII-C. FOOD TECHNOLOGY

A LIMITED number of outstanding students in the regular four-year curriculum, Course VII-B, 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 VII-B through Third Year.

Fourth Year

First Term	2·601	Food Engineering	4–2	*Second Term*	2·602	Food Engineering	4–2
	*7·711	Technology Food Products	6–4		7·22	Chemistry of Nutrition	2–2
	*7·80	Biochemistry	8–4		7·222	Chem. of Nutrition Lab.	5–0
	10·28	Chemical Engineering	4–6		*7·712	Technology Food Products	6–4
		†Humanities IV	3–5		10·29	Chemical Engineering	4–6
			25–21			†Humanities IV	3–5
						Elective Subject	8
							51

* See Requirements for Bachelor's Degree, page 38.

† See page 117 for list of subjects.

VII-C. Food Technology Continued

GRADUATE YEAR

First Term	7·721	Food Technology, Adv.	8–4	*Second Term*	7·722	Food Technology, Adv.	6–4
	7·791	Food Technology Seminar	2–2		7·792	Food Technology Seminar	2–2
	7·81	Enzymology	6–4			Thesis	20
		Thesis	15			Elective Subjects	14
		Elective Subject	10				48
			51				

VIII. PHYSICS

THE Course in Physics is intended to give its graduates a broad training in classical and modern physics, both experimental and theoretical. The student gains a knowledge of the facts of physics, training in modern experimental methods, and experience in applying mathematical methods to physical problems. This preparation is broad enough so that the graduate is equipped either to take a place in industry in a field employing physics for practical purposes, or to undertake graduate training in physics, to fit him for an industrial or academic career involving fundamental research or the more advanced aspects of physics.

Electives in the fourth year, to be chosen in consultation with the registration officer, may be taken in physics, in such fields as X-rays, nuclear physics, spectroscopy, electronics, and optics; or in other fields, such as mathematics, chemistry, metallurgy, or electrical engineering.

The Course leads to the degree of Bachelor of Science in Physics.

FIRST YEAR (See page 38)

SECOND YEAR

First Term	5·11	Qualitative Analysis	7–3	*Second Term*	5·00T	Electrical Eng., Prin.	4–8
	8·03	Physics	5–5		8·04	Physics	5–5
	E21	U. S. in World Hist. — Humanities II	3–5		E22	U. S. in World Hist. — Humanities II	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
		Language	3–5			Language	3–5
			24–24				21–29

THIRD YEAR

First Term	6·11	Electrical Eng., Prin.	4–8	*Second Term*	*8·062	Physics, Intermediate	3–6
	6·82	Electrical Eng. Lab.	2–3		*8·202	Electronics Laboratory	3–2
	*8·061	Physics, Intermediate	3–6		*8·311	Atomic Structure	3–6
	*8·09	Physical Measurements	3–2		*8·312	Atomic Structure Lab.	3–2
	*8·161	Optics	3–6		M77	Vector Analysis	3–6
	*8·162	Optical Measurements	3–2			†Humanities III	3–5
	Ec11	Economic Prin. — Humanities III	3–5				18–27
			21–32				

FOURTH YEAR

First Term	8·11	Experimental Physics	8–4	*Second Term*	8·462	Int. Theoretical Physics II	4–8
	8·461	Int. Theoretical Physics I	4–8			*Thesis	18
		†Humanities IV	3–5			†Humanities IV	3–5
		Elective Subjects	15			Elective Subject	9
			47				47

IX-A. GENERAL SCIENCE

(Administered by a Committee of the Faculty)

THE Course in General Science provides an opportunity for a student with a special objective to map out his own program of study in the fundamental sciences.

Since one-quarter of the units required for graduation are elective, the student may choose a comprehensive program involving several sciences, with specialization in one field. If his objective falls within one of the professional science courses, such as Biology, Chemistry, Food Technology, Geology, Physics, or Mathematics, he may depart from the prescribed course curriculum for the purpose of concentrating upon some specialty. Alternatively he may pursue a specialty breaking across the boundaries of the professional courses, such as acoustics, economics, medical preparation, optics, photography, plastics, or teaching.

The choice of electives is subject to the approval of the Committee on Course IX and, for the third and fourth years, must include a total of at least 48 units in one field of science. Substitutions may be made for the subjects marked (**) by subjects of similar content or in the same field. The composite group of science subjects must comprise an amount of scientific training equivalent to that obtained in the standard science courses.

Course IX-A is not separated from the other science courses until the third year. A student intending to transfer to Course IX-A at the beginning of the third year should consult the Course IX Registration Officer and register in the second-year course schedule which relates most closely to the student's objective.

The Course leads to the degree of Bachelor of Science in General Science.

* See Requirements for Bachelor's Degree, page 38. † See page 117 for list of subjects.

IX-A. General Science Continued

FIRST YEAR (See page 38)

SECOND YEAR (See text, page 51)

THIRD YEAR

First	**5·41	Organic Chemistry I	4–4	*Second*	**5·42	Organic Chemistry II	4–4
Term	**8·061	Physics, Intermediate		*Term*	**8·062	Physics, Intermediate	3–6
	Ec11	Economic Prin. — Humanities III			**M37	Advanced Calculus	3–6
	**M36	Advanced Calculus	3–6			†Humanities III	3–5
		‡Elective Subjects	16			‡Elective Subjects	16
			50				50

FOURTH YEAR

First		*Thesis	5	*Second*		*Thesis	10
Term		†Humanities IV	3–5	*Term*		†Humanities IV	3–5
		‡Elective Subjects	35			‡Elective Subjects	30
			48				48

Elective Subjects‡

5·414	Organic Preparations	9–0	5·424	Organic Compounds, Ident.	9–0
5·61	Physical Chemistry I	4–4	5·62	Physical Chemistry II	4–4
5·611	Physical Chem. Lab. I	4–0	5·621	Physical Chem. Lab. II	4–0
7·01	General Biology I	6–4	7·02	General Biology II	6–4
7·211	General Physiology Lab I	4–0	7·11	Embryology	8–4
7·301	Bacteriology	6–2	7·31	Biology of Bacteria	7–4
8·053	Architectural Acoustics	5–3	8·15	Photography	2–1
8·09	Physical Measurements	3–2	8·173	Color Measurements	3–2
8·161	Optics	3–6	8·202	Electronics Lab.	3–2
8·162	Optical Measurements	3–2	8·311	Atomic Structure	3–6
8·461	Int. Theoretical Physics I	4–8	8·312	Atomic Structure Lab.	3–2
12·321	Engineering Geology	4–4	8·462	Int. Theoretical Physics II	4–8
M31	Differential Equations	2–4	12·322	Engineering Geology	2–4
			M77	Vector Analysis	3–6

IX-B. GENERAL ENGINEERING

(Administered by a Committee of the Faculty)

THE Course in General Engineering provides an opportunity for a student with a special objective to map out his own program of study in the fundamental engineering subjects.

Since one-quarter of the units required for graduation are elective, the student may choose a comprehensive program involving several engineering subjects, with specialization in one field. If his specialization falls within one of the professional engineering courses, such as Aeronautical, Chemical, Civil, Electrical, Mechanical or Metallurgical, he may depart from the prescribed course curriculum for the purpose of concentrating upon some specialty. Alternatively he may pursue a specialty breaking across the boundaries of the professional courses, such as ceramics, fire protection, instrumentation, manufacturing, prepatent law, or textiles.

The choice of electives is subject to the approval of the Committee on Course IX and, for the third and fourth years, must include a total of at least 48 units in one field of engineering. Substitutions may be made for the subjects marked (**) by subjects of similar content or in the same field. The composite group of engineering subjects must comprise an amount of engineering training equivalent to that obtained in the standard engineering courses.

Course IX-B is not separated from the othe rengineer ng courses until the third year. A student intending to transfer to Course IX-B at the beginning of the third year should consult the Course IX Registration Officer and register in the second-year course schedule which relates most closely to the student's objective.

The Course leads to the degree of Bachelor of Science in General Engineering.

FIRST YEAR (See page 38)

SECOND YEAR (See text above)

THIRD YEAR

First	**2·04	Strength of Materials	3–6	*Second*	**2·42	Heat Engineering	3–6
Term	**2·40	Heat Engineering	4–5	*Term*	**6·40	Electrical Eng., Elem.	4–6
	Ec11	Economic Prin. — Humanities III	3–5			†Humanities III	3–5
		‡Elective Subjects	24			‡Elective Subjects	23
			50				50

* See Requirements for Bachelor's Degree, page 38. † See page 117 for list of subjects.

** Substitutions may be made only with subjects in the same field.

‡ Total elective subjects for the two years must include a total of at least 48 units in one field of science for Course IX-A and in one field of engineering for Course IX-B. Elective subjects other than those suggested will be approved if they conform to the student's general objective.

IX-B. General Engineering Continued

Fourth Year

First Term		*Thesis	5	*Second Term*		*Thesis	10
		†Humanities IV	3–5			†Humanities IV	3–5
		‡Elective Subjects	35			‡Elective Subjects	30
			48				48

Elective Subjects‡

	1·05	Surveying	3–1		1·401	Structures	3–6
	1·64	Hydraulics	3–6		2·06	Dynamics	3–6
	2·081	Strength of Materials	3–6		2·30T	Engineering Materials	5–4
	2·66	Air Conditioning	3–6		2·50	Heat Measurements	3–1
	2·683T	Engineering Laboratory	4–4		2·621T	Refrigeration	3–6
	2·701	Machine Drawing	6–0		2·792	Int. Comb. Engines	3–6
	2·730	Machine Design	4–2		5·35	Applied Chemistry	2–4
	2·791	Internal Combustion Eng.	3–6		6·17	Illumination	2–4
	3·12	Met.: Iron & Steel	2–4		6·48	Elec. Equipment of Bldgs.	2–4
	6·19	Electrical Eng., Fund.	4–6		15·50	Accounting	5–4
	6·221	Elec. Power Generation	3–6		Ec40	Money & Banking	2–4
	6·85	Electrical Eng. Lab.	2–3		M37	Advanced Calculus	3–6
	15·61	Law of Contracts	3–6				
	E33	Report Writing	2–4				
	M36	Advanced Calculus	3–6				

X. CHEMICAL ENGINEERING

THE needs of chemical industry for men competent to develop, design and operate new processes and to improve existing ones require a training which combines knowledge both of the underlying chemical reactions and of the engineering principles basic to design, construction and operation of plant equipment. The Course in Chemical Engineering is planned to afford students broad training in the fundamentals of science, chemistry and engineering.

The work in chemistry, covering inorganic, analytical, physical and organic chemistry, is practically 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 and the instruction is adapted to his requirements. The work in chemical engineering and in industrial chemistry is of a distinctly professional nature and is designed to develop capacity for original thought. Competent students may make substitutions in the curriculum with approval of the Head of the Department.

A graduate year of the Course, in Chemical Engineering or in Chemical Engineering Practice, provides opportunity for the development, correlation and application of the basic professional subjects.

The Course leads to the degree of Bachelor of Science in Chemical Engineering.

First Year (See page 38)

Second Year

First Term	5·11	Qualitative Analysis	7–3	*Second Term*	2·011	Statics & Dynamics	3–5
	8·03	Physics	5–5		5·12	Quantitative Analysis	7–3
	E21	U. S. in World Hist. — Humanities II	3–5		8·04	Physics	5–5
	M21	Calculus	3–6		E22	U. S. in World Hist. — Humanities II	3–5
	MS21	Military Science	3–0		M22	Differential Equations	3–6
		**Language	3–5		MS22	Military Science	3–0
			24–24				24–24

Third Year

First Term	2·04	Strength of Materials	3–6	*Second Term*	5·42	Organic Chemistry II	4–4
	5·41	Organic Chemistry I	4–4		5·426	Organic Compounds, Ident.	6–0
	5·416	Organic Preparations	6–0		5·62	Physical Chemistry II	4–4
	5·61	Physical Chemistry I	4–4		5·622	Physical Chem. Lab. II	2–0
	5·612	Physical Chem. Lab. I	2–0		10·17	Industrial Chemistry	3–4
	10·28	Chemical Engineering	4–6		10·29	Chemical Engineering	4–6
	Ec11	Economic Prin. — Humanities III	3–5			†Humanities III	3–5
			26–25				26–23

Required During Summer

10·26T Industrial Chem. Lab. 20–0

*See Requirements for Bachelor's Degree, page 38. † See page 117 for list of subjects.

**Students who have not had German will take German. Students who have had German will take Russian.

‡ Total elective subjects for the two 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.

X. Chemical Engineering Continued

FOURTH YEAR

First Term	2·371	Testing Materials Lab.	2–2	*Second Term*	6·85	Electrical Eng. Lab.	2–3
	2·681	Engineering Laboratory	3–3		10·21T	Industrial Chemistry	3–6
	6·18	Electrical Eng., Fund.	4–6		10·32	Chemical Engineering	4–6
	10·18	Industrial Chemistry	3–6			*Thesis	9
	10·31	Chemical Engineering	4–6			†Humanities IV	3–5
		*Thesis	3			Elective Subject	6
		†Humanities IV	3–5				47
			50				

X-B. CHEMICAL ENGINEERING PRACTICE

(Temporarily Discontinued)

THE privileges 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.

XII. GEOLOGY

THE following program for the second, third, and fourth years is designed for students desiring a broad training in geology, as well as for those planning to follow one of the several lines of specialization. The schedule is sufficiently flexible to permit an adequate range of specialization by the use of electives. Students whose interests and aptitudes have led to a choice may by consultation with their major professor arrange a suitable schedule. The principal lines of specialization are:

General Geology and Stratigraphy. A broad training in general geology, with emphasis on paleontology, stratigraphy, sedimentation, and allied subjects. This line of training gives suitable preparation for academic and professional work in general geology and its applications to coal, petroleum, and natural gas.

Physical and Economic Geology. This line of special interest leads to the application of physics and chemistry to fundamental research in geology, and is intended for those who plan to enter the field of geology as applied to ore deposits and non-metallic resources.

Mineralogy. Students desiring to prepare themselves for specialization and research in the science of mineralogy may arrange a schedule of subjects particularly designed for this purpose.

Geophysics. In recognition of the growing importance of fundamental research in geophysics and of the demand by petroleum and mineral industries, as well as by certain phases of engineering operations, for men trained along the combined lines of physics and geology, this Department is staffed and equipped to provide sound fundamental training in geology and geophysics. The training designed for this objective places special emphasis on physics, mathematics and certain phases of electrical engineering.

Engineering Geology. For students wishing to enter the field of engineering geology a suitable combination of subjects may be chosen from geology and civil engineering.

Mineral Resources. Students concerned with the field of economic geology, with a special interest in mineral industry and mining, will find the scheduled program sufficiently flexible to cover studies in mineral economics, mine valuation, elements of mining, and other related subjects pertinent to operational work in mineral industry.

This Course leads to the degree of Bachelor of Science in Geology.

FIRST YEAR (See page 38)

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
	12·301	General Geology	7–3		12·302	General Geology	7–3
	E21	U. S. in World Hist. — Humanities II	3–5		E22	U. S. in World Hist. — Humanities II	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			28–22				28–22

THIRD YEAR

First Term	*5·61	Physical Chemistry I	4–4	*Second Term*	*5·62	Physical Chemistry II	4–4
	*12·011T	Mineralogy	3–1		*12·012	Mineralogy	4–2
	*12·20	Elem. Crystallography	2–2		*12·15	Petrography	6–2
	*12·23	Optical Crystallography	5–4		*12·702	Structural Geology	3–6
	*12·701	Structural Geology	3–6			*Language	3–5
	Ec11	Economic Prin. — Humanities III	3–5			†Humanities III	3–5
		*Language	3–5				23–24
			23–27				

* See Requirements for Bachelor's Degree, page 38. † See page 117 for list of subjects.

XII. Geology Continued

FOURTH YEAR

First Term	*12·40	Economic Geology	3–6	*Second Term*	*12·37	Geomorphology	3–6
	*12·41	Economic Geology Lab.	6–0		*12·581	Sedimentation	5–4
		†Humanities IV	3–5			*Thesis	15
		Elective Subjects	24			†Humanities IV	3–5
			47			Elective Subject	6
							47

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 mainly comprises 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 is included an introductory course in ship construction which deals 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 38)

SECOND YEAR

First Term	2·00	Statics	3–5	*Second Term*	2·01	Dynamics	3–5
	2·30T	Engineering Materials	5–4		2·852	Machine Tool Prac.	4–0
	2·851	Machine Tool Lab.	4–0		8·04	Physics	5–5
	8·03	Physics	5–5		13·40	Ship Construction, Elem.	5–2
	E21	U. S. in World Hist. — Humanities II	3–5		E22	U. S. in World Hist. — Humanities II	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			26–25				26–23

THIRD YEAR

First Term	*2·04	Strength of Materials	3–6	*Second Term*	*2·062	Strength of Materials and Dynamics	3–6
	*2·251	Fluid Mechanics	3–6		*2·42	Heat Engineering	3–6
	*2·40	Heat Engineering	4–5		*13·02	Naval Architecture	3–6
	*13·01	Naval Architecture	3–6		*13·42	Ship Drawing	6–0
	*13·34	Ship Construction	3–3		*13·52	Marine Engineering	3–6
	Ec11	Economic Prin. — Humanities III	3–5			†Humanities III	3–5
			19–31				21–29

FOURTH YEAR

First Term	2·371	Testing Materials Lab.	2–2	*Second Term*	*13·46T	Ship Design	7–0
	*2·683T	Engineering Lab.	4–4		*13·55	Marine Engineering	2–4
	*6·18	Electrical Eng., Fund.	4–6		*13·62	Marine Engineering Design	7–1
	*13·45T	Ship Design	7–3		15·11	Business Management, Int.	3–6
	13·54	Marine Engineering	2–4			*Thesis	10
	*13·61	Marine Engineering Design	6–0			†Humanities IV	3–5
		†Humanities IV	3–5				48
			28–24				

XIII-C. MARINE TRANSPORTATION

IT is the intention in this five-year Course to provide for students who wish to enter the various branches of the shipping industry, or who wish to engage in other fields of marine transportation or allied pursuits, such as marine insurance, admiralty law, and port administration. The Course is a combination of science, engineering, economics, business studies and naval architecture.

It is essential that a student have a certain amount of actual experience aboard ships at sea in order to grasp thoroughly the problems of ship operation before finishing his course of study. It is also deemed necessary that sea experience be obtained before engaging in the various shore activities of a steamship company. For these reasons students in the Course are required to spend a year at sea as part of the requirements for graduation.

A number of American steamship companies coöperate,

* See Requirements for Bachelor's Degree, page 38. † See page 117 for list of subjects.

XIII-C. Marine Transportation Continued

as far as their facilities will allow, in placing the students at sea as cadets or student observers following the completion of the third year at the Institute. Part of the time at sea ordinarily is spent in the engine room and part on deck. In some cases, it also includes duty in the purser's department. Three months may be spent on the piers in connection with cargo handling.

While at sea the students are assigned regular duties in connection with the operation of the ship for which they receive a moderate amount of pay. The year at sea is considered an integral part of the student's educational program and he is required to make reports on assigned topics in addition to his regular duties on shipboard. Students entering the Institute with the required sea experience can finish the Course in four years by completing certain specified work.

The studies at the Institute are arranged to coördinate with the year at sea. In the second and third year, subjects are given in heat engineering, marine engineering, ports and port facilities and cargo handling and stowage, economic geography, naval architecture and a foreign language to give the student the proper preparation for the year at sea. During the fifth year the student takes advanced professional studies and approaches these with his practical knowledge gained at sea.

As a thorough knowledge of a ship's power plant is essential to the ship operator who must have a large share in its selection and economic operation, marine engineering is given a prominent place in the Course.

As the handling of ships' cargoes is one of the largest items of expense in connection with ship operation, and also influences the ship's stay in port, special attention is given to this phase of ship management.

The Course leads to the degree of Bachelor of Science in Marine Transportation.

FIRST YEAR (See page 38)

SECOND YEAR

First	2·00	Statics	3–5	*Second*	2·01	Dynamics	3–5
Term	8·03	Physics	5–5	*Term*	8·04	Physics	5–5
	E21	U. S. in World Hist. — Humanities II	3–5		12·36	Econ. Geography of World	2–4
	M21	Calculus	3–6		E22	U. S. in World Hist. — Humanities II	3–5
	MS21	Military Science	3–0		M22	Differential Equations	3–6
		Language	3–5		MS22	Military Science	3–0
			20–26			Language	3–5
							22–30

THIRD YEAR

First	*2·04	Strength of Materials	3–6	*Second*	2·42	Heat Engineering	3–6
Term	*2·40	Heat Engineering	4–5	*Term*	*2·683T	Engineering Laboratory	4–4
	*2·851	Machine Tool Lab.	4–0		*13·021	Naval Architecture	2–4
	*13·01	Naval Architecture	3–6		*13·52	Marine Engineering	3–6
	*13·34	Ship Construction	3–3		*13·84	Cargo Handling & Stowage	5–3
	*13·83	Ports & Port Facilities	3–4			†Humanities III	3–5
	Ec11	Economic Prin. — Humanities III	3–5				20–26
			23–29				

FOURTH YEAR (At Sea. See text above.)

FIFTH YEAR

First	*6·18	Electrical Eng., Fund	4–6	*Second*	*13·47	Ship Design	7–1
Term	*13·56	Marine Engineering	3–6	*Term*	*13·82	Ship Operation	3–6
	*13·81	Ship Operation	3–6		*15·20	Ocean Shipping Admin.	2–4
	*15·52	Accounting	4–2		Ec54	Corporations	2–4
	15·61	Law of Contracts	3–6			*Thesis	10
		†Humanities IV	3–5			†Humanities IV	3–5
			20–31				47

XIV. METEOROLOGY

THE rapid expansion of meteorology during recent years has led to the inauguration of a four-year undergraduate program in the field of Meteorology. It is the purpose of this course to prepare students for weather forecasting in the aviation organizations, those industries whose operations are dependent on the weather, the Weather Bureau, and for further study and research. Emphasis is placed on the application of physics, of mathematics, and of other allied subjects to the atmosphere and its processes.

In the field of dynamic meteorology, the subjects of thermodynamics, hydrodynamics, and fluid mechanics are developed with special reference to the atmosphere. In synoptic meteorology these theoretical developments (supplemented by observational, empirical, and statistical methods) are applied to the practical problems encountered by the weather forecaster. In the synoptic laboratory the student is taught to decode and plot the daily weather reports, to analyze the weather maps and prepare forecasts, and thus to put in practice the methods presented in the lectures. The facilities of the synoptic laboratory include teletype and radio receivers for the collection of weather data and equipment for the reproduction of weather maps for student instruction and for exchange with other meteorological institutions. A comprehensive file of past data and weather charts is also maintained.

The meteorological instruments laboratory provides training in the observation of weather elements, maintenance of a weather station, and care of equipment. In climatology, the atmosphere in its average state is dis-

* See Requirements for Bachelor's Degree, page 38. † See page 117 for list of subjects.

XIV. Meteorology Continued

cussed from a meteorological point of view with emphasis on the geographical distribution of various factors. In oceanography, the dynamics of the fluid, the interaction of atmosphere and ocean, and other topics of meteorological interest are stressed. The special physical phenomena of the atmosphere, such as solar and terrestrial radiation, evaporation, condensation and precipitation processes, electricity and atmospheric optics are taken up in other subjects.

The Course leads to the degree of Bachelor of Science in Meteorology.

FIRST YEAR (See page 38)

SECOND YEAR

First Term	2·00	Statics	3–5	*Second Term*	2·01	Dynamics	3–5
	2·851	Machine Tool Lab.	4–0		8·04	Physics	5–5
	8·03	Physics	5–5		E22	U. S. in World Hist. — Humanities II	3–5
	E21	U. S. in World Hist. — Humanities II	3–5		L12	German, Elementary	3–5
	L11	German, Elementary	3–5		M22	Differential Equations	3–6
	M21	Calculus	3–6		MS22	Military Science	3–0
	MS21	Military Science	3–0				20–26
			24–26				

THIRD YEAR

First Term	2·251	Fluid Mechanics	3–6	*Second Term*	14·02	Descriptive Meteorol. II	3–6
	2·40	Heat Engineering	4–5		14·30	General Climatology	2–4
	*14·01	Descriptive Meteorol. I	3–6		*14·50	Meteorol. Lab., Int.	9–3
	*16·33	Meteorol. Observations	4–2		*14·60	Thermodyn. of Atmos.	3–6
	Ec11	Economic Prin. — Humanities III	3–5		14·70	Physics of Atmos., Elem.	2–4
	M331	Math. Th. of Statistics	3–6			†Humanities III	3–5
			20–30				22–28

FOURTH YEAR

First Term	*14·43	Synoptic Meteorol. I	3–6	*Second Term*	*14·44	Synoptic Meteorol. II	3–6
	*14·51	Synoptic Lab. I	15–0		*14·52T	Synoptic Lab. II	15–0
	*14·61	Dynamic Meteorol. I	2–4		*14·62T	Dynamic Meteorol. II	3–6
	14·83	Oceanography	2–4			*Thesis	9
		*Thesis	3			†Humanities IV	3–5
		†Humanities IV	3–5				50
			47				

XV-A AND XV-B. BUSINESS AND ENGINEERING ADMINISTRATION

THE Courses in Business and Engineering Administration provide special curricula for men who combine an initial aptitude for engineering with a potential capacity for subsequent managerial responsibilities. They were first established in the conviction that fundamental training in science and engineering inculcates habits of precise thinking which are of value in the study and the practice of business administration. To an ever-increasing extent business is now being based on engineering, science, and the humanities. The successful business man today must coördinate engineering, practical economics, and fundamental personnel relationships.

Students enrolled in Courses XV-A and XV-B take in their first two years essentially the same basic scientific subjects as do students in the purely engineering Courses. In the third and fourth years, the arrangement of studies provides time for a series of special subjects which deal with the functions of business and economic organization as they bear upon the interests of the stockholder, the employee, the market, the community, the general public and the government. The program of required business subjects is the same for all students; at the beginning of the second year there is a choice between two courses, depending upon whether the student desires to base his technical work on the physical or the chemical sciences.

XV-A. (BASED ON PHYSICAL SCIENCES)

In Course XV-A, in which the engineering subjects are based on the physical sciences, the student is offered some latitude as to the particular type of engineering which he desires to study. This flexibility is accomplished by the provision of a number of elective hours in the fourth year and, where necessary to a well coördinated program, by a limited amount of substitution in the third year. For example, some students have arranged to take a substantial amount of work in the field of textiles and in the field of aeronautics.

XV-B. (BASED ON CHEMICAL SCIENCES)

In Course XV-B, in which the engineering subjects are based on the chemical sciences, the complete series of subjects is prescribed, as all of them are essential to any subsequent program of specialization. Following the preliminary study of physics, chemistry, and mathematics required in the first year, the student electing the Chemical Course undertakes a dependent sequence of technical subjects which begins the coördinated three-year program.

Business and Engineering Subjects:

The program of business and economic subjects covers external as well as internal aspects of management. It aims to encourage an enlightened attitude toward business problems as they relate to economic, sociological, and political trends. Thus it stresses the responsibilities of business to the consumer (in marketing), to the employee (in labor relations), to the investor (in finance), and to other business men (in business law). Although current techniques are discussed, there is no attempt to create narrow trade skills.

First, the student is introduced through the subject of Production to the nature of modern factory operations. Immediately thereafter, he considers the subject of personnel or labor relations. He then undertakes the study

* See Requirements for Bachelor's Degree, page 38. † See page 117 for list of subjects.

XV. Business and Engineering Administration Continued

of economics, in which he learns the nature of the forces which underlie business phenomena. In his third year he begins his study of business relationships, with marketing and the law of contracts. He also becomes familiar with accounting, and its application to analysis and control. In his last year he studies the more involved relationships in finance as well as the applications of the statistical method. Finally, after the various individual business functions have been studied, a term subject, Industrial Problems, serves to provide a coördinated view of business as a whole.

In addition to this basic program, the student is permitted in his fourth year to elect somewhat more advanced work in one or two functional areas, according to his own interests or aptitudes. The thesis, which is undertaken during the last year, is usually chosen within the field of this partial specialization. In the thesis the student demonstrates his capacity to carry through an individual piece of work on his own initiative.

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 38)

Second Year

First Term	2·00	Statics	3–5	*Second Term*	2·01	Dynamics	3–5
	2·851	Machine Tool Lab.	4–0		8·04	Physics	5–5
	8·03	Physics	5–5		15·30	Personnel Management	3–5
	15·70	Production	3–6		E22	U. S. in World Hist. — Humanities II	3–5
	E21	U. S. in World Hist. — Humanities II	3–5		M22	Differential Equations	3–6
	M21	Calculus	3–6		MS22	Military Science	3–0
	MS21	Military Science	3–0				20–26
			24–27				

Third Year

First Term	*2·04	Strength of Materials	3–6	*Second Term*	2·30T	Engineering Materials	5–4
	*6·18	Electrical Eng., Fund.	4–6		*2·41	Heat Engineering	4–5
	*15·61	Law of Contracts	3–6		3·30	Metallography	4–2
	*15·81T	Marketing & Reports	4–8		6·19	Electrical Eng., Fund.	4–6
	Ec11	Economic Prin. — Humanities III	3–5		*15·50	Accounting	5–4
			17–31			†Humanities III	3–5
							25–26

Fourth Year

First Term	1·63	Hydraulics	2–4	*Second Term*	15·92	Industrial Problems	3–6
	*15·41	Finance	3–6			*Thesis	10
	Ec38	Industrial Statistics	3–6			†Humanities IV	3–5
		*Thesis	1			Business or Econ. Elective Subjects	16
		†Humanities IV	3–5			Engineering Elective Subject	6
		Business or Econ. Elective Subject	9				49
		Engineering Elective Subject	6				
			48				

Suggested Engineering Elective Subjects

	1·24	Municipal Engineering	3–3		1·92	Engineering Construction	3–3
	1·771	Sanitation	2–4		2·32T	Engineering Metals	3–6
	2·31T	Engineering Metals	4–4		3·41	Industrial Non-Fer. Alloys	2–2
	2·66	Air Conditioning	3–6		3·42	Powder Metallurgy	2–4
	2·79T	Int. Comb. Eng., Elem.	3–6				
	3·40	Cor. & Heat Res. Alloys	2–4				
	3·70	Ceramics	5–4				

XV-B. Business and Engineering Administration (Based on Chemical Sciences)

First Year (See page 38)

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
	15·70	Production	3–6		15·30	Personnel Management	3–5
	E21	U. S. in World Hist. — Humanities II	3–5		E22	U. S. in World Hist. — Humanities II	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			24–25				24–24

Third Year

First Term	2·41	Heat Engineering	4–5	*Second Term*	*5·62	Physical Chemistry II	4–4
	*5·41	Organic Chemistry I	4–4		*6·18	Electrical Eng., Fund.	4–6
	*5·61	Physical Chemistry I	4–4		10·17	Industrial Chemistry	3–4
	*15·50	Accounting	5–4		*15.81T	Marketing & Reports	4–8
	*15·61	Law of Contracts	3–6			†Humanities III	3–5
	Ec11	Economic Prin. — Humanities III	3–5				18–27
			23–28				

XV. Business and Engineering Administration Continued

FOURTH YEAR

First	10·18	Industrial Chemistry	3–6	*Second*	10·32	Chemical Engineering	4–6
Term	10·31	Chemical Engineering	4–6	*Term*	15·92	Industrial Problems	3–6
	*15·41	Finance	3–6			*Thesis	10
		*Thesis	1			†Humanities IV	3–5
		†Humanities IV	3–5			Business or Econ. Elective Subject	8
		Business or Econ. Elective Subject	9				45
			46				

XVI. AERONAUTICAL ENGINEERING

THE primary objective of the Course in Aeronautical Engineering is to provide a sound general training in subjects fundamental to the practice of engineering, and then to familiarize the student with the general principles of flight and with some of the detail of design and construction as applied to the airplane. To this end, the greater part of the first three years of study is devoted to fundamental subjects, most of the strictly professional work being deferred until the fourth year. During the Course, lectures and recitations are supplemented by laboratory and drafting room work.

In general, the professional subjects are directed particularly toward airplane design, but in order that the student may gain some knowledge of other branches of aeronautical activity, he is allowed to elect in the fourth year certain subjects in a related professional field.

The students' Aeronautical Engineering Society, affiliated with the Institute of Aeronautical Sciences, serves to bring its members in touch with professional developments through the National Society and its Journal.

On account of the large number of students who wish to take the Course in Aeronautical Engineering, and on account of limited facilities, it has been found necessary to limit the number admitted to the Course. Applications will be received during the second term of the first year, and notifications of admission or refusal will be issued shortly after the end of the second term of the Freshman year. Toward the end of the second year, a limited number of additional applications will be considered.

The professional work of the fourth year presupposes preparation in theoretical and applied aerodynamics and structures (16·01, 16·02, and 16·10 and 16·20).

The Course leads to the degree of Bachelor of Science in Aeronautical Engineering.

HONORS COURSE

(*Admission to the Honors Course is closed for the duration of the war.*)

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 coördinated schedule of studies through the senior and graduate years. A single thesis with a minimum of 30 units will be required in the graduate year and the time allotted to thesis in the senior year will be available for advanced mathematics or other subjects preparatory to the program of graduate studies. 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 degrees of Bachelor of Science and Master of Science in Aeronautical Engineering, awarded simultaneously at the end of the Graduate year.

FIRST YEAR (See page 38)

SECOND YEAR

First	2·00	Statics	3–5	*Second*	2·01	Dynamics	3–5
Term	2·30T	Engineering Materials	5–4	*Term*	2·701	Machine Drawing	6–0
	8·03	Physics	5–5		2·851	Machine Tool Lab.	4–0
	E21	U. S. in World Hist. — Humanities II	3–5		8·04	Physics	5–5
	M21	Calculus	3–6		16·82	Aeronautical Eng., Int.	3–1
	MS21	Military Science	3–0		E22	U. S. in World Hist. — Humanities II	3–5
			22–25		M22	Differential Equations	3–6
					MS22	Military Science	3–0
							30–22

THIRD YEAR

First	*2·04	Strength of Materials	3–6	*Second*	‡2·42	Heat Engineering	3–6
Term	2·371	Testing Materials Lab.	2–2	*Term*	*16·02	Aeronautical Mechanics, Int.	6–6
	2·40	Heat Engineering	4–5		*16·10T	Aerodynamics, Applied	4–8
	2·730	Machine Design	4–2		*16·20	Structures	3–6
	*16·01	Aeronautical Mechanics, Int.	6–6			†Humanities III	3–5
	Ec11	Economic Prin. — Humanities III	3–5				19–31
			22–26				

FOURTH YEAR

First	6·18	Electrical Eng., Fund.	4–6	*Second*	*16·16	Power Plant Perform. & Install.	3–6
Term	*16·13	Airplane Stability & Cont.	3–6	*Term*	*16·75	Const. Details Aircraft	5–4
	*16·17	Airplane Design Practice	6–0			*Thesis	9
	*16·21	Structures	3–6			†Humanities IV	3–5
	16·62	Aerodynamic Laboratory	4–4			‡Prof. Elective Subject (see next page)	10
		†Humanities IV	3–5				45
			23–27				

* See Requirements for Bachelor's Degree, page 38. † See page 117 for list of subjects.

‡ Students expecting to specialize in graduate research or instrumentation should substitute 16·34 Aircraft Instruments 5–6 in third year, second term, and include 6·19 Electrical Eng., Fund. 4–6 as the Elective Subject in fourth year, second term.

XVI. Aeronautical Engineering Cont.nued

*Second Term Professional Elective Subjects***

6·19	Electrical Eng., Fund.	4–6	16·34	Aircraft Instruments	5–6
16·06	Wing Flutter, Int.	2–4	16·50	Rotat. Wing Aircraft	3–6
16·14	Airplane Des. Prob.	8–4	16·52	Aircraft Propeller Design	4–4
16·22T	Aircraft Structures	5–6	16·63	Aerodynamics Lab.	4–4

XVII. BUILDING ENGINEERING AND CONSTRUCTION

THE objective of the Course in Building Engineering and Construction is to provide sound basic training in the engineering design and construction of buildings. It aims to develop in the student a sound conception of the related problems of the owner, the architect, the engineer, the builder and the materials manufacturer and distributor in the process of planning and erecting buildings, to the end that he may become either a principal or a responsible manager in any of the many varied fields of this great industry.

Slightly more than half of the entire Course is devoted to fundamental and applied science. The strictly professional work is provided in a progressive sequence of correlated subjects in engineering, construction, materials and the economic aspects of the industry.

At the beginning of the fourth year, the student may choose between two Options, depending upon whether he desires to base his training upon the technical work involved in Heavy Construction or upon the technical and marketing aspects of the field of Light Construction.

Option 1. Heavy Construction

Under this Option, the student is offered professional courses which train him in the structural design, construction and supervision of semi-fireproof and fireproof buildings of so-called heavy construction. Professional subjects provide the student opportunity for further specialization in structural design, materials, or construction practice.

Option 2. Light Construction

This Option offers professional training in the planning, engineering, construction, management and marketing of structures and facilities required for housing or shelter. Not only the physical, but the legal and economic aspects of housing construction and engineering are emphasized. Summer coöperative employment is arranged so that the student may obtain intimate first-hand acquaintance with the construction and business problems of the field.

Both Options lead to the degree of Bachelor of Science in Building Engineering and Construction.

First Year (See page 38)

Second Year

First	2·00	Statics	3–5	*Second*	2·01	Dynamics	3–5
Term	8·03	Physics	5–5	*Term*	4·78	Planning Principles	4–0
	17·22	Building Construction	5–4		8·04	Physics	5–5
	E21	U. S. in World Hist. — Humanities II	3–5		17·71	Materials	2–4
	M21	Calculus	3–6		E22	U. S. in World Hist. — Humanities II	3–5
	MS21	Military Science	3–0		M22	Differential Equations	3–6
			22–25		MS22	Military Science	3–0
							23–25

Required During Summer. At Camp Technology

1·00T	Surveying Fieldwork	13–0
1·04	Construction Survey. Fieldwork	10–0

Third Year‡

First	*2·04	Strength of Materials	3–6	*Second*	*1·401	Structures	3–6
Term	*2·41	Heat Engineering	4–5	*Term*	*15·50	Accounting	5–4
	*6·40	Electrical Eng., Elem.	4–6		*17·32	(1) Building Construction	5–4
	*17·31	(1) Building Construction	5–4		*17·34	(2) Building Construction	5–4
	*17·33	(2) Building Construction	5–4		*17·52	Structural Problems	7–5
	Ec11	Economic Prin. — Humanities III	3–5		*17·72	Materials	2–4
			19–26			†Humanities III	3–5
							25–28

Fourth Year

Option 1. Heavy Construction

First	*1·351	Soil Mech. and Found. Eng.	4–4	*Second*	*1·42	Structures	3–6
Term	*1·41	Structures	3–6	*Term*	*2·373	Testing Materials Lab.	5–2
	*17·53	Structural Design	8–6		*17·40	Estim. and Job Manage.	5–4
	*17·73	Materials	2–4		*17·54	Structural Design	7–5
		*Thesis	4			*Thesis	5
		†Humanities IV	3–5			†Humanities IV	3–5
			49				50

* See Requirements for Bachelor's Degree, page 38. † See page 117 for list of subjects.

‡ Students planning to take a certain option in the fourth year, take the Group Electives indicated by the corresponding number.

** Other electives may be chosen with approval of registration officer.

XVII. Building Engineering and Construction Continued

OPTION 2. LIGHT CONSTRUCTION

First Term	15·41	Finance	3–6	*Second Term*	*2·373	Testing Materials Lab.	5–2
	15·61	Law of Contracts	3–6		15·82	Sales Promotion	3–6
	15·81T	Marketing & Reports	4–8		*17·40	Estim. and Job. Manage.	5–4
	*17·73	Materials	2–4		*17·56	Structural Design	7–5
		*Thesis	4			*Thesis	5
		†Humanities IV	3–5			†Humanities IV	3–5
			48				50

XVIII. MATHEMATICS

THE Institute offers exceptional opportunities for the study of mathematics, either in its theoretical aspects or as applied to scientific and engineering work.

The Course outlined is for students who desire to study more mathematics than is contained in the professional courses. It is well adapted to serve as a preparation for specializing in pure mathematics, in mathematical physics, or in engineering fields requiring proficiency in pure mathematics. The course also offers excellent opportunities for students who wish to major in mathematical statistics, applied statistics or actuarial work.

Any student who has completed satisfactorily the work of the first two years in any of the professional courses in the Institute or their equivalent, provided always that a creditable record has been obtained in mathematics and physics, may be admitted to the third year in this Course.

OPTION 1. PURE AND APPLIED MATHEMATICS

Option 1 is intended for students interested in technical applications of mathematics or a career of research and teaching. Students planning to take this option are required to take electives in science and engineering which, together with their courses in pure mathematics, constitute a well-integrated program in pure or applied mathematics.

OPTION 2. INDUSTRIAL STATISTICS

Option 2 is adapted to those preparing for industrial work where the statistical interpretation of data is important, or for the actuarial profession. Students planning to take this Option are required to take subjects in mathematics and engineering related to statistics to fulfill the elective requirements.

Both options lead to the degree of Bachelor of Science in Mathematics.

FIRST YEAR (See page 38)

SECOND YEAR

First Term	5·11	Qualitative Analysis	7–3	*Second Term*	8·04	Physics	5–5
	8·03	Physics	5–5		E22	U. S. in World Hist. — Humanities II	3–5
	E21	U. S. in World Hist. — Humanities II	3–5		M22	Differential Equations	3–6
	M21	Calculus	3–6		M32	Statistics, Elementary	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
		Language	3–5			Language	3–5
			24–24				20–27

THIRD YEAR**

First Term	Ec11	Economic Prin. — Humanities III	3–5	*Second Term*	*M332	(2) Math. Th. of Statistics	3–6
	*M331	(2) Math. Th. of Statistics	3–6		*M62	(1) Modern Algebra	3–6
	*M731	(1) Mechanics	3–6		*M732	(1) Mechanics	3–6
	*M77	(1) Vector Analysis	3–6		*M832	Analysis	3–6
	*M831	Analysis	3–6			†Humanities III	3–5
		(1) Elective Subject	12			(1) Elective Subject	12
		(2) Elective Subjects	21			(2) Elective Subjects	21
			47				47

FOURTH YEAR

OPTION 1. PURE AND APPLIED MATHEMATICS

First Term	M571	Differential Equations	3–9	*Second Term*	M442	Diff. Geometry, Elem.	3–6
	M681	Calculus of Variations	3–9		M572	Differential Equations	3–9
		*Thesis	4			*Thesis	7
		†Humanities IV	3–5			†Humanities IV	3–5
		Elective Subject	12			Elective Subject	12
			48				48

OPTION 2. INDUSTRIAL STATISTICS

First Term	M341	Modern Statistical Th.	3–6	*Second Term*	M342	Modern Statistical Th.	3–6
		*Thesis	4			*Thesis	7
		†Humanities IV	3–5			†Humanities IV	3–5
		Elective Subjects	27			Elective Subjects	24
			48				48

* See Requirements for Bachelor's Degree, page 38. † See page 117 for list of subjects.

** Students planning to take a certain option in the fourth year, take the Group Electives indicated by the corresponding number.

MILITARY SCIENCE

ALL physically fit male students who are citizens of the United States, under twenty-six years of age and who enter the Institute as first-year students, are required to complete satisfactorily the entire basic course given below, unless exempted therefrom on conscientious grounds as approved by the Faculty. Similarly qualified students who enter in the second year are required to complete the second year of the basic course unless exempted therefrom on conscientious grounds as approved by the Faculty. Students who have received instruction in these subjects at another institution will receive credit therefor upon presentation of suitable evidence to the Professor of Military Science and Tactics.

For instruction in the first year, the students are organized as an infantry regiment. Cadet officers and non-commissioned officers are selected from first-year students who demonstrate especial aptitude for military instruction.

The instruction in the second year includes drill. The students are organized as an infantry regiment. Cadet officers and non-commissioned officers are selected from those second year students who best demonstrated leadership in the previous year.

First Year

First Term	MS11	Infantry drill, physical drill, and elementary military subjects	3–0
Second Term	MS12	Infantry drill, rifle marksmanship, and elementary military subjects	3–0

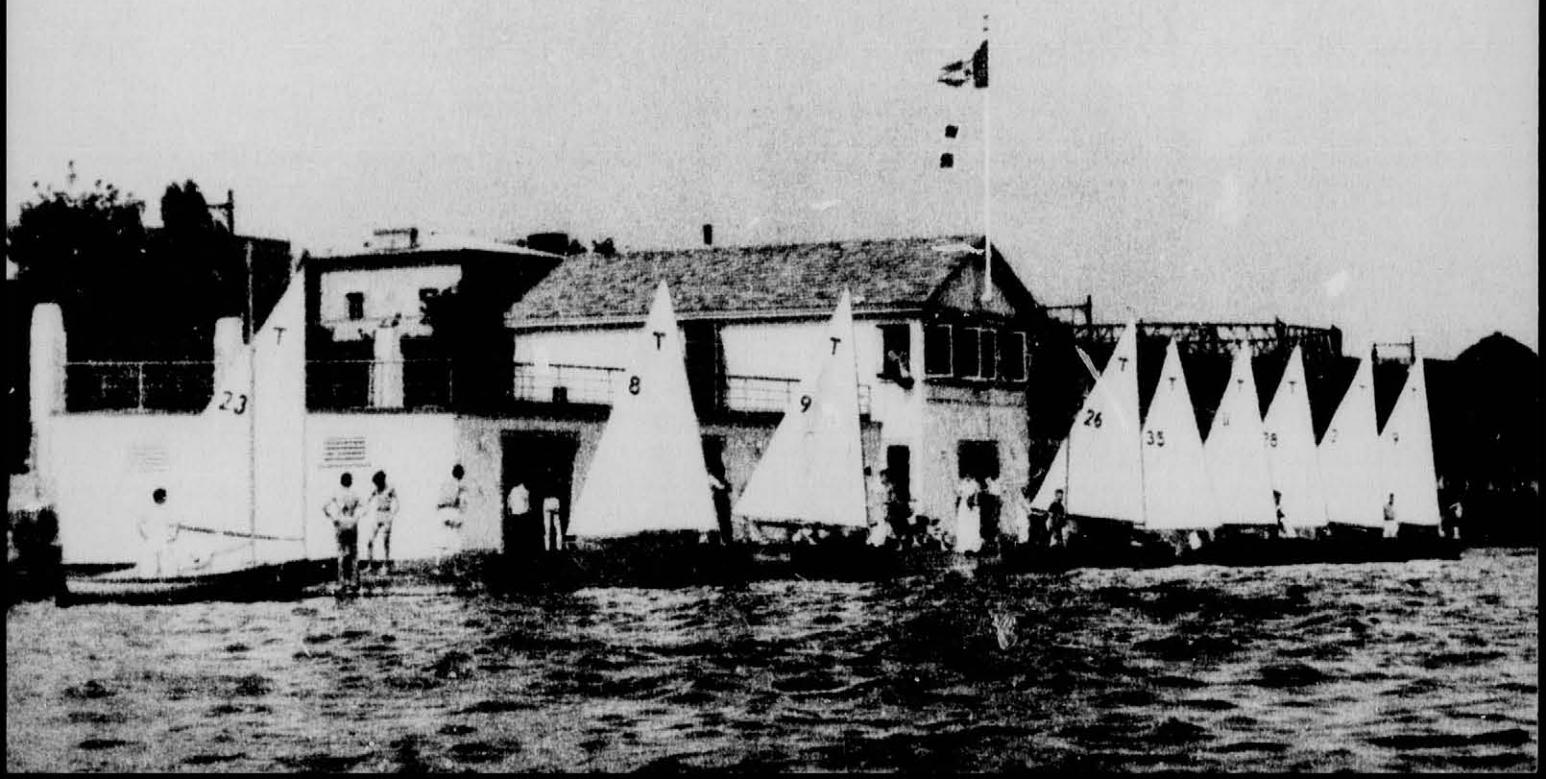
Second Year

First Term	MS21	Field and class instruction in military fundamentals	3–0
Second Term	MS22	Map reading and elementary military subjects	3–0



SAILING

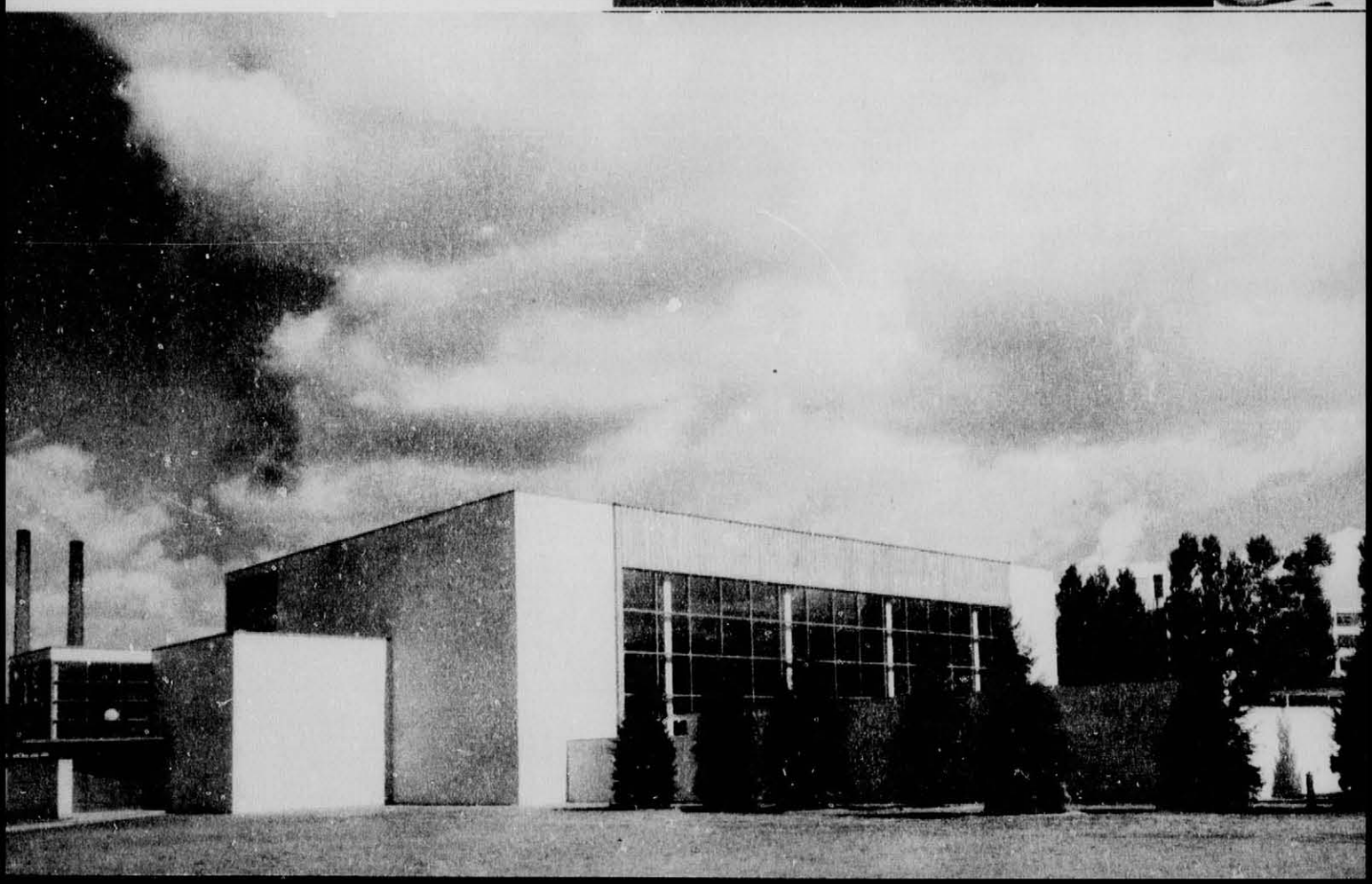
ONE OF THE MOST POPULAR RECREATIONS AT TECHNOLOGY IS SAILING ON THE CHARLES RIVER. THE SAILING PAVILION, LOCATED ON THE RIVER DIRECTLY IN FRONT OF WALKER MEMORIAL, HOUSES A LARGE FLEET OF TECHNOLOGY-DESIGNED DINGHIES AS WELL AS A NUMBER OF THE LARGER AND FASTER "110'S." THE NAUTICAL ASSOCIATION DIRECTS ALL SAILING ACTIVITIES, AND EVERY STUDENT IS ELIGIBLE TO PARTICIPATE.



SWIMMING

THE SPLENDID ALUMNI POOL, COMPLETED IN 1940, IS ONE OF THE BEST APPOINTED IN THE EAST. THE BUILDING HOUSES A STANDARD INTERCOLLEGIATE SIX-LANE SWIMMING POOL AS WELL AS A SMALLER PRACTICE POOL. A HUGE WINDOW EXTENDING ACROSS THE ENTIRE SOUTH WALL GIVES UPON A WALLED GARDEN AND SUNNING AREA.





THE GRADUATE SCHOOL

(As of April 10, 1945)

ADMINISTRATION OF THE GRADUATE SCHOOL

PRESIDENT, KARL T. COMPTON, D.Sc., D. ENG., PH.D., LL.D., D. APP. SCI.

DEAN OF THE GRADUATE SCHOOL,* JOHN W. M. BUNKER, PH.D.

COMMITTEE ON THE GRADUATE SCHOOL

J. W. M. BUNKER, PH.D., *Dean, Chairman Ex-Officio*

B. A. THRESHER, S.B., A.M., *Director of Admissions, Secretary*

L. B. ANDERSON, M. ARCH.
Associate Professor of Architectural Design

D. V. BROWN, PH.D.
Professor of Industrial Relations

M. J. BUERGER, PH.D.
Professor of Mineralogy and Crystallography

W. M. FIFE, S.M.
Associate Professor of Structural Engineering

W. P. FISKE, M.B.A., LL.B., LITT.D.
Professor of Accounting

M. F. GARDNER, S.M.
Professor of Electrical Engineering

F. L. HITCHCOCK, PH.D.
Professor of Mathematics

H. G. HOUGHTON, JR., S.M.
Associate Professor of Meteorology

E. H. HUNTRESS, PH.D.
Professor of Organic Chemistry

G. C. MANNING, S.M.
Professor of Naval Architecture

B. E. PROCTOR, PH.D.
Professor of Food Technology

T. K. SHERWOOD, SC.D.
Professor of Chemical Engineering

I. W. SIZER, PH.D.
Associate Professor of Physiology

J. C. SLATER, PH.D.
Professor of Physics

R. H. SMITH, PH.D.
Professor of Aeronautical Engineering

G. W. SWETT, S.B.
Professor of Machine Design

R. S. WILLIAMS, PH.D.
Professor of Physical Metallurgy

CHAIRMEN† OF DEPARTMENT COMMITTEES ON GRADUATE STUDENTS

Aeronautical Engineering	R. H. SMITH
Architecture	L. B. ANDERSON
Biology	I. W. SIZER
Business and Engineering Administration	W. P. FISKE
Chemical Engineering	T. K. SHERWOOD
Chemistry	E. H. HUNTRESS
Civil and Sanitary Engineering	W. M. FIFE
Economics and Social Science	R. E. FREEMAN
Electrical Engineering	H. L. HAZEN
Food Technology	B. E. PROCTOR
Geology	W. J. MEAD
Mathematics	H. B. PHILLIPS
Mechanical Engineering	G. W. SWETT
Metallurgy	J. T. NORTON
Meteorology	H. C. WILLETT
Naval Architecture and Marine Engineering	L. B. CHAPMAN
Physics	J. C. SLATER

* Correspondence regarding work of 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 of the Massachusetts Institute of Technology is a natural development of a policy approved by the Corporation in 1872 and announced in the catalogue of that year as follows: ". . . advanced courses . . . are intended to afford to Bachelors of Science of this Institute — and others of equal attainment — the means of continuing their studies." Its Faculty is the Faculty of the Massachusetts Institute of Technology; its officers are the President of the Institute, the Dean of the Graduate School, and the members of the Committee on the Graduate School comprising a Faculty representative of each department which offers graduate work leading to a higher degree.

Degrees Awarded

Upon recommendation by the Faculty, the Corporation may award any of the following advanced degrees:

Doctor of Philosophy, Ph.D.
Doctor of Science, Sc.D.
Master of Science, S.M.
Master in Architecture, M.Arch.
Master in City Planning, M.C.P.

ADMISSION

Admission to Graduate School as Graduate Student

To be admitted as a Graduate Student, an applicant must have received a Bachelor's degree in a four years' course of 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

(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 Student by approval of the instructors under whom he desires to enroll and of the Director of Admissions.

A report of a Graduate Record Examination if filed with application for admission will receive due consideration.

Application for admission must be filed on forms available upon request from the Director of Admissions, and should be forwarded to him six months, if possible, in advance of the date of desired entrance. Applicants who file requests for admission during their final year of work toward a degree elsewhere may be accepted for admission conditional upon satisfactory completion of such work. Early application is advisable because enrolment in certain departments is limited. Each applicant will be notified promptly of the action taken upon his application for admission.

Correspondence concerning preparation or qualifications for admission should be directed to the Chairman of the appropriate Departmental Committee on Graduate Students (see preceding page).

Prerequisites for Graduate Work

For admission to graduate work the following undergraduate preparation is essential.

Mathematics. The equivalent of this Institute's subjects in mathematics of the first and second undergraduate years, namely Calculus, M11, M12, M21, and Differential Equations, M22, except as specific exception may be stated under requirements peculiar to an individual field of science or engineering, or architecture.

Chemistry. One or more years of college chemistry passed with such grades that it may be accepted as substantially equivalent to this Institute's first-year chemistry, 5·01, 5·02.

Physics. Two or more years of college physics, passed with such grades that it may be accepted as substantially equivalent to the Institute's first and second year physics, 8·01, 8·02, 8·03, and 8·04, except as otherwise specified under requirements peculiar to an individual field of science or engineering, or architecture.

Cultural Subjects. Training in English, history, humanities, and social science, substantially equivalent to the kind and amount of such subjects included in the undergraduate curricula of this Institute.

Professional Subjects. Professional subjects prerequisite for advanced study as specified by departments hereinafter.

Deficiencies in Prerequisites. Deficiencies in quantity or quality of prerequisite training in professional subjects or otherwise, must be removed before the student may proceed with graduate work dependent thereon.

In exceptional cases, the Committee on the Graduate School will pass upon a proposal for modification of certain specified requirements if initiated by a Department Committee on behalf of an applicant for an advanced degree in a specialized field, and may modify any of the above requirements.

Coöperative Arrangement with Harvard University. Graduate students at the Massachusetts Institute

of Technology may enroll, without additional tuition, in "Advanced courses (at Harvard or Radcliffe) other than courses prescribed in undergraduate programs or courses in research," with the consent of the Instructor and of the Dean of the School in which such courses are offered. The agreement provides for a reciprocal arrangement in behalf of Harvard graduate students in respect to courses at the Massachusetts Institute of Technology.

A graduate student at the Institute desiring to avail himself of the above privilege must present to the Dean of the Graduate School from the Chairman of the Committee on Graduate Students of the department in which he is enrolled, a written request therefor, specifying the name and number of the subject desired, and whether it is desired to enroll as listener or for academic credit; the Dean's office will issue to the petitioner certain forms which are to be presented to the appropriate authorities at Harvard University.

THE DEGREE, MASTER OF SCIENCE

The degree MASTER OF SCIENCE is awarded by the Corporation upon recommendation of the Faculty based upon approval of the Committee on the Graduate School upon the satisfactory completion of a course of advanced study and research approved by the department in which the student has been enrolled and complying with the regulations as set forth hereunder, during residence of at least one academic year.

The residence requirement is further defined as comprising at least one academic year of study and research at the Institute including a full schedule (48 units) of such work for one regular term.

Students who complete the requirements for the S.B. degree at this Institute, together with substantial extra advanced credits in graduate subjects, may, upon application, be granted a waiver of the one year's residence requirement and will be recommended for the degree Master of Science upon completion of the requirements therefor.

A graduate of the Institute in the department in which he enrolls for the Master of Science 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 amount 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 it is desired to enroll. Attention is advised to the statement of professional prerequisites under the appropriate department in the following pages.

Degree Requirements. The degree of Master of Science is awarded upon satisfactory completion of a program of advanced study and research, approved by a department Committee on Graduate Students, which comprises

(1) 72 units of "A" subjects including 20 to 40 units (except where otherwise specified) of thesis.
(2) 24 units of "B" or "A" subjects.
(3) The above 96 units completed with a satisfactory academic rating. (See "Subjects of Instruction Tabulated" for "A" or "B" subjects.)

The degree is awarded with specification of field provided that at least 64 units of "A" subjects (including thesis) in the above program be in a single field of science or engineering. The degree Master of Science, without specification of field, may be awarded for a program of the above specifications in which the "A" subjects of any one field comprise less than 64 units, but the satisfactory academic rating in all 96 units must be maintained, irrespective of diversification of fields.

The requirements set forth immediately above apply equally to the degree S.M. awarded for part of a five-year curriculum even though in such cases certain "B" or "A" subjects have been taken before the fifth year.

The academic rating of a graduate student is compiled from his grades in all subjects of "A" or "B" grade for which he registers, plus credits in "A" or "B" subjects offered in anticipation from undergraduate years at this Institute, or obtained by examination for advanced standing; it does not comprise credits for work completed in other institutions and accepted in lieu of advanced subjects at this Institute.

Credit cannot be granted for thesis work, done in absentia, and all thesis work must be done under supervision of a member of the Institute's Staff.

Choice of Field.

The choice of field of specialization, and of subjects elected therein, 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.

MASTER'S DEGREES OTHER THAN THE S.M.

The requirements for the degrees M.Arch., M.C.P. differ only from those for the degree Master of Science in respect to certain prerequisites and in the number of units permitted or required for thesis. They are specified under the appropriate department hereinafter.

THE DOCTORATES

The degrees DOCTOR OF PHILOSOPHY in fields of science (Biology, Chemistry, Food Technology, Geology, Mathematics or Physics), in Industrial Economics, and in Group Psychology; and DOCTOR OF SCIENCE in fields of applied science or of engineering [Aeronautical Engineering, Biology, Ceramics, Chemistry, Chemical Engineering, Civil Engineering, Electrical Engineering, Food Technology, Geology (including Geophysics), Mathematics, Mechanical Engineering, Metallurgy (including Ore Dressing), Meteorology, Physics, and Sanitary Engineering] certify to performance of original research of high grade and to creditable completion of an approved program of advanced study.

The advanced study and research must be pursued in the Graduate School for at least two academic years, except in the case of applicants who satisfy the Faculty that they have successfully accomplished at another institution advanced work of a grade equal to that required at this Institute, in which case the period of residence may be reduced to not less than one academic year.

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.

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.

Requirements for the Degree.

The four basic requirements for the award of a doctorate are as follows:

(1) Completion of a Major program of advanced work.
(2) Preparation of a thesis upon original research.
(3) Demonstration of a proficiency in the use of scientific modern languages.
(4) Completion of a Minor program of advanced study.

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.

Examinations for the Doctorate.

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.

A final oral examination upon the thesis and its field will be held after the thesis has been accepted and tentatively evaluated by the examiners.

An examination upon the field of the Minor may be required, especially if credit for a Minor requirement in part is granted for work done elsewhere, but usually a record of satisfactory accomplishment in Minor subjects at the Institute satisfies this requirement.

The LANGUAGE Requirement.

All candidates for a doctorate must demonstrate to the department of Modern Languages their ability to read scientific literature in English, German, and a third modern language approved by the committee in charge of the student's major work, except that the requirement of a third language may be waived upon the recommendation of that committee in the case of a candidate for the degree of Doctor of Science in a field of engineering in which the scientific literature of a third language is unimportant.

The MINOR Requirement.

The Minor requirement for the Ph.D. or Sc.D. consists of at least 25 units of credit in some field of science or of engineering other than that wherein the Major lies, more advanced in character than required in the undergraduate curriculum of the department in which the student majors. Subjects elected to satisfy this requirement will usually but not necessarily be offered in some department other than that of the Major; will be selected primarily with the purpose of broadening the student's professional information rather than of improving his proficiency in the field of his specialization; and will be comprised in part at least of "B" or "A" grade subjects.

The approval of the *field* of the Minor must be obtained from the student's Registration Officer; the *program* proposed for the Minor must have the approval of the Chairman of the Committee on Graduate Students of the department in which a plurality of the minor subjects is offered.

Subjects to be included in the Minor program must be approved in advance of enrollment therein, except that a major department may accept transfer of credit for acceptable work previously completed elsewhere, for a reasonable proportion of the Minor.

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 the Graduate School, the degree may be awarded by the Corporation of the Institute.

In conferring the doctorate, the appropriate hood is presented by the Institute to each candidate who receives his degree in person at Commencement; otherwise a hood is not given.

I. CIVIL AND SANITARY ENGINEERING

THE Department of Civil and Sanitary Engineering offers programs of advanced study and research leading to the degrees of Master of Science in Civil Engineering, Doctor of Science in Civil Engineering, Master of Science in Sanitary Engineering, and Doctor of Science in Sanitary Engineering.

Graduate work in Civil Engineering is available in the fields of Structural Engineering, Soil Mechanics, Theoretical and Experimental Hydraulics, Water Power Engineering, Transportation Engineering and Geodesy. In Sanitary Engineering advanced students may specialize in Sanitary Engineering Design, in studies relating to Operation of Sanitary Works, or in Environmental Sanitation and Public Health.

In Structural Engineering a number of advanced subjects are offered dealing with modern methods of analysis and design for statically indeterminate and other complicated structures. The Structural Analysis Laboratory affords an opportunity for instruction and research in the use of models for determining structural behaviour. The Seismological Laboratory has facilities which may be used to study vibrations and for research in earthquake-resistant construction. The number of separate graduate subjects offered in Structural Engineering is considerable, and the student wishing to specialize in this field has a wide choice.

Both theoretical and laboratory subjects are offered in the field of Soil Mechanics and Foundation Engineering. The Soil Mechanics Laboratory is well equipped and supplies excellent opportunities for research.

Advanced work may be taken in Theoretical and Experimental Hydraulics. The River Hydraulics Laboratory is available both for laboratory subjects and for research.

Students interested in Water Power Engineering will find an opportunity to study both the theory and design of hydroelectric projects.

Advanced subjects in Transportation Engineering afford opportunities for study of the design and construction of highways and airports, the economics of highway transportation, the design of railway terminal facilities and economic problems in railway transportation.

Graduate work in Geodesy may be taken at Cambridge with an opportunity for field work in the summer at Camp Technology. Instruction in Photogrammetry is also available.

Students interested in Sanitary Engineering will find basic subjects in principles and practice of water, sewage and industrial waste treatment, in sanitary chemistry and

I. Civil and Sanitary Engineering Continued

sanitary bacteriology and in the principles of sanitation and public health administration. Those students with some training in Sanitary Engineering will find additional subjects in the design phases of sanitary engineering, in the operation of sanitary works and sanitary research, or in environmental sanitation and public health.

The Sanitary Laboratories include facilities equipped and arranged for instruction and research in sanitary chemistry, sanitary bacteriology and for study and investigation of water and sewage treatment processes.

Undergraduate Prerequisites for Civil Engineering

In addition to the general requirements for all graduate students, a candidate for the degree of Master of Science in Civil Engineering must present evidence of training in certain professional studies considered essential for all Civil Engineers and corresponding approximately to the following Institute subjects:

1·00T, 1·01T	Surveying
1·21	Route and Construction Surveys
1·40T, 1·41	Structures
1·441	Bridge Design
1·61, 1·62	Fluid Mechanics
2·04	Strength of Materials
12·321	Engineering Geology

He must also present evidence of having had, in addition, sufficient undergraduate training to prepare him for the advanced subjects he wishes to take. The amount o' such training should be approximately equivalent to tha included in the following Institute subjects, indicated for each field:

Structural Engineering; Soil Mechanics; Hydraulics
  No further requirements
Geodesy
  1·03 Advanced Surveying
Transportation Engineering
  1·271; 1·272 Transportation Engineering
Water Power Engineering
  1·70 Hydrology and Flood Control
  1·71 Water Power Engineering
  6·18 Fundamentals of Electrical Engineering

If a student has not completed, before entering the Institute, the special training in his chosen field listed above, deficiencies may be made up during attendance at the Institute; all subjects in the list, except 1·03 Advanced Surveying and 6·18 Fundamentals of Electrical Engineering, may be taken as B subjects and (up to a total of 24 units) counted for credit toward the Master's degree.

Undergraduate Prerequisites for Sanitary Engineering

In addition to the general requirements for all graduate students, a candidate for the degree of Master of Science in Sanitary Engineering must present evidence of having had training in certain professional studies considered essential for all Sanitary Engineers, the field covered corresponding approximately to that covered by the following courses at the Institute:

1·00T, 1·01T	Surveying
1·40T, (1·41)	Structures
1·61, 1·62	Fluid Mechanics
(1·75), (1·76)	Sanitary Engineering
2·04	Strength of Materials

If the student has not completed, before entering the Institute, all the subjects in the foregoing list, deficiencies may be made up during attendance at the Institute; those subjects shown in parentheses may be taken as B subjects and (up to a total of 24 units) counted for credit toward the Master's degree.

II. MECHANICAL ENGINEERING

The Department of Mechanical Engineering is equipped to provide opportunities for graduate work leading to the degrees of Master of Science or Doctor of Science in Mechanical Engineering. The major fields of study are:

Applied Mechanics. Dynamics, elasticity, photoelasticity, plasticity, fluid mechanics.

Heat. Thermodynamics, prime movers and power plants, refrigeration and air conditioning, heat transmission.

Materials. Various aspects of materials testing and processing.

Design. Turbines, pumps, compressors, heat exchanger apparatus; steam turbines, internal combustion engines, gas turbines; control aspects of machinery, general machine design.

Advanced studies in mathematics are considered by the Department as an essential complement to graduate work in any of these fields. Other fields, such as metallurgy, hydraulics, aerodynamics, electrical engineering, and business and engineering administration may be included in the candidate's program. To the extent possible, the Department encourages graduate work in topics which combine two or more of the above fields.

Requirements for Advanced Degrees

In addition to the general requirements for the Master of Science and Doctor of Science degrees, candidates for the degree of Doctor of Science in the major field of Mechanical Engineering will be required to pass satisfactorily scientific reading tests in two modern languages, one of which must be French or German. There must be included in the major field, graduate studies in mathematics, mechanics and thermodynamics; except that a student wishing to specialize in the field of engineering mechanics may limit his major field of study to graduate subjects in mathematics and mechanics. In general, not less than three years of graduate study are necessary for the Doctor's degree.

Laboratory Equipment

For research there is available the extensive equipment of the following laboratories of the Mechanical Engineering Department: Steam, Compressed Air, Air-conditioning, Refrigeration, Hydraulic, Sloan Automotive Engine, Lubrication, Heat Measurements, Power Measurements, Engineering Metals, Materials, Dynamic Strength of Metals, Machine Tool, Textile Technology.

Textile Technology

The Institute offers opportunity for advanced study and research in the field of textiles, leading to the degree of 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 four years' 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.

Mechanical Engineering Continued

TORPEDO ENGINEERING

A graduate course in Torpedo Engineering, leading to the degree of Master of Science in Mechanical Engineering, has been arranged for officers in the United States Navy. Open only to officers designated by the Navy Department.

ARMY ORDNANCE

A graduate course leading to the degree of Master of Science, especially arranged for officers in the United States Army. The course is open only to officers designated by the War Department. (Not offered for duration of war.)

III. METALLURGY

(INCLUDING MINERAL DRESSING AND CERAMICS)

The Department of Metallurgy offers graduate work leading to the degrees of Master of Science or Doctor of Science in Metallurgy or Ceramics which may be pursued along a number of lines. The major divisions are Process Metallurgy, Physical Metallurgy, Mineral Dressing, and Ceramics.

Process Metallurgy deals with the production of metals and alloys from ores or concentrates; Physical Metallurgy with the study of physical properties of metals and their alloys. Mineral Dressing deals with mechanical, physical, and chemical purification and preparation of ores, solid fuels, ceramic raw materials, and other minerals. Ceramics covers pottery, structural clay products, refractories, abrasives, glass, and enamels.

In the Metallurgy laboratories facilities are provided for the roasting and special treatment of ores, the extraction of the metals by wet methods or by furnace smelting, including the electrometallurgical processes, and the study of high temperature equilibria. In addition to various types of smelting furnaces the laboratories are equipped with gas and electric furnaces for the making of alloys in small quantities. A coreless induction furnace with a melting capacity of one hundred and fifty pounds makes possible the production of steel and other alloys on a semi-commercial scale. Equipment is available for detailed metallographic investigation, for heat treatment study and research, as well as for X-ray examination. The latter field is provided for by a lead room in which radiographic studies may be made and by facilities for research in the atomic arrangement in metals. Facilities are available for advanced research in the field of magnetism. Through coöperation with the Department of Mechanical Engineering, physical testing of all sorts is possible.

Opportunity is given for study and research in more specialized subjects as heat and corrosion resisting alloys, the light alloys, and nitriding. Facilities are also available for the study of many of the fundamental physical properties of metallic systems such as electrical and thermal conductivities, magnetic properties and similar topics.

In the Mineral Dressing laboratories facilities are available for the study of crushing, grinding, screening, classification, thickening, filtration, tabling, jigging, electrostatic and magnetic separation of ores, fuels, and minerals. In addition, complete microscope equipment is available for the study 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 synthesis.

The field of Ceramics, covering as it does pottery, structural clay products, refractories, abrasives, glass and enamels, is a very broad one, but a sound training in the fundamentals of the subject gives a basis for later specialization. The laboratories are equipped with testing apparatus and with machines and kilns for carrying out regular plant processes.

A number of Group A subjects listed in other Courses may be taken for credit in the field of Ceramics. Such for example are:

First Term	10·70	Principles of Combustion	4–8
	10·74	Furnace Design	3–6
Second Term	8·28	X-ray Diffraction	3–6
	8·29	Quantum Theory of the Solid State	3–6
	10·74	Furnace Design	3–6

IV. ARCHITECTURE AND PLANNING

The department offers work leading to the degrees of Master in Architecture and Master in City Planning.

The work leading to the degree of Master in Architecture is so arranged as to give the student who has completed the multiple requirements of an acceptable undergraduate curriculum an opportunity to devote himself without interruption to his professional work. In long periods of consecutive hours, he is enabled to conduct research under the guidance of the School and with the assistance of Institute specialists in various related fields. This activity is enriched by availability of unusual library and laboratory facilities and by association with graduate students from other backgrounds.

Only those students will be accepted as applicants for the Master's degree in Architecture whose previous performance in the required work, whether at Technology or elsewhere, has shown evidence of unusual ability.

The degree of Master in Architecture is awarded upon the satisfactory completion of a program of 96 units of advanced study, three-quarters of which, or 72 units, are chosen from "A" subjects primarily for graduates, and the remaining 24 units are chosen from "A" subjects, or from "B" subjects open to graduates and undergraduates, and approved by the School of Architecture, followed by the preparation of a thesis. This thesis is to be prepared immediately following the completion of the required courses of study and presented in time for the candidate to file his application on the next degree list.

Graduates from other colleges who desire to obtain the Master's degree in Architecture must present evidence that they have had the essential equivalent of the following undergraduate subjects as prerequisites for graduate work. Deficiencies in these subjects may be removed by taking the subjects at the Institute.

2·011	Statics and Dynamics
2·04	Strength of Materials
4·811	Structural Analysis
4·812	Structural Analysis
M11	Calculus

Architectural Design, Thesis Research and Thesis are required graduate subjects. Other subjects required to complete the prescribed units should be elected in consultation with the Registration Officer and subject to the approval of the Dean of the Graduate School.

Cultural Subjects and Economics: It is expected that the applicant shall have a knowledge of English, general and architectural history, economics and general studies similar to that included in the undergraduate Courses at the Institute. In case the applicant is unusually deficient in meeting this requirement, he may be required to take these subjects.

The following undergraduate subjects in Architecture are also required, but as these are open to both graduate

IV. Architecture and Planning Continued

and undergraduate students they may be elected in part as "B" subjects leading to the Master's degree.

4·051T	Freehand and Color
4·052T	Freehand and Color
4·621	Site Planning and Construction
4·751T	Architectural Design

City Planning

The degree of Master in City Planning is awarded on the completion of 96 units of advanced study, including a thesis of 20 to 40 units. There is no stated curriculum for this degree, the subjects being selected in consultation with the registration officer. The degree is open to:

1. Students graduated with the Institute degree of Bachelor in City Planning, who may expect to complete the requirements in one year.

2. Students graduated from the Institute or other accepted college with the A.B., S.B., or B.Arch., or equivalent degree, whose academic records and background are considered satisfactory as preparation for graduate study in the field of city planning. Such students will normally have to spend two years in residence to qualify for the degree of Master in City Planning.

Graduates of other colleges who desire to obtain the Master's degree in City Planning must present evidence that they have had the essential equivalent of the following undergraduate subjects as prerequisites for graduate work. Deficiencies in these subjects may be removed by taking the subjects at the Institute.

1·05	Surveying
4·641	City Planning, Prin.
Ec83	Urban Sociology
M11	Calculus
1·24	Municipal Engineering
4·59	Government and Public Administration
4·62	Site Planning and Construction
4·651	Theory and Practice of City Planning
4·652	Theory and Practice of City Planning

The following undergraduate subjects in City Planning are also required, but as these are open to both graduate and undergraduate students they may be elected in part as "B" subjects leading to the Master's degree.

4·60	Planning Legislation and Administration
4·683	City and Regional Planning
Ec85	Land Economics

V. CHEMISTRY

Modern developments in chemistry and the present position of the American chemical industry have combined to make desirable a program of study beyond the traditional four-year period required for a Bachelor's degree.

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 Inorganic, Organic, or Physical Chemistry are recorded below. Students working toward the Doctorate are expected to choose one of these three 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.

Teaching Fellows

The Department appoints a limited number of Teaching Fellows who are candidates for the degree of Doctor of Philosophy in Chemistry. Teaching Fellows serve in the laboratories of the Department, or in such other capacity as may be advisable, on a part time regular schedule throughout the academic year. For information in regard to appointments, address correspondence to the Head of the Department.

The Research Laboratory of Physical Chemistry

A considerable portion of the more recent advance in science has been in fields lying between the divisions of science as they were originally established. One of the most important of these developments is physical chemistry, which has come into existence as a result of investigations lying between the previously loosely defined borders of the sciences of physics and chemistry.

There is a demand for men of mature scientific education to serve as investigators and to direct investigational work in industry, in endowed research institutions, in government bureaus and in academic institutions. 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. In consequence of the benefits already derived from systematic investigation, many industrial research laboratories have been and are being organized. It is universally agreed that graduate work is an essential preparation for positions in connection with these divisions. Since the work involved is of a widely varying nature, a student considering the possibilities in this field of activity should endeavor to pursue an educational course which will give him a broad lasting foundation and a wide scientific perspective. In respect to the latter, physical chemistry with its outlook on two or more fundamental sciences is particularly useful.

Recent research in the Research Laboratory of Physical Chemistry, other than war research, has been concentrated on the following subjects, and the laboratory is especially well, often uniquely, equipped for such research:

Pressure-volume-temperature relations of gases and liquids.
The absolute temperature scale.
Molecular weights of gases by limiting densities.
Heat capacities and latent heats at low temperatures.
Properties of gases at low pressures.
Scattering and other properties of molecular beams.
Electromotive force in concentration cells, and oxidation-reduction potentials.
Freezing points of liquid solutions.
Vapor pressures of liquid solutions.
Infra-red spectroscopy.
Precision photometry.
Kinetics of thermal and photochemical reactions.
Properties of high polymers.

The Research Laboratory of Organic Chemistry

Organic chemistry has always provided an ever increasing field for industrial and scientific developments. The great interest stimulated in earlier times in the coal tar chemicals and pharmaceuticals has in more recent years not only been maintained but also extended to petroleum, cellulose, solvents, plastics, and many other branches. So great has been this progress that there is an urgent need for adequately informed and competently trained men.

The Department offers subjects in organic chemistry which cover fundamental reactions, structures, and theory. Special topics, such as carbohydrates, cellulose, heterocyclic compounds, natural products are also discussed,

V. Chemistry Continued

and new developments are presented by the members of the staff. Current literature reviews are presented by the students.

Laboratory instruction follows two general lines. One deals with identifying and testing organic compounds, a particularly complete and thorough training in the essentials of characterization being provided; the other stresses laboratory manipulation in which the present day demands on the organic chemist for fine fractionation columns, high vacuum work, skill in micro manipulation, ability to work on a large scale, full understanding of the principles of purification, separation, crystallization, etc. are met. The Massachusetts Institute of Technology was a pioneer in both types of instruction and every effort is being made to insure that this training is maintained at a high level.

Research projects in the Research Laboratory of Organic Chemistry are in the general fields of carbohydrates, cellulose chemistry, heterocyclic compounds, identification studies, organometallic compounds, polymerization, vitamins and other special subjects. The laboratory is unusually well equipped for research work in these and related fields.

The Research Laboratory of Inorganic Chemistry

(Including Analytical Chemistry)

Realization of the growing need for men trained in research methods in the field of inorganic and analytical chemistry led to the establishment in 1930 of the Research Laboratory of Inorganic Chemistry. It is safe to assert that the demand for trained graduate inorganic chemists will continue to be felt in greater volume in the postwar period than has been experienced in the past dozen years, during which time the supply has never exceeded the demand.

The progress which has been made in the utilization of certain of the less familiar elements, such as zirconium, columbium, tantalum, molybdenum, indium, rhenium — to mention but a few — is but one indication of the need for scientific investigation of the chemistry of such elements and of their compounds.

The preparative side of the science has been stressed from the beginning, as it has been felt that a primary function of the inorganic chemist is the study of methods of preparation of substances in a reasonably high state of purity. To this end, his work is closely associated with that of the analytical chemist.

In addition to the preparation of pure substances, the inorganic research chemist is naturally interested in the study of the physical properties and the interactions of various substances under fixed experimental conditions, and this may be said to constitute his second objective. The contributions of the Laboratory, therefore, will be found to include a number of analytical researches, the isolation and study of numerous inorganic compounds, and investigations of theoretical and factual aspects of inorganic reactions.

Particular attention has been given to the chemistry of the less familiar metallic and non-metallic elements, as well as to the elaboration of the chemistry of some of the common elements.

Requirements for the Degree of Master of Science

In addition to the general requirements* for admission to the Graduate School, *all* candidates for the Master's degree in Chemistry must present equivalents of the following subjects:

*Differential Equations M22 is not required of Master's candidates specializing in either Inorganic or Organic Chemistry.

Analytical Chemistry: 5·10, 5·12, 5·13; *Organic Chemistry:* 5·41, 5·42, 5·414, and 5·424; *Physical Chemistry:* 5·61, 5·62, and 5·63; *Languages:* Elementary German (L11 and L12), Elementary French (L51 and L52).

As part of their programs of graduate study, candidates specializing in one of the following fields of Chemistry must include certain other subjects (or certification of their equivalent), as indicated:

Inorganic Chemistry: 5·061, 5·062, 5·071, 5·072, and 5·08.
Organic Chemistry: 5·43, 5·44, 5·51, 5·52, 5·581, and 5·582.
Physical Chemistry: 5·64, 5·65, and 5·66.

General Requirements for the Degree of Doctor of Philosophy in a Field of Chemistry

Each candidate for the Doctor's degree in chemistry must fulfill the five general requirements given below, and in addition must complete a program the content of which varies according to the major field: Inorganic, Organic, or Physical Chemistry.

1. A substantial research project, including formulation of the work and results into a thesis, and a satisfactory oral examination primarily devoted to the candidate's research.
2. A general examination in the major field of chemistry in which the candidate is carrying on his research.
3. Written examinations in French and German.
4. A minor comprising at least 25 units of subjects taken in some department other than Chemistry. Candidates majoring in Physical Chemistry must take the minor in Mathematics or Physics.
5. Completion or certification of the equivalent of Analytical Chemistry 5·10, 5·12, and 5·13, and of all starred subjects in the Course V undergraduate curriculum with certain exceptions: *viz.*, majors in Inorganic Chemistry need not present 5·417; majors in Organic Chemistry need not present 5·611 and 5·621; majors in Physical Chemistry need not present 5·417, 5·43, and 5·44.

In addition to the general requirements indicated above, candidates for the Doctor's degree must also 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 is expected to include the following subjects:

Inorganic Chemistry: 5·071, 5·072, 5·08, 5·71T, 5·911, 5·912, together with 14 to 18 hours in either X-rays and Crystal Physics, Nuclear Physics, X-ray Metallography, or Crystallography, and during each year of residence 5·941 and 5·942.
Organic Chemistry: 5·51, 5·52, 5·581. 5·582,5·55 and during each year of residence 5·913, 5·914, 5·591, and 5·592.
Physical Chemistry: 5·73, 5·74, 5·75, 5·76, 5·77, and during each year of residence 5·931, 5·932, and the Departmental Colloquium.

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.

Inquiries should be addressed to the Chairman, Committee on Graduate Study, Department of Chemistry.

VI. ELECTRICAL ENGINEERING

The Department of Electrical Engineering offers advanced work leading to the degrees of Master of Science or Doctor of Science in Electrical Engineering. The general rules governing the granting of these degrees are set forth

VI. Electrical Engineering Continued

under the general information on the Graduate School, while such special rules as apply to the Department of Electrical Engineering are given below.

All graduate students in the Department who have not had equivalent experience in the preparation and oral presentation of technical papers are required to register for Seminar 6·501, 6·502. In the seminar meetings, papers dealing with the history of the development of various phases of electrical engineering and the influence of these developments upon present practices, are presented and discussed. The student may select his seminar topic so as to utilize the seminar time for examination of the literature relating to the general field of his thesis.

Students working for the Master's degree are expected to devote themselves to a few subjects, not more than three each term, in addition to their seminar and research. The subjects of study are wholly elective, with the exception of Electrical Engineering Seminar and Thesis, 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.

The Language requirement for the Master's degree is a reading knowledge of either technical German or French along lines of the student's professional interest. When a choice can be made, German is preferred, as German literature in the field of Electrical Engineering is the more extensive of the two. This requirement may be satisfied by: (1) certificate grade in three years of preparatory school German or French; (2) certificate grade in two years of preparatory school German, and two years of French; (3) by two years of German or French taken at the Institute; (4) by passing a reading test in either German or French.

Graduate study in the Department is considered to include much more than class exercises and assignments pursued in a routine manner. Each student is expected to conceive of his program as a coördinated whole, having as its objective the advancement of his professional preparation. It should provide for a substantial amount of independent and correlative study in current literature and independent investigation in the laboratories. Such independent study and investigation are essential parts of the seminar and thesis requirements, both of which are expected to demonstrate the ability for sound constructive reasoning, and to embody a contribution to the advancement of the art.

Only students who have demonstrated outstanding ability in work of a creative nature are encouraged to go on 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 in order to demonstrate this ability. The thesis research for the doctorate is expected to make a substantial and noteworthy contribution in Electrical Engineering or a related field.

Each year a limited number of appointments to assistantships are available to men especially qualified by training and natural endowment for teaching and research. Every effort is made to arrange the assigned work of an assistant so that he can carry approximately forty per cent of a full-time program of study toward an advanced degree. Should his research assignment result in material appropriate for use in a graduate thesis, a research assistant is permitted so to use the material.

In addition to the general requirements for all graduate students, candidates for the degree of Master of Science in Electrical Engineering or Doctor of Science in Electrical Engineering must present evidence of training which is equivalent substantially to that afforded by the undergraduate professional subjects as offered in one of the options of Course VI. 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.

If the student has not completed, before entering the Institute, the undergraduate subjects deemed important preparation for the graduate study and research that he desires to undertake, he may make up these subjects as deficiencies while in attendance at the Institute. Those having a (B) classification may be counted up to a total of 24 units for credit toward the Master's degree.

Facilities for Research

The research of the Department is directed by many members of the instructing staff who are actively interested in the general progress of this phase of the Department's activities, and particularly in those researches which lie within their own special fields of endeavor. The available laboratory equipment is extensive, permitting effective work toward the solution of fundamental problems in all of the more important branches of Electrical Engineering.

Applications of high-frequency currents to communications and other problems are advancing rapidly and the Department of Electrical Engineering has for many years had an important place in this advance. Its activities in this field include an extensive program covering measurements in the meter-centimeter region, the generation, propagation and radiation of centimeter waves and the behavior of systems at these wavelengths where circuit conceptions become less and less real and the field conception more and more apparent. A well equipped general ultrahigh-frequency laboratory is available for undergraduate and graduate student use.

A laboratory for the scientific and systematic study of the fundamental properties of automatic control systems is available. Attention is being given to the development of means for stabilizing automatic control systems, to the reduction of the transient and steady-state errors of such control systems, and the development of high-power fast-response output drives.

An important problem, various phases of which have occupied the attention of the staff, is the study of the fundamental properties of insulation. One research program in this field is directed primarily toward a comprehensive study in terms of atomic physics of the fundamental electrical properties of solid, liquid, and gaseous dielectrics, and in particular dielectric strength, and is approached through the study of the basic electronic and atomic processes taking place in materials under electric stress.

Another program utilizes precise electrical measurements of properties of insulating materials (with emphasis on oils), such as conductivity, dielectric constant, and power factor, in studying the structure of the materials, the mechanism of dielectric loss, and the nature of the deterioration characteristics.

Flash photography, utilizing light sources which furnish illumination of great intensity and extremely brief duration, has been developed to a state permitting technical application in engineering and other fields.

Many problems in engineering and physics are of such complexity that satisfactory progress in their solution is dependent upon machine methods of carrying out mathematical processes. The Differential Analyzer, which was originally developed here, was designed to perform mechanically the necessary operations required in the solution of

VI. Electrical Engineering Continued

differential equations. A larger, faster, and more precise Differential Analyzer which performs these necessary operations electrically is in operation. Another machine, the Cinema Integraph, utilizing illumination in its operation, is available for solving integral equations having under the integral sign the product of two functions, one of which has a variable parameter.

A program for the development of X-ray equipment employing potential differences of one to several megavolts, including the associated direct-current generators, has been under way for several years. Incidental to these developments, studies have been made of the design of insulating structures for maximum dielectric strength, and of the dielectric strengths of gases and vapors as functions of pressure.

In the illumination laboratories of the Department, investigations have been made among which are studies of the visual effect of light from sodium lamps, the visibility of objects on highways under various lighting conditions, the elimination of glare by use of polarized light, the reflection characteristics of road surfaces, and the design of reflectors.

The Network Analyzer, used for steady-state and transient power system analysis, is adequate for single-phase representation on a 60-cycle, 200-volt, 1-ampere basis of power systems embodying as many as sixteen generating stations with their loads and interconnecting transmission and distribution circuits. Its measuring equipment is fast and accurate. In addition to its use in research and in connection with class instruction, it is available for the solution of commercial power-system problems. It was built with the coöperation of the General Electric Company.

A special machine-transients laboratory is equipped with motor-generator sets and necessary accessories for the study of transients, both electrical and mechanical, occurring in electrical machines as a result of short circuit, of sudden terminal voltage changes, or of sudden or periodic load changes.

In the engineering electronics laboratory facilities are provided for the study and the semi-automatic construction of various types of vacuum or gas-filled electronic devices.

The various shop facilities of the Department are adequate to care for the maintenance of the existing equipment and the construction of new equipment for carrying on the research of the Department. The student shop, in charge of a competent mechanician, is equipped with all the machine tools necessary for ordinary wood and metal working.

Consideration of the theoretical as well as the experimental aspects of research is essential for rapid and intelligent progress in an advancing art such as Electrical Engineering. The theoretical work of the Department is particularly strong in the fields of circuit theory, transmission line theory and traveling waves, electromagnetic wave propagation in both free and confined space, transient behavior of electrical circuits and mechanical systems, vibrations, acoustics, and electrical machinery.

The Vail Library

A necessary adjunct to all Electrical Engineering Department research is the Vail Library. 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 which now comprises some 43,000 volumes. The Vail Library is one of the three great Electrical libraries of the world. 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.

VII. BIOLOGY

Graduate study and research in this Department may be selected in one of the following fields: Bacteriology, Basic Biological Sciences, Biochemistry, Biophysics, General Physiology, Microbiology. Advanced work in these fields leads to the degrees of Master of Science in Biology, and Doctor of Philosophy or Doctor of Science in the Department of Biology and Biological Engineering. Course VII-A, listed under the undergraduate course schedules, leads to the degree of Master of Science in Physical Biology.

Acceptance of Applicants for Advanced Degrees

Only students with superior credentials, who have had excellent training in biology and chemistry, may be accepted as applicants for advanced degrees in the Department. Previous award of the Master's degree in an appropriate field by an accredited institution will usually be adequate for acceptance of an applicant for a doctorate.

The number of graduate students in any one year is limited by spatial and other considerations.

A student desiring to enter the Department as a graduate student must comply with the regulations concerning filing of application with credentials, as set forth under Admission to the Graduate School.

Requirements for the Degree of Doctor of Philosophy

In addition to the general requirements for the Doctorates, attention is directed to the essential requirement of satisfactory completion of the Oral and Written Examinations within the Department, with the demonstration of scientific competence and breadth of understanding of various phases of biology.

The general examinations are held in two groups. The preliminary group includes fundamentals of general biology, bacteriology, physiology and bio-chemistry; the other group is the professional examinations which relate particularly to the field of specialization.

Requirements for the Degree of Master of Science

In the case of an applicant for a Master of Science degree in Physical Biology, the 5-year curriculum, Course VII-A, must be taken. The usual Institute requirements apply to candidates for the degree of Master of Science in Biology.

The Biological Research Laboratories

The Biological Laboratories offer facilities for advanced work in bacteriology, biochemistry, biophysics, cytology, enzymology, general physiology, microbiology, and nutrition. Properly prepared graduate students may elect to undertake research in one or more of these fields under guidance of staff members. Included in the program of research in which staff members have an interest, and with which advanced graduate students may hope to become affiliated, are the following:

VII. Biology Continued

In bacteriology particular emphasis is laid on physiological and biochemical studies and on the development of quantitative methods of dealing with bacterial processes.

Biochemical studies are concerned with the purification and chemical characterization of substances important in plant and animal growth and metabolism. Among specific problems under investigation may be mentioned the mechanism of fermentation, antibacterial substances, and the purification and chemical characterization of the protein, collagen.

Equipment is available for research in a wide variety of fields of physical biology. Exceptional instrumentation has been assembled for an investigation of the molecular organization of cells, tissues, and their products. Included are X-ray diffraction units, an electron microscope, and polarization optical equipment. For identification of biological substances there is equipment for investigating ultraviolet and visible absorption spectra, Raman, emission, and fluorescence spectra. Studies employing these methods bear importantly on the problem of the mechanism of inflammatory processes, proliferation and neoplasia. There is a well-equipped laboratory for the study of the properties of mono- and polymolecular films. Electrical instrumentation is provided for a study of the biological action of high-frequency electric fields, and ultrasonic radiation.

Physiological investigations include studies of nerve action with the cathode ray oscillograph, of permeability processes by the radioactive tracer method, of cellular metabolism by manometric and volumetric methods, of the action of enzymes, with special reference to their kinetics as related to temperature and oxidation-reduction potential.

In nutritional biochemistry opportunity is offered for research in the composition of foods and tissues and in the biochemical processes involved in nutrition. Among the nutritional factors being studied are natural and synthetic fatty acids, amino acids, and certain vitamins. Particularly timely is the research program on the development of highly nutritious, inexpensive food mixtures for populations in economic distress or made destitute by the war, and on the development of complete rations for armed forces and for postwar feeding.

VII-B. FOOD TECHNOLOGY

The Department of Food Technology offers advanced courses leading to the degrees of Master of Science and Doctor of Philosophy or Doctor of Science in Food Technology.

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 courses in chemical engineering, chemistry, mechanical engineering, physics, business administration, or others.

The Food Technology Laboratories provide facilities for research in the investigation of food processes, packaging, heat treatment, and the development of new food products. Numerous phases of the problems of food refrigeration, including quick freezing, have constituted a part of the food technology research program for several years. An extension of this program has been made possible through the generous coöperation of the Dewey & Almy Chemical Company in making available for joint use their conveniently located, modern and complete food-freezing laboratory, where students may conduct semi-plant scale research on frozen foods.

Research in food technology includes the following: various aspects of food processing, plant design, and product control; instrumentation; objective measurements for quality evaluation; packaging research with new materials; electronic applications in food industries; by-products utilization; detergents in food industries; unit-process methods in food manufacture. The evaluation of food flavors and the relation of processing methods to flavor development and conservation are fields of research of primary interest to the Department of Food Technology. Another basic field of research is that of low temperature food dehydration, including drying from the frozen state, which presents interesting possibilities applicable to numerous food industries.

A five-year course leading to the degree of Master of Science in Food Technology is outlined under the Undergraduate Course Schedules. This course, combining the undergraduate four-year course with a fifth year of instruction following a six-month period in industry, presents opportunities for those desiring actual experience in food industries before starting their graduate year of advanced work.

For students working toward the doctorate no prescribed curriculum is required, the choice of subjects being determined by the background and field of interest of the individual in consultation with the graduate registration officer. 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 general requirements for graduate work are outlined under the general information on the Graduate School.

The graduate requirements necessitate 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. Language requirements for the doctorate are cited under the general information on the Graduate School. An approved minor of at least 25 units in some other department of the Institute is also required.

Facilities for graduate research in the various phases of food technology are available in the Samuel Cate Prescott Laboratories of Food Technology. The number of graduate students accepted will be limited to the capacity of these facilities.

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

Physics is the fundamental science underlying almost all branches of engineering. During the last fifty years of extraordinary progress, it 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

VIII. Physics Continued

matter in bulk, of electronics and gas discharges, of atomic spectra and the nature of light. The discovery of radioactivity, of induced radioactivity, 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 like X-ray diffraction, electron diffraction, the electron microscope, and modern spectroscopy, throw completely new light on 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 great energy released in nuclear reactions suggests that even the hopes of atomic power may not be without foundation. The day has passed when any branch of physics could be considered as merely of academic interest. The physicist, with his broad knowledge of principles and methods, has shown himself particularly able to undertake new problems in the industrial laboratory, to apply his science to practical ends.

The Physics Department recognizes the importance both of the development of fundamental knowledge, and of the applications of physics. The laboratory is equipped with excellent research facilities, and carries out extensive research programs, in practically all fields of active interest. In nuclear physics, equipment includes a large cyclotron, and high voltage electrostatic generators. There are active research programs in both nuclear structure and in applied radioactivity. Other fields with outstanding equipment and research are electronics, spectroscopy, X-ray diffraction and crystal structure, the structure of dielectrics, color measurements, and acoustics. Electron microscopes, and facilities for the production of high magnetic fields and of low temperatures, are available. Courses 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.

Requirements for Advanced Degrees

The following special requirements must be met, in addition to the general requirements:

Undergraduate subjects, which may be taken at the Institute or elsewhere, but may not be counted for an advanced degree:

8·061	Intermediate Physics (Thermodynamics and Kinetic Theory)
8·062	Intermediate Physics (Electronics)
8·161	Optics
8·311	Atomic Structure

Undergraduate subjects which may be counted as "B" subjects toward an advanced degree:

8·11	Experimental Physics
8·461, 8·462	Introduction to Theoretical Physics

For the master's degree, a reading examination in either French or German is required.

The further requirements for the doctor's degree are: reading examinations in both French and German; a Minor of at least 25 units in some other department; a general examination; a thesis; and an examination on the thesis. The student is expected to take graduate subjects to prepare himself for the general examination, but there are no stated required subjects. The general examination consists of a written examination, followed by an oral one.

X. CHEMICAL ENGINEERING

Graduate study in this Department leads to the degrees of Master of Science in Chemical Engineering or Chemical Engineering Practice or Doctor of Science in Chemical Engineering.

Because of the breadth of the field of Chemical Engineering the undergraduate Course must be devoted to training in fundamentals, and strictly professional subjects must be elementary in character. Postgraduate work is therefore of peculiar 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, although individual schedules may be planned to specialize in a given field. Work for the Sc.D. degree is more specific in character and the Department offers coördinated programs in three fields: Engineering Operations of Chemical Engineering, Applied Chemistry, and Fuel Engineering. Special programs are developed for individual cases.

School of Chemical Engineering Practice

(Temporarily discontinued)

The Department of Chemical Engineering offers a Course leading to the degree of Master of Science in Chemical Engineering Practice (designated as X-A).

In the School of Chemical Engineering Practice a carefully selected group of graduate students who have completed at least four years of undergraduate study at the Institute or elsewhere spend six months 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 coöperative effort under industrial conditions.

The field of Chemical Engineering has been divided into a series of unit operations which are studied quantitatively and in detail in the Practice School. Plant investigations are carried out by the students at each of the stations, this work covering two fields: first, investigation of some special phase of one of the unit operations; or second, investigation of some problem of industrial chemistry 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.

X. Chemical Engineering Continued

For twenty-four weeks, from the beginning of the term following graduation, students are at the field stations (10·81, 10·82 and 10·83). They then return to the Institute for intensive work in Chemical Engineering Design (10·53) and thesis until the end of the examination period of the second graduate term. The work of the second term, including thesis, is elective, though subject to the approval of the department registration officer of graduate students.

For graduates in Chemical Engineering from other institutions the usual program of study for the Master's degree involves one school year at the Institute, followed by the seven months in field station work in the Practice School and in the Design Course, 10·53. Graduates in chemistry from other institutions usually require an additional half year. Students are usually not permitted to enter the Practice School until they have spent at least one term at the Institute. The student's program is so dependent on previous training and experience that individuals interested are requested to communicate directly with the Department.

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.

Applied Chemistry. A group of subjects in Applied Chemistry, such as colloidal chemistry, catalysis and high pressure processes, 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 or the 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, any one interested is requested to furnish information permitting individual consideration.

Requirements for Graduate Study

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 or in Fuel Engineering will be expected to meet requirements in chemistry and in engineering to an extent justified by the field of specialization.

The preparation required above that common to all courses of the Institute is outlined below:

Mathematics: through differential equations, equivalent to the undergraduate M22; Physics: two years of college physics; 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; Language: elementary French or elementary German; Economics: an introductory course. Graduates in Chemistry or Chemical Engineering may usually remove deficiencies in the above subjects in the course of their graduate programs.

For Chemical Warfare Officers

A special course for Officers of the Chemical Warfare Service, leading to the degree of Master of Science in Chemical Engineering Practice, may be arranged.

XII. GEOLOGY

Due to absence of staff members on work connected with the war effort and anticipated reduction in graduate enrollment, no formal graduate courses will be offered in geology. However, graduate students who may wish to enroll under these temporarily modified conditions may carry on directed reading and study and pursue research work in the departmental laboratories under the direction of the resident staff.

In Geology many opportunities are given to pursue advanced work leading to the degrees of Master of Science, Doctor of Philosophy, or Doctor of Science in Geology. One line of work is in Economic Geology, and the student may specialize in mining geology, petroleum geology, hydrology, or geology applied to engineering or geophysics. Or again, he may elect to devote the greater part of his time to geology, mineralogy, petrography and paleontology in their more theoretical aspects as preparation for teaching and research.

The advanced work is facilitated by laboratories provided with modern appliances for work in the various phases of geology, mineralogy, crystallography, petrography, geophysics, and paleontology. The collections in economic geology are supplied with material from the mining districts of all parts of the world.

Requirements for the Degree of Master of Science

Candidates for the degree of Master of Science in Geology must present approved equivalents for the subjects of the first and second years in keeping with indicated field of special interest. In the field of Geology they must present a record of attainments satisfactory to the Department Committee on Graduate Students.

Requirements for the Degree of Doctor of Philosophy, or Doctor of Science

The preparation of the candidate for the Doctor's degree must be such as to satisfy the Department Committee on Graduate Students that he is qualified to undertake the course of advanced study and research.

Each candidate upon his entrance in the Department is given a preliminary examination which may be partly oral and partly written. This is designed to survey his training and attainments in the field of geology. This preliminary examination precedes the major examination. The Minor requirements should likewise be passed before the major examination.

A reading knowledge of both French and German is required.

Subject to the approval of the Department Committee on Graduate Students, other subjects for which a student has adequate preparation may be elected from the subjects primarily for graduates offered by related departments. A number of advanced subjects in geology and mineralogy, given at Harvard University, are also open to the student.

XIII. NAVAL ARCHITECTURE AND MARINE ENGINEERING

Naval Architecture

Opportunity is offered to graduates of courses in Naval Architecture (a) to work for a Master of Science degree in Naval Architecture, in which case the student's program must include certain subjects in this department, or (b) to undertake a course of advanced study in fields allied to ship design and ship construction which will lead to the degree of Master of Science *without specification*. In the latter case the program can include a much broader range of subjects.

In addition to meeting the general requirements for admission to the Graduate School, candidates must have completed the necessary prerequisites for the graduate subjects they wish to pursue.

Marine Engineering

The Department of Naval Architecture and Marine Engineering offers opportunities for graduate work in Marine Engineering leading to the degree of Master of Science in Marine Engineering. Advanced study may be pursued in steam engineering; vibrations of ships and their machinery; propeller design and research; and other fields of marine engineering. The Institute's propeller testing tunnel is available for research work.

In addition to subjects offered in the Department of Naval Architecture and Marine Engineering, the student may elect subjects closely related to marine engineering given in the Department of Mechanical Engineering, or other departments of the Institute, in making up his program of studies such, for example, as: applied mechanics, hydromechanics, thermodynamics, refrigeration, Diesel engineering, steam turbine engineering, heat transmission, air conditioning, advanced machine design, metallurgy, metallography, and advanced mathematics.

The preparation required for graduate work in Marine Engineering is the equivalent of the Institute's undergraduate course in Naval Architecture and Marine Engineering.

In addition to the general requirements for all graduate students, candidates for the degree of Master of Science in Marine Engineering must meet the approximate equivalent of the following undergraduate subjects:

1·62 or 2·251	Fluid Mechanics
2·01, 2·04, 2·062	Applied Mechanics
2·40, 2·42	Heat Engineering
2·683T	Engineering Laboratory
2·851	Machine Tool Laboratory
6·18	Electrical Engineering
13·01, 13·02	Naval Architecture
13·52, 13·55	Marine Engineering
13·62	Marine Engineering Design

However, graduates in Mechanical Engineering who take 13·75 and 13·76 may substitute courses in machine design, power plant engineering and advanced heat engineering for the marine engineering subjects listed above.

If a student has not had training in all the undergraduate prerequisites listed above before entering upon the work of the graduate year, those listed as "B" subjects may be taken during the graduate year, up to a total of 24 units, and counted as credit towards the Master's degree.

Naval Engineering. A graduate course in Naval Engineering, leading to the degree of Master of Science in Marine Engineering, has been arranged for officers of the United States Navy. (Discontinued for duration of war.)

XIII-A. Naval Construction and Engineering

The Department of Naval Architecture and Marine Engineering offers to United States Naval Officers only a graduate Course of prescribed studies extending over six terms, leading to the degree of Master of Science in Naval Construction and Engineering.

		Prior to First Term of Senior Year	
	M73	Review of Mathematics	20–0
		Senior Year	
First	2·046	Strength of Mat. & Dynamics	3–6
Term	2·402	Heat Engineering	6–7
	2·851	Machine Tool Lab.	4–0
	3·391	Properties of Metals	3–3
	13·01	Naval Architecture	3–6
	13·21	Warship Design	5–0
	M36	Advanced Calculus	3–6
			27–28
Second	2·256	Fluid Mechanics	3–6
Term	2·422	Heat Engineering	2–4
	2·852	Machine Tool Practice	4–0
	3·392	Properties of Metals	3–3
	13·02	Naval Architecture	3–6
	13·12	Theory of Warship Design	2–4
	13·22	Warship Design	5–0
	M37	Advanced Calculus	3–6
			25–29
		First Graduate Year	
First	2·081	Strength of Materials	3–6
Term	6·43	Electrical Engineering	3–6
	10·311	Heat Transfer	3–3
	13·13	Theory of Warship Design	4–8
	13·75	Naval Engineering	5–8
	13·79	Propeller Design	2–2
			20–33
Second	2·805	Diesel Engines	3–6
Term	6·44	Electrical Engineering	4–6
	13·24	Warship Design	5–0
	13·73	Mechanical Vibration	3–6
	13·76	Naval Engineering	6–4
	Ec15	Economic Principles	3–5
			24–27
		Second Graduate Year	
First	2·211	Mech. Eng. Prob., Adv.	3–9
Term	2·72	Machine Design	3–6
	6·45	Electrical Engineering	4–6
	13·15	Theory of Warship Design	3–6
	13·25	Warship Design	5–0
	13·74	Mechanical Vibration	3–6
			21–33
Second	2·213	Gas Turbine Prob., Adv.	3–9
Term	6·46	Electrical Engineering	4–6
	13·16	Theory of Warship Design	3–6
	13·26	Warship Design	8–0
		Thesis	15
			54

XIII-B. Naval Construction

The Department of Naval Architecture and Marine Engineering offers a Course in Warship Design which is open to those who hold the Bachelor of Science degree and who have had at least one year of experience at sea or in a

XIII. Naval Architecture and Marine Engineering Continued

shipyard. This course of study extends over three years and leads to the degree of Master of Science in Naval Construction. It is possible for a student with a Bachelor of Science degree in Naval Architecture or Marine Engineering to complete the Course in less than three years.

The number of students allowed to register in this course is limited, and the course may not be given in any year in which the number of applicants is insufficient. The complete curriculum is given below.

Senior Year

First Term	2·04	Strength of Materials	3-6
	2·251	Fluid Mechanics	3-6
	2·40	Heat Engineering	4-5
	13·01	Naval Architecture	3-6
	13·421	Naval Arch. Drawing	6-0
	M36	Advanced Calculus	3-6
			51
Second Term	2·062	Strength of Mat. & Dynamics	3-6
	2·371	Testing Materials Lab.	2-2
	13·02	Naval Architecture	3-6
	13·10	Hist. of Warship Design	2-4
	13·23	Warship Design	6-0
	13·341	Hull Engineering	2-4
	M37	Advanced Calculus	3-6
			49

Required During Summer:

2·851	Machine Tool Lab.	4-0
2·852	Machine Tool Lab.	4-0

First Graduate Year

First Term	2·081	Strength of Materials	3-6
	3·391	Properties of Metals	3-3
	13·11	Structural Des. Warships	4-8
	13·27	Warship Design	6-0
	13·57	Marine Engineering	3-6
	Ec11	Economic Principles	3-5
			50
Second Term	3·392	Properties of Metals	3-3
	13·14	Protection & Armament	3-6
	13·28	Warship Design	9-0
	13·54	Marine Engineering	2-4
	13·58	Diesel Engineering	2-4
	13·64	Marine Engineering Design	3-0
		Economic Elective Subject	3-5
			47

Second Graduate Year

First Term	†1·461	Structures	3-6
	6·43	Electrical Engineering	3-6
	13·17	Basic Des. Naval Vessels	3-6
	13·791	Propeller Design	2-2
	16·81	Aeronautics, General	3-6
		Elective Subject in Human. or Bus. Admin.	8
			48
Second Term	†1·462	Structures	6-6
	6·44	Electrical Engineering	4-6
	13·29	Warship Design	8-0
		Thesis	20
			50

† Students may substitute 13·71 Naval Engineering 5-4 in the first term and 13·72 Naval Engineering 6-6 in the second term.

XIV. METEOROLOGY

The purpose of this Course is to prepare students for research and for practical work in the field of meteorology, leading to the degree of Master of Science or Doctor of Science in Meteorology. Emphasis is placed on the application of physical principles and mathematical technique to atmospheric processes, as well as on observational, empirical, and statistical methods. With the inauguration of the undergraduate program in meteorology the graduate courses have been revised to meet the needs either of students who have had the equivalent of the undergraduate curriculum or who have had adequate training in mathematics and physics and practical experience in the field of meteorology. The subjects offered include advanced work in synoptic laboratory, synoptic meteorology, dynamic meteorology, long range weather forecasting and physical meteorology.

The instruction in long range weather forecasting is based on theories and results obtained at the Institute and the Weather Bureau during the last few years. Advanced dynamics of atmospheric motion is studied with special reference to turbulence and atmospheric oscillations. Some problems in graphical analysis are treated as a laboratory course.

The Meteorological Instrument Laboratory contains standard instruments for the measurement and recording of atmospheric phenomena, including instrumentation for pilot balloon, airplane meteorograph and radio meteorograph soundings. Calibration chambers for use over a wide range of pressure, temperature and humidity are available, as well as other special laboratory apparatus.

Laboratory facilities for research in atmospheric condensation and precipitation processes are also available and equipment is at hand for experimental research in other fields of meteorology.

Meteorological Seminars sponsored jointly by Technology, Harvard University and the American Meteorological Society are held weekly during the academic year. At these meetings, recent developments in meteorology and allied sciences are discussed by guest speakers, members of the staff, and students. Close coöperation is maintained with the Blue Hill Observatory of Harvard University, the Mount Washington Observatory, the Woods Hole Oceanographic Institution, the United States Weather Bureau, the United States Navy and the United States Army Air Forces.

Prospective students in this Department must meet the general requirements for admission to the Graduate School and should have had the equivalent of the undergraduate curriculum in Meteorology. Students with no previous training in meteorology should have specialized in one of the physical sciences, or in engineering, with particular emphasis on physics and mathematics; in general, such students will have to spend two years in residence to qualify for the Master's degree.

XV. BUSINESS AND ENGINEERING ADMINISTRATION

Because of the war it is necessary to withdraw temporarily all "A" subjects required for the Master's degree in Business and Engineering Administration.

Designed to prepare the technical graduate for ultimate executive responsibilities of an important nature, the course leading to the degree of Master of Science in Business and Engineering Administration has for its three primary objectives an appreciation of the social implications of industry, an understanding of the interrelations of

XV. Business and Engineering Administration Continued

business and economics, and a familiarity with managerial as well as technical problems.

Breadth of viewpoint is developed by foundation subjects dealing with the economic, social and political background of business. Facility is stimulated through the study of actual problems encountered in the major fields of management: production, marketing, finance, accounting, law and labor relations. The professional point of view is encouraged by original investigations of contemporary industrial situations, selected because of their unusual interest and value to the individual student. Finally, through the privilege of electing subjects in other departments of the Institute, opportunity is offered for further advance in allied technical areas which have especial bearing upon the student's subsequent industrial activities.

Graduate study in this department presupposes preparation equivalent to that of a graduate of the Courses in Business and Engineering Administration. With this preparation the candidate may reasonably expect to complete the requirements for the Master's degree in one year. Without it, graduates from other courses at the Massachusetts Institute of Technology or from non-business courses in other accredited technical schools will undertake a two-year program. The first year of residence is devoted to the satisfying of prerequisites, and any remaining time during that year is assigned to additional subjects chosen from undergraduate electives. The second year is given wholly to graduate work, in accordance with the general requirements for the Master's degree.

Prerequisites to Graduate Study

In addition to satisfying undergraduate requirements* for the Master's degree common to all courses, candidates should have taken a substantial number of engineering units similar to those prescribed in XV-A and XV-B, the undergraduate Courses in Business and Engineering Administration. Candidates should also present evidence that they have had the equivalent of the following undergraduate subjects:

15·30	Personnel Management	15·81T	Marketing and Reports
15·41	Finance	15·92	Industrial Problems
15·50	Accounting	Ec11	Economic Principles
15·61	Law of Contracts		
15·70	Production		

and the equivalent of *any three* additional subjects to be selected from "B" subjects (other than those listed in the preceding group).

The second or graduate-year program comprises a selection largely of "A" subjects, and the undertaking of a Master's thesis.

XVI. AERONAUTICAL ENGINEERING

Advanced study in this Department leads to the degrees of Master of Science 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 very desirable.

Students may also elect subjects given in other departments, but bearing a useful relation to their program of aeronautical studies. Those specializing in aircraft design will, in general, be advised to take advanced work in materials and elasticity; those choosing aerodynamics as their field may advantageously take courses in advanced physics, while those chiefly interested in engines should supplement their aeronautical studies by work in physical chemistry and in dynamics. The selection of such subjects is subject to approval of the registration officer.

* M22 Differential Equations is not prerequisite for graduate work in this Department.

Undergraduate Preparation

The preparation required for graduate work in Aeronautical Engineering is equivalent to that possessed by a graduate of the Massachusetts Institute of Technology in the undergraduate Course in Aeronautical Engineering. With this preparation the candidate may reasonably expect to complete the requirements for the Master's degree in Aeronautical Engineering in one year. Graduates of other engineering courses at the Massachusetts Institute of Technology or from non-aeronautical courses in other accredited engineering schools may register as graduate students but will usually find it necessary to devote a considerable portion of their first year of residence to making up their deficiencies in undergraduate aeronautical subjects, with a second year of strictly graduate work.

In addition to the general requirements for all graduate students, candidates for the degree of Master of Science in Aeronautical Engineering must present evidence of training in certain basic professional studies, corresponding approximately to the following Institute subjects:

2·30T	Engineering Materials
2·40	Heat Engineering
2·701	Machine Drawing
16·01	Aeronautical Mechanics, Int.
16·02	Aeronautical Mechanics, Int.
16·10T	Aerodynamics, Applied
16·20	Structures

Candidates must also present evidence of having had, in addition, sufficient undergraduate training to prepare them for the advanced subjects they wish to take. The amount of such training for the groups given below should be approximately equivalent to that included in the Institute subjects listed.

Group A. (Aerodynamics): 16·13, 16·17, 16·21, 16·62.
Group B. (Aeronautical Design): 16·13, 16·14, 16·17, 16·21, 16·22T, 16·62, 16·75.
Group C. (Aeronautical Structures): 16·13, 16·17, 16·21, 16·22T.
Group D. (Instrumentation): 6·18, 6·19, 16·13, 16·21.
Group E. (Aeronautical Powerplants): 2·791, 2·792, 16·16, 16·21.

If candidates have not had the special training in their chosen field of study listed under A, B, C, D or E before entering the Institute, they should acquire such training during attendance at the Institute. All subjects in these groups, except 6·18 and 6·19, as well as 16·01, 16·02, and 16·10T from the basic list of prerequisites, may be counted as B subjects and (up to a total of 24 units) counted as credit toward the Master's degree.

Attention is drawn to the five-year program leading to simultaneous bachelor's and master's degrees, described under the Course XVI Undergraduate schedules.

Requirements for the Doctor's Degree

Special requirements for the degree of Doctor of Science in Aeronautical Engineering beyond the general requirements of the Graduate School are the following:

The student is expected to take graduate subjects in preparation for the general examination and thesis research, but no particular subjects are required. The general

XVI. Aeronautical Engineering Continued

examination for the doctorate consists of two parts. The first is a written examination, consisting normally of six questions which require, on the average, one day each to complete and are to be answered with the aid of the student's notes and the library within one week from the date of issue.

The second is a three-hour oral examination following the successful completion of the first. The general examination, Minor and language requirements must be completed before the student is admitted to candidacy for the degree.

For United States Naval Officers course leading to the degree of master of science

The degree of Master of Science will be awarded to United States States Naval Officers who have completed satisfactorily Schedules E and E2 listed in the United States Naval Academy catalogue of 1944–45, and the summer instruction at the Naval Aircraft factory, and have completed satisfactorily the one-year schedule in the Department of Aeronautical Engineering. (The regular three years of German, French, or Spanish taken at Annapolis will be accepted as satisfying the language requirement.)

Research Facilities

For aerodynamical research several wind tunnels are available. The largest, the Wright Brothers Wind Tunnel, with an elliptical throat 7½ by 10 feet, is a pressure tunnel. Operating pressures are from ¼ to 4 atmospheres and the maximum speeds vary up to 350 miles per hour at ¼ atmosphere. Other tunnels include: 5 by 7½ foot rectangular throat closed return, 5 foot diameter Venturi type, an instrument tunnel arranged with multi-stage throats. There is also a 3 foot throat tunnel especially equipped for spray and icing studies located on the roof.

The Instrumentation Division is equipped with two laboratories. One supplies instruction in the fundamentals of instrumentation with particular emphasis on the behavior of measuring systems under rapidly changing conditions. In this laboratory there is available apparatus for studying aircraft instruments and meteorological instruments. This apparatus includes a testing chamber in which flight similitude conditions can be reproduced. The other laboratory is concerned with vibration measurements and is equipped with instruments of many types for measuring vibratory displacement, velocity, acceleration and strain. Calibration apparatus and a vibration testing machine are included in this laboratory.

The Structures Laboratory is equipped for supporting various types of structures not readily adaptable to testing in ordinary testing machines. Loading devices and electrical and mechanical strain gauges are available so that studies of strain distribution under static loadings can be made on structures of types commonly employed in aircraft. By using some of the equipment available in the Vibrations Measurement Laboratory, stress distributions in structures subjected to dynamic loadings can also be investigated. The Structures Laboratory and the Vibrations Measurements Laboratory are operated in close coöperation.

The laboratories of the Mechanical Engineering Department are used for the investigation of mechanical and structural problems. Also, the facilities of the Sloan Automotive Engine Laboratory are available to students in Aeronautical Engineering, as are also the Meteorology, Metallurgy, Photoelastic and other laboratories of the Institute.

XVIII. MATHEMATICS

This Department offers courses leading to the degrees of Master of Science, Doctor of Philosophy, or Doctor of Science in Mathematics.

The course of each student will be arranged in consultation with the Department. A student who is interested in applied mathematics may also be allowed to select subjects offered in other departments. Before receiving a Graduate Degree in mathematics a student is expected to complete the undergraduate mathematics subjects in Course XVIII, Option 1, or their equivalents.

To obtain the degree of Master of Science the student must elect in each term at least three subjects of advanced mathematics or allied subjects, and fill the remaining time with other electives and thesis.

For the degree of Doctor of Philosophy, each candidate must select a major field of interest — analysis, geometry or applied mathematics — and complete the program of subjects prescribed by the Department as appropriate to this major field. Ordinarily the last year will be spent on research and the completion of the thesis.

Candidates for advanced degrees who work in the field of applied mathematics will be required to follow a course of study covering important aspects of one or more engineering and scientific fields together with a selected sequence of mathematics subjects. Assistance or even collaboration in practical problems in applied mathematics being investigated by members of the staff will constitute an important part of graduate programs. The student working for an advanced degree in applied mathematics thus will be enabled to carry on his research work with any of the members of the staff working in his field in any department of the Institute. His thesis advisers may include experts familiar with these practical problems as well as experts familiar with advanced mathematical techniques.

ECONOMICS AND SOCIAL SCIENCE

Graduate Work in Economics

A small group of graduate students will be admitted to the Institute as candidates for the degree of Doctor of Philosophy in Industrial Economics. The following admission requirements have been established:

1. *General requirements:* S.B. or A.B. degree with a high academic record from a university of recognized standing.
2. *Course requirements:* Three full-year college 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 technical developments.) A knowledge of English similar to that included in the undergraduate curriculum of the Institute. At least one full year course in college mathematics and a year's work in college science.

Deficiencies in certain of these requirements may be removed at the Institute, although this special work may lengthen the necessary period of residence.

In the field of the Major, the candidate will be required to have some understanding of all the fields listed below. The candidate will take a general examination specifically covering at least four of these fields: Economic Theory, Socio-psychological Theory, Industrial Relations, Industrial Organization and Price Policy, Economics of Technological Change, Statistical Method and Theory, Economic History, the State in Relation to Industry.

Economics and Social Science Continued

There is already available at Technology a variety of subjects in the fields comprising this area. More advanced work in particular fields will be offered through the use of "reading and research" subjects taught by the tutorial method.

Following the Institute rules, the candidate for the Ph.D. will be required to take a Minor in a related field. Possibilities include: Business Administration, Biology and Biological Engineering, Mathematics, Mechanical Engineering, Electrical Engineering, Geology, Metallurgy, Chemical Engineering, or any of the other technical subjects in which the student is qualified to participate. It would be expected, for example, that a student writing his thesis on certain economic problems in the textile industry would elect some subjects in textile technology.

Graduate Work in Group Psychology

Graduate students will also be admitted as candidates for the degree of Doctor of Philosophy in Group Psychology. The following admission requirements have been established:

1. *General requirements:* S.B. or A.B. degree with a high academic record from a university of recognized standing. Only students who have received the equivalent of our cumulative rating of 4.00 as undergraduates will be admitted.
2. *Course requirements:* One full year subject each in college mathematics and science. Three full year subjects in social science (psychology, sociology, anthropology, economics), of which at least one must be in psychology.

Following the Institute rules, the candidate for the Ph.D. degree will be required to take a Minor in another field. The Minor may be taken in the Department of Economics and Social Science (Industrial Economics or Industrial Relations) if it deals with Economics or Sociology rather than Psychology.

In the field of the Major, the candidate for the degree will be expected to have some understanding of all of the following subjects, and is required to take general examinations in four of them: Psychological Theory, Theory of Group Dynamics, Industrial Organization, Cultural Anthropology, Sociology, Public Administration, Statistical Methods. He must take the examination in Psychological Theory or in Group Dynamics.

The usual requirements with respect to language, residence, the thesis, and the final examination will apply to candidates for the degree of Doctor of Philosophy in Industrial Economics or in Group Psychology. It is expected that the work will normally require three years of full-time graduate study and research.

Special significance will be attached to the thesis as a measure of the student's power in the field. For this thesis, which will occupy at least one year, it is expected that the student will select a topic involving considerable field work in industry. Research will be carried on in close collaboration with one or more members of the staff. The number of students accepted will be limited to the few who can be given an individual type of instruction.

Five-Year Course

The five-year course, combining undergraduate and graduate work, leads to the degree of Master of Science either in Economics and Engineering or in Economics and Natural Science. The degree is conferred at the end of the fifth year together with the degree of Bachelor of Science in the professional course in which the student has completed his undergraduate work. The student during the first four years completes his undergraduate requirements and at the same time takes one additional economics or business subject in each term of the third and fourth years. These additional subjects are made possible by omission of the senior thesis, and by means of electives available in the professional course, or by substitution, or by postponement of one or more professional subjects to the fifth year. The major part of the fifth year is devoted to social science subjects, including a thesis which should have an economic as well as an engineering aspect. The usual requirements as to "A" and "B" subjects for the Master's degree apply to this curriculum.

This five-year course is open to graduates of the Institute who may be admitted to the Graduate School and who meet the requirements of the Master's degree based on a program of advanced work as outlined above. It is not open to students in the Course in Architecture or in Business and Engineering Administration, or to graduates of other colleges who come to the Institute to specialize in Economics unless, in addition to the advanced work in Economics, they complete in residence a program of work in one of the departments of engineering or science approved by the Committee on the Graduate School.

The Department of Economics and Social Science also offers instruction to graduates who are studying for advanced degrees in other departments. Such students may, for example, submit economics as their Minor requirements for the doctorate.


INSTITUTE OF TECHNOLOGY

DESCRIPTION OF SUBJECTS

The list below is necessarily subject to change due to present conditions

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

1·00. SURVEYING. Elementary theory and methods of plane and topographical surveying. Breed, *Surveying.*

1·00T. SURVEYING FIELDWORK. At Camp Technology. Theory and practice of plane and topographic surveying. Introductory exercises in the use of the tape, transit and level; a complete topographic survey of a given area using the stadia method and plane table; and engineering astronomy for the determination of azimuth, time and latitude. Drafting room work on preparation of maps and plans from original field notes. Class room work on description of methods and theoretical background of the fieldwork.

1·01. TOPOGRAPHICAL DRAWING. Scale drawings, profiles, contour maps, and conventional signs for topography. Application to solution of engineering problems. Brief treatment of photogrammetry. Breed, *Surveying.*

1·01T. ADVANCED SURVEYING FIELDWORK. At Camp Technology. Continuation of 1·00T. Methods and fieldwork of the more precise surveys. Triangulation by use of repeating and direction instruments. Measurement of base lines with both invar and steel tapes. Measurement of a precise traverse by "buck-chaining" methods. Precise leveling with micrometer tilting levels. Hydrographic surveying including soundings and use of current meter.

1·03. ADVANCED SURVEYING. Detailed discussion of methods of conducting advanced surveys. Principles of triangulation, base line and leveling, treated from a practical standpoint. Engineering astronomy including the determination of latitute, time and azimuth with the engineer's transit. Aerial surveying and photogrammetry including a study of the methods of preparing planimetric and topographic maps from aerial photographs.

1·04. CONSTRUCTION SURVEYING FIELDWORK. At Camp Technology. Fieldwork problems pertinent to construction surveys. Determination of quantities, proper location of structures relative to the terrain and the layout of building lines before and during construction. Designed for Course XVII.

1·05. SURVEYING. Elementary surveying, including theory and fieldwork. Breed, *Surveying.*

1·054. SURVEYING FIELDWORK. Use of tape, transit and level; complete topographic survey using the stadia method and plane table; astronomical observations for azimuth, time and latitude. Drafting of topographic map from field notes. Breed, *Surveying.*

1·06. PHOTOGRAMMETRY (B). Various methods of constructing maps from photographs for engineering purposes; methods of making topographic maps from vertical and from oblique photographs; methods of control of aerial surveys. Does not include the technical work of photography or of flying.

1·07. GEODETIC SURVEYING (B). Fieldwork, class work and computation at Camp Technology. Fieldwork including measuring a base line with invar tapes; triangulation with repeating and with direction instruments; precise leveling; astronomical observations.

1·08. NAVIGATION. Principles underlying piloting and celestial navigation. Study of piloting including use of compass, log and fathometer; various plane and great circle sailings; aids to navigation such as charts, tide tables and light lists. Celestial navigation comprising the use of chronometer and sextant; systems of spherical coördinates; correction to altitudes; use of Greenwich Hour Angle for time data; latitude sights; line of position sights; navigator's day's work at sea.

1·12. ENGINEERING ASTRONOMY. Methods of determining latitude, longitude, time and azimuth with the engineer's transit.

1·13. GEODESY. Methods of conducting a geodetic survey, including the mathematical treatment of base line measurements, triangulation and precise leveling.

1·141, 1·142. ADVANCED GEODESY (A). Methods of developing the higher formulas for computing geodetic positions; theories of potential and the earth's figure; theories of astronomical, magnetic and gravity observations; and application of least squares to the adjustment of geodetic surveys.

1·15. INTRODUCTION TO VIBRATION THEORY (A). Free and forced vibrations with and without solid and fluid friction. Emphasis upon the analysis of various vibration measuring devices, accelerographs, frequency meters, etc. Proper interpretation of the results; principles of design of instruments and recording systems. Practical problems of mechanical vibration and of vibration prevention.

1·16. VIBRATION PROBLEMS (A). Available methods of solving the more complex problems in vibrations-step-by-step integration, the differential analyzer, model study, electrical network solutions, Rayleigh and Rayleigh-Ritz methods, Lagrange's equations, and the general solution of nth order vibration equations, including non-harmonic vibrations. Analysis of complex mechanical systems under transient and periodic forces and displacements. Practical problems illustrating the application of the various methods and principles.

1·20. ROUTE SURVEYING FIELDWORK. Location survey for a railway or highway project; systematic drill in laying out curves, setting slope stakes for earthwork and staking out masonry structures. A limited amount of class work and drafting supplementing fieldwork. Allen, *Railroad Curves and Earthwork;* Allen, *Field and Office Tables.*

1·21. ROUTE AND CONSTRUCTION SURVEYS. Continuation of 1·20. Application of curves to location and property lines of railways, highways and other route surveys. Simple, compound, reversed, spiral and vertical (parabolic) curves. Horizontal and vertical control, lines and grades, and quantity surveys of earthwork and masonry for civil engineering construction.

1·24. MUNICIPAL ENGINEERING. Location, design, layout, drainage, construction and maintenance of highways and streets; urban problems of highway traffic control and public transportation; railroad problems in City Planning; and a consideration of airport location, design and operation.

1·26. RAILWAY SIGNALING (B). Interlocking and block signals; and remote, centralized and automatic train control. Development of modern signaling practices with reference to the economics of train operation. Inspections of railway signal installations.

1·271, 1·272. TRANSPORTATION ENGINEERING (B). Transportation by railway, highway, and air with some attention to inland waterways. Subjects in the highway field include traffic surveys and traffic control, highway pavement design, construction methods, characteristics of motor vehicles, cost of highway transportation, and economics of highway design,

Civil and Sanitary Engineering Continued

finance regulation and taxation. Railroad subjects include maintenance of way, signals, motive power and cars, train resistance and tonnage rating, I. C. C. accounting and regulation, and economics of location and operation. Coördination of the different forms of inland transportation. Design problems in highway, railway and airport location.

1·28. Highways and Airports (B). Principles and practice in the location, design, construction and maintenance of highways, streets and airports.

1·29. Transportation (B). Transportation by rail, highway and air, with some attention to inland waterways and pipe lines. Physical plant such as tracks, roads, airways, rail and motor terminals and airports; transportation equipment; organization and operational methods; Government regulation; operating costs and bases for rates and fares; economic field of operation and coördination.

1·301, 1·302. Advanced Railway Transportation (A). A continuation of 1·271 and 1·272. Design and operation of locomotive, freight and passenger terminals; use of motor transport; railway economics; public relations and regulation; involving individual investigations and reports.

1·311, 1·312. Advanced Highway Transportation (A). Research results and methods of design, construction, maintenance, operation and economics of highways.

1·32. Airport Design (A). Development of a complete layout for an airport, including selection of site, layout of runways, drainage, runway surface type and thickness, terminal layout, lighting, traffic control and maintenance facilities.

1·35T. Soil Mechanics and Foundation Engineering (B). 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, retaining walls, shallow footings and pile foundations. Reading assignments on soil sampling, excavation, cofferdams, caissons, types of piles and types of foundations. Special attention given to pressure distribution on retaining walls and footings; to site investigations and selection of sites; to correlation with the closely related field of engineering geology; and to case studies of a wide range of general foundation problems. Laboratory work covering the important soil tests.

1·351. Soil Mechanics and Foundation Engineering (B). Same material in general as covered in 1·35T but somewhat abbreviated; coördinated with design courses in Building Construction instead of Civil Engineering.

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 followed by settlement analysis of structures founded above compressible soil strata; relationships of stresses, strains, and shearing strengths in cohesive and cohesionless soils; critical densities and the quicksand phenomenon in cohesionless soils. *Mimeographed Notes.*

1·362. Soil Mechanics (A). Modern soil research on the basis of the physical studies of 1·361. Stability of slopes and retaining walls; earth and masonry dams, with reference to stability, seepage, and piping effect; bearing capacity and settlement of foundations; piles and pile groups; frost action; and special types of foundations. *Mimeographed Notes.*

1·37. Soil Mechanics Laboratory (A). Technique of soil testing, including measurements of specific gravity, water content, density and limits of consistency; mechanical analyses; permeability, consolidation and shear tests; various special tests.

1·38. Soil Engineering Special Studies (A). Assigned reading, special lectures and conferences covering advanced studies of either theoretical or practical nature in various phases of soil engineering. Material varying with the theoretical background and the special interests of individual students or small groups of students.

1·40. Structures. The same as 1·40T except for the omission of Graphic Statics. Spofford, *Theory of Structures.*

1·40T. Structures. Outer forces, reactions, moments and shears for fixed and moving loads, the use of influence lines, the design of steel and wooden beams, plate girders, the analysis of continuous beams by the use of the Equation of Three Moments, and Graphic Statics. Spofford, *Theory of Structures.*

1·401. Structures. Abridgement of 1·40T. Spofford, *Theory of Structures.*

1·41, 1·42. Structures (B). Continuation of 1·40T. Analysis of the more common structures of wood, steel, and masonry, principally by algebraic methods. First term: statically determinate trusses of various forms including simple end supported trusses, three-hinged arches, cantilevers, bracing, towers, and space frames; also statically indeterminate structures of certain types by approximate methods, such as, building frames under horizontal loading, trusses with multiple web systems, and portal frames. Second term: determination of deflections of structures by methods of moment areas, elastic loads, virtual work and Williot diagram. Methods of solution for stresses in statically indeterminate structures by virtual work, least work, slope deflection, and moment distribution. Continuous beams, trusses, building frames and arches.

1·43. Reinforced Concrete Design. Elementary principles involved in the determination of stresses in beams and columns. Design of reinforced concrete buildings of various types and other structures as governed by current specifications.

1·441. Bridge Design (B). Relation of the theory of structures to engineering practice through the preparation of designs and drawings for a riveted plate girder railway bridge, and a steel truss highway bridge. Development of careful, systematic and practical habits of computation.

1·442. Structural Design (B). An extension of 1·441 including the design of a welded girder bridge, a wooden roof truss, a reinforced concrete highway bridge, a reinforced concrete retaining wall, and a steel truss continuous over two spans. Analysis for a reinforced concrete arch.

1·45. Engineering Materials. Important structural materials, especially timber, concrete and steel, with some attention to other forms of masonry, and certain non-ferrous metals. Consideration of the characteristics of these materials in relation to their use for construction purposes, both permanent and temporary; the principal manufacturing processes, and especially circumstances affecting the quality and durability of completed structures.

1·461, 1·462. Structures (B). Problems of structural engineers and usual methods in stress analysis for, and design of, structures. Includes use of influence lines and the analysis of simple trusses, portals, rigid frames, trusses with redundant members, space framework, continuous beams, computation of deflections and the analysis of statically indeterminate structures. Design calculations and drawings for a small steel truss bridge. Spofford, *Theory of Structures.*

1·521, 1·522. Structural Laboratory (A). Lectures, conferences, assigned reading and laboratory work, covering the theory and practice of structural analysis by the use of models. Discussion of the fundamentals of the entire field, with later work in fields of special interest to individual students. Time arranged to suit these individual requirements.

1·541, 1·542. Advanced Reinforced Concrete Design (A). First term: advanced treatment of 1·43 designed for graduate students from other colleges having some training in this field. Complete design for an interior bay of typical factory buildings, illustrating design of floors of various types, columns, footings, etc. and with the application of methods of analysis as applied to continuous structures. Second term: continuation of 1·541, dealing with more difficult types of concrete structures, such as the rigid frame bridge, domes, tanks and similar structures.

Civil and Sanitary Engineering Continued

1·551, 1·552. Advanced Structural Design (A). Problems met by the designing engineer, such as choice of type, economics, design, erection methods, with special reference to indeterminate structures, such as high buildings, arches, suspension bridges, and continuous trusses.

1·561, 1·562. Advanced Structural Theory (A). Basic theorems underlying the analysis of statically indeterminate structures, and the methods of applying these theorems in the analysis of such structures, computation of deflections by various methods, secondary stress analysis.

1·571, 1·572. Statically Indeterminate Structures (A). A detailed study of indeterminate structures of certain types such as continuous and suspension bridges, high building frames, arches, arched dams.

1·61. Fluid Mechanics. Mechanics of compressible and incompressible fluids. Emphasis on viscosity effects, Bernoulli's theorem, the force-momentum principle, laws of similarity and dimensional analysis. Statics, kinetics and dynamics, and application of basic principles to the flow of fluids through orifices, tubes, nozzles, and measuring devices.

1·62. Fluid Mechanics. Continuation of 1·61 with emphasis on the flow of water. Flow in pipes and open channels, dynamics of immersed bodies, and the theory and operation of hydraulic turbines and centrifugal pumps.

1·63. Hydraulics. Essentially the same as 1·62, omitting turbines and pumps, and abbreviating the treatment of pipeflow and open channels. Russell, *Hydraulics, Fifth Edition.*

1·64. Hydraulics. Essentially the same as 1·62 but abbreviating the treatment of pipeflow and open channels. Russell *Hydraulics, Fifth Edition.*

1·66. Advanced Hydraulics (A). Studies in the advanced field of theory and practice. General fluid flow in pipes; open channels with special reference to non-uniform flow, alternate stages, critical stage, surface curves, hydraulic jump, transitions and wave formations. Russell, *Hydraulics, Fifth Edition; Professional Papers.*

1·67. Design of Harbor Works (A). Study of tides, currents, wave action, methods of shore protection, layout of channels and anchorage basins, size of ships; methods of making soundings, borings, pile driving, pile tests, wharf construction, dredging, land reclamation and other waterfront construction; design of wharves, bulkheads and similar structures; methods and equipment for cargo handling; study of preservative treatment of timber. Field trips including inspection of Boston Port facilities and waterfront construction.

1·681. Theory of Models (A). Principle of dimensional analysis and application to many problems, theory of models as applied to conditions of dynamic similarity when terrestrial gravitation, universal gravitation, viscosity, capillarity and elasticity are the physical forces acting. Numerous model studies illustrating the work covered.

1·682. River Hydraulic Laboratory (A). Instruction in the construction of models for river hydraulic experiments, method of making such experiments, and interpretation of the results.

1·69. River Engineering (A). Hydraulic factors affecting river flow, theory of bed load transportation, and means of improving rivers with respect to navigation and flood control.

1·70. Hydrology and Flood Control (B). Basic theory of the occurrence and distribution of water on the surface of the earth including precipitation, run-off, infiltration, water losses and their relations, analysis of stream flow data, and frequency and magnitude of flood flows and the effect of reservoirs in reducing them. Classroom work supplemented by supervised problems of applied hydrology in the drafting room. Barrows, *Water Power Engineering.*

1·701. Hydrology and Flood Control (B). An abridgement of 1·70 including the theory, but omitting the practical application in the drafting room. Barrows, *Water Power Engineering.*

1·71. Water Power Engineering (B). Problems involved in the location, design, construction and economics of hydroelectric developments as a foundation for practice in this field, or for the advanced studies of the graduate year. Estimates of water power from stream flow data, theory and practice of hydraulic turbines, elements of design of dam, waterway and power house, cost and value of water power. Supplemented by drafting room exercises with reports and problems of design. Barrows, *Water Power Engineering.*

1·711. Water Power Engineering (B). An abridgement of 1·71 including the theory but omitting the practical design work in the drafting room. Barrows, *Water Power Engineering.*

1·72. Hydrology and Water Power Engineering (B). Condensation of 1·70 and 1·71 omitting the design problems but including the more important phases of the theory.

1·731, 1·732. Advanced Water Power Engineering (A). Supplemented by 1·741, 1·742. Study and design of the various portions of some water power project at a site where actual data are available from surveys and reports. Other general problems of power development with basic theory and practice. A field trip of several days' duration to examine typical power and storage developments. Barrows, *Water Power Engineering*, Creager and Justin, *Hydroelectric Handbook;* Justin and Mervine, *Power Supply Economics.*

1·741, 1·742. Advanced Water Power Design (A). (For description see Advanced Water Power Engineering **1·731, 1·732.**)

1·75. Water Supply and Purification (B). 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.

1·76. Sewerage and Sewage Treatment (B). 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.

1·77T. Water Supply and Sewerage (B). 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. Development of design project, including water mains, sanitary and storm sewers for a small community.

1·771. Sanitation. Survey of public and individual water supply and purification methods; uses of water in buildings, cooking, washing, bathing, swimming, waste disposal, and fire protection; elementary hydraulics as applied to plumbing fixtures and supply, waste, and vent piping; public and individual methods of sewage disposal and treatment. Surface and ground water drainage problems. Health aspects of water supply, of sewage and refuse disposal, of heating and ventilation of housing and of food supplies. Also, insects and rodents in relation to health.

1·78. Sanitary Analysis. Laboratory problems in the analysis of water and sewage and study of chemicals used in water and sewage treatment. Laboratory exercises giving the student an elementary knowledge of certain basic bacteriological and chemical principles involved in water purification and sewage disposal.

1·79. Sanitary Engineering Design (B). 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 the same small community.

Civil and Sanitary Engineering Continued

1·811. Advanced Sanitary Engineering (A). Principles of modern water treatment engineering, including coagulation, sedimentation, filtration, sterilization, softening, corrosion, and removal of tastes and odors. Also group inspection of nearby treatment works.

1·812. Advanced Sanitary Engineering (A). Principles of modern sewage treatment engineering, 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 works.

1·821, 1·822. Sanitary Engineering Laboratory (A). Lectures, conferences, assigned readings, and laboratory studies of water, sewage and industrial wastes and treatment processes.

1·831. Sanitary Chemistry (B). Physical chemistry of water and its impurities; solutions, suspensions, colloids, and chemical equilibria. Chemistry of sewage with reference to treatment processes and effect of sewage pollution on waterways.

1·832. Water and Sewage Analysis (B). Laboratory exercises to demonstrate the technique and principles involved in physical and chemical tests used in water and sewage analysis; application of the tests to water supply and disposal of sewage; interpretation of results with reference to accuracy of sampling, laboratory technique, potability of water supplies and the effectiveness of sewage treatment processes.

1·84. Bacteriological Examination of Water and Sewage (B). Bacteriology with particular application to the examination and interpretation of bacteriological analysis of water and sewage. Laboratory procedures including the cultural, microscopical and biochemical methods employed in studying and identifying bacteria with particular reference to water, sewage and sanitation.

1·85. Advanced Sanitary Bacteriology (A). Problems of bacteriology in relation to environmental sanitation; including the atmosphere, the soil, shellfish, swimming pools and bathing beaches, milk and dairy products, water and sewage, with particular attention to the indices of pollution, their use and interpretation.

1·86. Principles of Sanitary Science (A). Lectures and discussions dealing with sources of infection, modes of spread, principles of immunity, antibiotic agents, and the relationship of water, sewage, milk, food, insects and rodents to the spread of disease. Sanitary problems such as rural sanitation; the sanitation of swimming pools and bathing beaches; summer camps and other overnight camps; street cleaning; refuse collection and disposal; food sanitation; the sanitation of eating and drinking establishments; housing; the atmosphere in relation to health and comfort; school sanitation; industrial sanitation.

1·871. Public Health Administrative Practice (A). Lectures, discussions and problems pertaining to public health administration, epidemiology and vital statistics, including organization and proper functioning of municipal, state and federal health agencies; the case history of specific epidemics of particular interest to the sanitary engineer; and the use of statistical methods and procedures in the collection, analysis and interpretation of vital statistics.

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). 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). Design of a modern sewage treatment plant effecting the proper treatment of a given raw sewage. Conducted in parallel with 1·812.

1·91. Professional Problems (B). 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.

1·92. Engineering Construction (B). Construction of civil engineering works, such as railways, highways, water power, water supply and similar projects, covering estimates and reports, contracts and specifications, methods of economic comparison, financing of engineering projects, engineering organization and duties, acquisition of land, and construction methods including clearing of the site, earth and rock handling, and construction of structures of concrete, steel and timber. Typical projects illustrating the principles.

MECHANICAL ENGINEERING

Subjects 2·00 to 2·99

2·00. Statics. Analysis of force systems in two and three dimensions. Laws of equilibrium, principle of virtual work. Analysis of simple frames in machine structures. Cables and chains. Friction. Distributed forces center of gravity. Stress and strain in tension and compression. The tension test. Statically indeterminate cases.

2·01. Dynamics. Velocities and accelerations of various types of mechanisms. Rectilinear and curvilinear translation of particles and rigid bodies. Rotation of rigid bodies about fixed axes. Moments and products of inertia of areas and rigid bodies. Elementary problems in vibrations. Applications to engineering problems.

2·011. Statics and Dynamics. Abridgment of 2·00 and 2·01.

2·013. Basic Mechanics. *Statics:* Coplanar and non-coplanar force systems, centers of gravity and moments of inertia and simple elasticity problems in preparation for strength of materials. *Dynamics:* Translation of rigid bodies, rotation of rigid bodies about fixed axes. *Kinematics:* Lectures and drafting-room exercises covering kinematic design of the basic mechanisms. Seely and Ensign, *Analytical Mechanics for Engineers, Third Edition;* Sloane, *Engineering Kinematics.* (Restricted to selected U. S. Naval Officers only.)

2·04. Strength of Materials. Elementary analysis of stress and strain in two dimensions; shear stresses and torsion of circular bars, riveted and welded joints; stress concentration; cases of simple loading of thin rings, cylinders and spheres, Theory of bending including shearing forces and bending moments; distribution of normal and shearing stresses, composite and curved beams, differential equation of the elastic curve, methods for the determination of slopes and deflections. Column theory. Working stresses. Applications to important engineering problems. Timoshenko and MacCullough, *Elements of Strength of Materials.*

2·044. Strength of Materials. Fundamental training in strength of materials, photoelasticity, and materials testing. Classroom topics covering tension and compression, combined stresses, shear, riveted joints, stresses in thin walled cylinders, torsion, helical springs, shearing force and bending moment, stresses in beams, deflection of beams, certain statically indeterminate problems in bending, columns, basic theory of photoelasticity. Laboratory tests on tension, torsion, transverse columns, hardness, photoelasticity. Timoshenko and MacCullough, *Elements of Strength of Materials;* Frocht, *Photoelasticity;* Cowdrey and Adams, *Materials Testing.* (Restricted to selected U. S. Naval officers only.)

2·046. Strength of Materials and Dynamics. Abridgment of 2·04 and 2·06. (Restricted to selected officers of the U. S. Navy and Coast Guard only.)

Mechanical Engineering Continued

2·06. Dynamics. Plane motion of rigid bodies, relative motion with application of Coriolis accelerations, the principal of virtual work, and d'Alembert's principle, momentum and energy, introduction to vibrations of simple systems. Application to important engineering problems, such as balancing and vibration of rotating and reciprocating machinery, methods of measuring power, governors, etc. Timoshenko and Young, *Engineering Mechanics*.

2·062. Strength of Materials and Dynamics. Theory of continuous beams; maximum strain-energy theory; and more advanced problems in dynamics.

2·07. Dynamics. Similar to 2·06. Arranged for students in Course VI with emphasis on electromechanical systems.

2·081. Strength of Materials (B). Review of stress and strain at a point in two dimensions, the torsion problem with description of membrane analogy, review of bending with application to composite beams, beams on elastic foundations, plates and sheets, curved beams and thick cylinders, strain energy methods, failure of metals under stress, plastic flow, creep, fatigue, influence of stress concentration and working stresses. Miscellaneous applications to problems of industry, such as steam piping, rotating machinery, railroad tracks, turbine buckets, etc.

2·082. Dynamics (B). Vibrations of simple systems, free and forced motion with damping, nature of damping and internal friction, self-excited motions. Vibration of systems with several degrees of freedom, normal modes and frequencies, approximate methods. Torsional vibration. Vibration isolation. Vibration dampers. Control problems. Rotation of rigid bodies about a point with applications to gyroscopic problems. Brief review of the historical development of mechanics, with emphasis on the significance of the basic principles. Application to important engineering problems in power and marine engineering, automotive engineering, aeronautics, railroads, etc.

2·10. Ordnance Engineering (B). Lectures and calculations on gun design, including stresses and strains in built-up and wire-wrapped guns; the design of recoil and counter recoil mechanisms.

2·11. Industrial Plant Engineering (B). Soils, foundations, footings (plain and reinforced) and types of superstructures; heating and ventilation, air conditioning, and mechanical equipment of buildings; fire protection methods.

2·121. Photoelasticity (B). Use of commercial photoelastic apparatus with applications in the analysis of common engineering problems in two and three dimensions, together with lectures on modern photoelastic theory, materials, and methods.

2·125. Photoelasticity Research (A). Opportunity for graduate students to apply photoelasticity to the solution of special problems, or to take part in current development of photoelastic theory and technique.

2·126. Experimental Stress Analysis (B). Introduction to some of the more common experimental methods of analyzing stress distributions. Photoelasticity, brittle lacquers, strain gage techniques and instrumentation, analogies, and X-rays, as applied to problems involving static, dynamic, and residual stress distributions.

2·128. Experimental Stress Analysis (B). Similar in content to 2·126, with more time assigned for greater detail in the laboratory exercises.

2·141, 2·142. Dynamics (A). Introduction to the fundamentals of rigid dynamics with emphasis on aspects of importance in mechanical engineering. Development of the fundamental principles leading to Lagrange's Equations and Hamilton's Principle. Theory of vibrations with applications to mechanical systems. Rotation of rigid bodies about a point with application to gyroscopes, etc. Problems of control in mechanical engineering, such as the control of speed, temperature and pressure in power stations.

2·211, 2·212. Advanced Mechanical Engineering Problems (A). Analytical treatment of advanced problems in mechanical engineering, with emphasis on topics which have contributed to recent industrial developments, and which impose limitations on further progress.

2·213, 2·214. Advanced Gas Turbine Problems (A). Review of basic aspect of gas turbine type of prime movers. Fundamental design problems on turbines, compressors, combustion chambers and regenerators. Emphasis on those problems which impose limitations on progress.

2·221. Plasticity (A). Mechanics of the plastic state of materials with particular emphasis on engineering applications. Mohr's representation of stress and strain in both two and three dimensions. Theories of strength in relation to design. Choice of working stresses under combined stress. New developments in stress-reduction in area relations for metals. General laws of plastic flow as applied to torsion, bars under combined stress, rotating discs, the cold working of tubes under internal pressure, etc.

2·222. Advanced Plasticity Problems (A). Continuation of 2·221 with practical applications to a number of modern engineering problems. Bending, deflection, and buckling of bars and tubes in the plastic state. Creep of both metals and non-metals at normal and elevated temperatures. Relaxation of stresses in bolted flanged connections, and in other design applications. Residual stresses as determined from calculation and experiment. Rolling, drawing, and extrusion of metals. Plastic flow problems in the field of synthetic plastics. Selection of special problems in consultation with the instructor, and some laboratory work.

2·223. Plasticity Research (A). Experimental and theoretical investigations in the general field of the plasticity of engineering materials.

2·231, 2·232. Theory of Elasticity (A). Theory of elasticity and structures presented from the point of view of the needs of mechanical engineering with emphasis on strain energy methods.

2·251. Fluid Mechanics. Physical properties of fluids, hydrostatics, continuity, Euler's equations, steady flow energy equation, momentum equation, dimensional analysis. Applications to flow in pipes and fittings, and to hydraulic machinery.

2·252. Fluid Mechanics. Continuation of 2·251. Potential flow, circulation theory of lift, boundary layers, drag, heat transfer between solids and fluids, lubrication.

2·253, 2·254. Fluid Mechanics. Properties of fluids, statics of fluids, flotation; kinematics and continuity; equations of motion of frictionless fluid and Bernoulli equation; vortex motion; energy equation; momentum equation; dimensional analysis and dynamic similarity; laminar and turbulent flow; incompressible flow in pipes; dynamics of compressible fluids, including pipe flow; drag of bodies immersed in incompressible and compressible fluids and drag of floating bodies; lift and circulation; airfoils and propellers; cavitation; superchargers; lubrication; hydraulic transmission and control. Laboratory work including exercises on fluid-measuring instruments, flow in pipes, centrifugal fan, lubrication, and basic wind-tunnel measurements. Binder, *Fluid Mechanics; Mimeographed Notes*. (Restricted to selected U. S. Naval Officers only.)

2·256. Fluid Mechanics (B). Physical properties of fluids, hydrostatics, kinematics and continuity, dynamics of ideal and of viscous fluids, dimensional analysis and physical similarity, potential flow and circulation, flow in pipes, boundary layers, single airfoils and a series of airfoils, hydraulic machinery, lubrication, heat transfer.

2·258. Hydraulic Transmission and Control. Review of principles of fluid mechanics and application to basic problems, such as: leakage, flow in pipes, orifices and valves; elasticity of fluid and piping. Current practice in the application of hydraulic pumps and motors, control devices and auxiliaries. Analysis of typical hydraulic circuits. (Restricted to selected U. S. Naval Officers only.)

2·271. Hydromechanics (A). Mechanics of ideal, viscous, compressible, and incompressible fluids. Applications to flow in pipelines, boundary layer flow, hydraulic machinery.

2·30T. Engineering Materials. Manufacture, processing, properties and uses of the common engineering materials. Manufacture of iron and steel, and the important non-ferrous metals and alloys; processing of metals as in casting, hot and

Mechanical Engineering Continued

cold working heat treatment, and welding; effects of composition and structure on the processing and properties of metals; corrosion resistance and protection of metals; properties and uses of the important non-metallic materials such as plastics, wood and wood products, concrete, rubber, glass, fabrics, refractories, insulators, paints and other protective coatings. Emphasis on developing a working knowledge of the properties of materials and their selection for engineering applications.

2·301. Engineering Materials. Part of 2·30T, comprising a study of hot and cold working processes, heat treatment, and welding.

2·31T. Engineering Metals (B). Processing, properties, and uses of the common engineering metals and alloys. Effects of the various processing operations on the properties of metals and the selection of the method of manufacture for metal parts. Metals studied: cast iron; carbon and alloy steels; copper, aluminum, magnesium, and their alloys; and other important non-ferrous metals and alloys. Foundry melting and alloying, including cupola operation; foundry sand control; sand, permanent mold, dies, precision, and centrifugal casting; hammer, press, and drop forging; rolling; extrusion; wire, rod, and tube drawing; spinning; press operations, such as deep drawing; shearing, bending, and coining; heat treatment processes including annealing, hardening, tempering, carburizing, nitriding, flame and induction hardening, and aging; arc, gas, and resistance welding; brazing; oxygen cutting; and hard surfacing.

2·32T. Engineering Metals (B). Continuation of 2·31T, covering in more detail some of the important aspects of the metal processing operations and their effect on the metallurgical and mechanical properties of metals. Recent developments in this field and application of our present knowledge of the behavior of metals to the solution of problems in the foundry, metal working, and welding industries.

2·322. Engineering Metals (B). Similar to 2·32T. Students attend lectures in 2·32T, but have additional time for carrying on related experimental work in the metal processing laboratories.

2·33. Metal Processing (B). Casting, hot and cold working, and welding of metals. Foundry melting and alloying including cupola operation; foundry sand control; sand, permanent mold, die, precision, and centrifugal casting; hammer, press and drop forging; rolling; extrusion; wire, rod and tube drawing; spinning; press operations such as deep drawing, shearing, bending, and coining; arc, gas, and resistance welding; brazing; oxygen cutting; and hard surfacing.

2·34. Mechanical Properties of Metals (B). Mechanical properties of metals and their interpretation and use in design; including strength, ductility, hardness, impact, fatigue, creep, and wear. Application of test data to industrial problems.

2·35. Fatigue of Metals (A). Failure of metals by fatigue, and application of laboratory data to the solution of problems in the design of machine parts. Methods of testing; speed, size, and temperature effects; stress concentration; corrosion; fretting corrosion; shrink and press fits; surface finish; effects of endurance limit and endurance life of shot peening, surface rolling, nitriding, flame hardening, and induction hardening. Effect of mean stress of the cycle as illustrated by means of empirical relationships, such as those of Goodman and Gerber. Application of fatigue data to the solution of problems in the design of automotive, aircraft, and marine engine crankshafts and connecting rods; piston rods; leaf and coil springs; railroad car and locomotive axles; turbine blades; airplane components and propeller shafts.

2·37. Testing Materials Laboratory. Laboratory methods for the determination of the physical properties of engineering materials and their behavior under stress. The usual method supplemented by stress analysis through strain determination and photoelastic methods, tests at abnormal temperatures, special hardness tests. Fabrics testing, X-ray examination and research problems included in the lecture material. Cowdrey and Adams, *Materials Testing.*

2·371. Testing Materials Laboratory. Methods of making physical tests to determine the properties of the more common engineering materials and a study of their behavior under stress. Cowdrey and Adams, *Materials Testing.*

2·373. Testing Materials Laboratory. Same as 2·371, and in addition a three-hour period per week devoted to the study of cement and concrete.

2·40. Heat Engineering. First Law of Thermodynamics and internal energy. Properties of liquids, vapors, and gases. Second Law of Thermodynamics, the temperature scale and entropy. Applications to closed systems and to fluids in steady flow. Steady-state heat transfer through resistances in series and between flowing streams. Keenan, *Thermodynamics;* Keenan and Keyes, *Steam Tables.*

2·402. Heat Engineering. First and second laws of Thermodynamics, with applications to the properties of gases, vapors and mixtures. The laws governing the flow of gases and vapors, with applications to boilers, nozzles, orifices, throttle valves, calorimeters, steam engines, steam turbines, gas engines and gas turbines. Steady-state heat transfer through resistances in series and between flowing streams. Keenan, *Thermodynamics;* Keenan and Keyes, *Steam Tables.* (Restricted to selected officers of the U. S. Navy and Coast Guard only.)

2·403. Thermodynamics. First and second laws of thermodynamics, with applications to the properties of gases, vapors and mixtures. Laws governing the flow of gases and vapors, with applications to heat exchangers, nozzles, orifices, throttle valves, pipe lines, calorimeters, steam engines, steam turbines, air compressors, gas engines, gas turbines and air conditioning. Steady-state heat transfer through resistances in series and between flowing streams. Laboratory classes will supplement the lectures. Keenan, *Thermodynamics;* Keenan and Keyes, *Steam Tables;* Berry, Svenson, and Moore, *Problems in Engineering Thermodynamics and Heat Engineering.* (Restricted to selected U. S. Naval Officers only.)

2·404. Thermodynamics and 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. Consideration given to selection of the most suitable type of engine for various specific applications. Laboratory work illustrating the effect of different variables on the behavior of both spark-ignition and Diesel engines. (Restricted to selected U. S. Naval Officers only.)

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.

2·42. Heat Engineering. Reciprocating engines and turbines, power-plant cycles, the air standard cycle of the internal combustion engine, gas mixtures and internal combustion engines, mixtures of air and water vapor, and an introduction to the thermodynamics of chemistry. Keenan, *Thermodynamics;* Keenan and Keyes, *Steam Tables.*

2·422. Heat Engineering. Application of the laws governing the flow of gases, vapors and mixtures in power plant cycles, air conditioning, air compressors and refrigerating compressors. Comparison of the freon, carbon dioxide, water and air compression refrigeration cycles. Elementary discussion of absorption refrigeration systems. Keenan, *Thermodynamics;* Keenan and Keyes, *Steam Tables.* (Restricted to selected officers of the U.S. Navy and Coast Guard only.)

Mechanical Engineering Continued

2·43. Heat Engineering (B). Review of first and second laws of thermodynamics, compressors, refrigeration cycles. The design of apparatus for heat transfer by conduction, convection and radiation. Keenan, *Thermodynamics;* McAdams, *Heat Transmission.*

2·44. Heat Engineering (B). Availability with applications to closed systems and to steady flow. Applications of first and second laws to reactions and solutions. Introduction to chemical equilibrium. Introduction to thermodynamics of mixtures. Pressure-volume-temperature relations for pure substances and mixtures. Phase diagrams for mixtures. Mass transfer by diffusion and turbulence. Keenan, *Thermodynamics.*

2·45. Advanced Engineering Thermodynamics (A). First and second laws of thermodynamics, their application to fixed mass and steady flow processes and to the determination of the properties of fluids. Introduction to the thermodynamics of solutions and chemical reactions and study of the equilibrium of a pure substance. Keenan, *Thermodynamics.*

2·47. Steam Turbine Engineering (B). Thermodynamics, hydrodynamics, and mechanics applied to problems in steam turbine engineering.

2·48. Gas Turbine Engineering (B). Comparative study of gas turbine processes. Design of the flow path for compressor and turbine. Stress analysis of the rotor. Stability and critical speed. Design of regenerator.

2·482. Gas Turbine Engineering (B). Same as 2·48 with laboratory and special problems added.

2·50. Heat Measurements. Laboratory exercises in the practice of heat measurements, including various types of temperature measuring instruments, heat of combustion and heat transfer. Lectures on the theory of temperature measurement, heat transfer and heat insulating materials.

2·501. Heat Measurements. Same as 2·50, omitting the lectures.

2·53. Heat Measurements (B). Selected experiments with laboratory investigation of problems connected with the industrial application of heat such as thermal conductivity, thermal expansion, specific heat, ceramics, etc.

2·551. Power Plant Engineering (B). Production and use of steam for the generation of power, including a study of the fundamental types of steam boilers, fuel burning equipment, prime movers and their allied apparatus, and the fundamentals of the Diesel and hydraulic power plant.

2·56. Mechanical Engineering Practice (B). Application of Mechanical Engineering fundamentals to the solution of problems encountered by the Mechanical Engineer, with emphasis on the generation and use of steam for the production of power and in industrial processes.

2·562. Mechanical Engineering Practice (B). Similar to 2·56 with additional time devoted to laboratory or design.

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.

2·59. Torpedoes (RA). Utilization of energy in the power plant of a torpedo. Thermodynamics of gas and vapor mixtures, laws of combustion of gaseous mixtures, heat losses, and laws of heat transmission. Principle of flow of fluids applied to calculation of time required to decrease pressure in the air tank, to design gas turbine nozzles and to determine the power developed in the turbine. (Restricted to selected U. S. Naval Officers only.)

2·601, 2·602. Food Engineering. Brief survey of the elementary principles of mechanism, mechanics, heat engineering, heat, transfer, refrigeration and air conditioning. Discussion of the methods, processes, materials and equipment used in the preparation and handling of foodstuffs, including canning machinery, packaging machines, bottling equipment, conveying systems, bakery installations, etc.

2·621T. Refrigeration (B). Refrigeration at more than one level. Low temperature refrigeration. Operation of various types of compressors, evaporators, condensers, and automatic controls used in commercial refrigerating systems. Heat flow problems in condensers and evaporators. Theory and calculation of size of cooling towers. Application of refrigeration in the manufacture of water ice, eutectic ice and dry ice.

2·622T. Applied Refrigeration (B). Physical properties of low temperature insulants; heat transfer through typical walls of cold storage plants, refrigerator cars, and refrigerator ships; moisture and temperature conditions necessary for the preservation of important foods; brief study of the microbiology of foodstuffs.

2·66. Air Conditioning (B). Study and calculation of load, direct and indirect heating systems, heating boilers and water heaters, ventilation and the fundamentals of air conditioning.

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.

2·671. Air Conditioning, Advanced (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.

2·672. Heating and Ventilation Design (A). Choice of type of heating and ventilating system for a particular building, layout of piping and duct system together with complete calculations and estimation of cost. Investigation and study of existing plants with trips to these plants, whenever possible, to bring out the practical problems involved in design.

2·681. Engineering Laboratory. Use and calibration of instruments in mechanical engineering; use of metering devices for air, steam, and water; practice of heat measurements including heat of combustion of fuel and heat transfer; experimental studies involving use of steam engines, steam turbine driven pumps, steam pumps, steam specialties, stationary internal combustion engines, an air blower and a single stage air compressor.

2·682. Engineering Laboratory (B). Continuation of 2·681 with equipment such as the following: an air washer for humidity control, a two-stage air compressor, the M. I. T. power and heating plant, heat exchangers, a hydraulic turbine, and a refrigeration machine.

2·683T. Engineering Laboratory. More complete coverage of the work outlined in 2·681.

2·684. Engineering Laboratory. Second half of 2·683T.

2·687. Hydraulic Laboratory. Supplement to classroom theory, including exercises upon orifices, nozzles, weirs, pipes, hydraulic turbines, centrifugal pumps, and other hydraulic equipment.

2·701. Machine Drawing. Engineering drafting room procedure and technique in the production of working drawings of machinery. James, Mackenzie and Sloane, *Working Drawings of Machinery.*

2·72. Machine Design. Theories of common mechanisms, with their application in design, including wrapping connectors, screws, spur and bevel gears, worm gearing, shafts, bearings, etc.; materials, forms and proportions of parts, friction and efficiencies. (Restricted to Course XIII-A only.)

2·730. Machine Design. Lectures and drafting-room exercises covering the kinematic design of the basic mechanisms. An introductory course in machine design by application

Mechanical Engineering Continued

of the fundamentals of kinematics to geometric design. Sloane, *Engineering Kinematics.*

2·731. Machine Design. Discussion and design of machine elements with special reference to the selection of materials, proportions of parts and economies of manufacture and assembly. Frames, fastenings, wrapping connectors, shafting, and all forms of gearing.

2·732. Machine Design (B). Continuation of 2·731, including bearings, theory of lubrication, shaft connectors, flywheels, etc. Complete engineering design of a comprehensive machine.

2·733. Machine Design. Material selection, working stresses, factors of safety, machine frames, fastenings, universal joints, gears, shafts, couplings, clutches, brakes, and bearings. Vallance and Doughtie, *Design of Machine Members, Second Edition.* (Restricted to selected U. S. Naval Officers only.)

2·751, 2·752. Machine Design (RA). Thorough and rigorous discussion of the many factors involved in the design of complex machines. (Restricted to selected U. S. Naval Officers only.)

2·78. Design of Hydraulic Machinery (B). Theory and design of displacement type hydraulic machinery and its applications in industry. Discussion of problems in the control of speed, position, torque, and power.

2·782. Design of Mechanical Systems (B). Discussion and design of mechanical systems involving application of hydraulic, pneumatic, and electronic equipment. Consideration of simple closed cycle control systems. Reduction of machine vibrations. Applications of principle of similitude to machine design problems.

2·79T. Elementary Internal Combustion Engines (B) 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.

2·791. Internal Combustion Engines (B). Fundamentals of the internal combustion engine, including capacity, efficiency, thermodynamics and combustion. Taylor and Taylor, *The Internal Combustion Engine.*

2·792. Internal Combustion Engines (B). Continuation of 2·791. Fuels, lubricants, cooling, carburetion, distribution, ignition, friction, and supercharging. Taylor and Taylor, *The Internal Combustion Engine.*

2·793. Dynamics of Engines. Crank and connecting rod mechanism. Unbalanced forces and couples in single- and multi-cylinder engines. Elementary problems in crankshaft torsional vibration. R. E. Root, *Dynamics of Engine and Shaft.* (Restricted to selected U. S. Naval Officers only.)

2·794. Internal Combustion Engine Laboratory (B). Laboratory exercises supplementing the classroom work of 2·791 and 2·792. Effects of operating and design variables on engine performance, and use of instruments, with especial emphasis on precision of measurements.

2·7941, 2·7942. Internal Combustion Engine Laboratory (B). Content same as 2.794 but extended over two terms.

2·796. Internal Combustion Engine Design (B). Introduction to engine design, including work in engine dynamics stresses, materials, and design procedure.

2·797. Internal Combustion Engine Design (A). Fundamental principles of design of automotive engines. Performance and stress computations. Assembly drawings of a complete engine are started.

2·798. Internal Combustion Engine Design (A). Continuation of the assembly drawing begun in 2·797.

2·799. Automotive Dynamics (A). Balance of automotive engines and vibration problems associated with automotive engines and vehicles. Den Hartog, *Mechanical Vibrations.*

2·801, 2·802. Advanced Internal Combustion Engine Problems (A). Analytical and experimental treatment of special problems in connection with internal combustion engines.

2·805. Diesel Engines (B). Fundamentals of the compression-ignition engine, including charging process, fuel injection, combustion, cooling, fuels, and lubrication. Critical examination of existing types. Taylor and Taylor, *The Internal Combustion Engine.*

2·851. Machine Tool Laboratory Use and application of machine tools. Includes laying-out work, filing, scraping, machine parts, drilling, reaming, counterboring and tapping, tool grinding, straight and taper turning, screw cutting, milling, cylindrical and surface grinding and chucking. Special attention to the cutting angles and adjustments of cutting tools and cutting speeds for each material worked. Smith, *Advanced Machine Work.*

2·852. Machine Tool Practice. A continuation of 2·851, including fundamentals of tool making, hardening and tempering, gear cutting, thread milling and generating, planing and shaping, turret lathe and automatic screw machine practice, grinding and lapping, broaching, precision measuring, time study and production manufacturing processes. Smith, *Advanced Machine Work.*

2·871. Manufacturing Engineering (B). Principles and practice in production design, selection of factory equipment, tool and gage design, and inspection methods. Lectures and drawing-room exercises on the manufacturing design of a commodity to be produced in quantity, including the principles of dimensioning detail drawings with tolerances and the preparation of other necessary specifications required to convey precise and complete information for the selection of equipment, tool design, production, and inspection. Study and drawing exercises in tool and fixture design, as well as gages. Buckingham, *Principles of Interchangeable Manufacturing;* Roe and Lytle, *Factory Equipment;* Dowd and Curtis, *Tool Engineering.*

2·872. Preparation for Manufacturing (B). Study of many of the engineering problems which must be solved before a finished article can be manufactured in large quantities after the design of the article has been completed; such as, engineering organization, estimating costs of production, design of tools and equipment, factory extensions, and quality control. The practices of large corporations having the most highly organized engineering departments along these lines cited as illustrations and used as the foundation for discussion.

2·88. Metrology and Dimensional Engineering Standardization (A). Fundamental units of measure, measuring systems, calibration of standards; the purpose of measurements in scientific and research work, engineering in general use; conventional measuring instruments, their characteristics and methods of calibration; accuracy of measurements; analysis of measurements; shop measurements and analysis by means of measurement; dimensional engineering standardization; inspection engineering. *American Engineering Standards; S. A. E. Handbook; Notes prepared for class and Library Research.*

2·901, 2·902. Principles of Fabric Structure [2·902 (B)]. 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 (B). 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.

Mechanical Engineering Continued

2·905, 2·906. Textile Technical Analysis (A). Physical determinations of strength, stretch, moisture regain, twist and various mechanical properties of interest to the yarn and fabric technician. Formulation and proper presentation of data, precision of measurements, graphical interpretation of data, variable factors which influence textile testing results, and outlining of present trends in textile research in this country and abroad.

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 Testing Laboratory (A). Opportunity for the student to operate standard textile-testing equipment and obtain practical experience in the field covered by the lectures of 2·905.

2·912. Textile Research Laboratory (A). Studies of the variable factors influencing textile tests with opportunity to carry out one or more individual research problems in the physical or optical analysis of textiles.

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.

2·991, 2·992. Mechanical Engineering Seminar (A). Discussion and reports on special topics in mechanical engineering and related fields. Development and test of ability of candidates for the doctorate to digest and summarize an assigned topic within their general field of study, taking an active part in discussion and criticism of such presentation. At least one contribution per term by each registrant. (Open only to students working for the Sc.D. degree.)

METALLURGY

Subjects 3·00 to 3·99

3·01. Non-Ferrous Metallurgy I. Copper, lead and zinc, covering the extraction of the metal from ores and concentrates by pyro-, hydro-, and electrometallurgical methods and the refining of the crude products. The more general application of such fundamental operations as roasting, sintering, smelting, leaching, etc. Closely coördinated with 3·04. Hayward, *Outline of Metallurgical Practice.*

3·02. Non-Ferrous Metallurgy II. Production and refining of aluminum, magnesium, nickel, and other non-ferrous metals, not covered in 3·01. Hayward, *Outline of Metallurgical Practice.*

3·03. Non-Ferrous Metallurgy III (B). For men who wish special work in some phase of non-ferrous metallurgy. Work in the laboratory, drafting room and library. Each student to select his own field and work alone or in collaboration with others. One seminar per week arranged for reporting individual progress and to allow general discussion.

3·04. Metallurgical Laboratory. Roasting, sintering, smelting and leaching of copper and lead ores, together with refining and desilverizing of copper and lead. Practice in the use of various types of electric furnaces. Production of steel, ferro-alloys, calcium carbide, etc. by electrothermic methods and other pyrometallurgical and electrochemical processes.

3·041. Electric Furnaces (B). Theory and practice of electric furnaces with particular attention to metallurgical applications.

3·05. General Metallurgy (B). Fuels, refractories, fluxes and slags and their relation to the entire field of process metallurgy. Fundamental principles of roasting, smelting and refining together with charge calculations, thermal balances and materials balances. Hofman, *General Metallurgy;* Hayward, *An Outline of Metallurgical Practice.*

3·06. Advanced Non-Ferrous Metallurgy (A). Smelting and refining of the principal non-ferrous metals discussed in a weekly seminar. Present practice discussed and possible improvements suggested and criticized.

3·07. Metallurgy of Common Metals. For engineering students who do not expect to practice metallurgy as a profession. Iron and steel, copper, lead, zinc, aluminum, antimony, tin and nickel. Sources, methods of extraction, physical properties of metals, principal uses, origin and effect of impurities, refining and industrial alloys. Hayward, *An Outline of Metallurgical Practice.*

3·08. Advanced General Metallurgy (A). Fuels, refractories and the principles of roasting and smelting. Critical analysis of the manner in which these principles are carried out in present practice and suggested improvements.

3·09T. Metallurgical Calculations. Stoichiometric aspects of industrial processes in ferrous and non-ferrous metallurgy illustrated by the solution of numerous problems. Butts, *Metallurgical Problems.*

3·10. Metallurgical Plant Visits. One week spent in visiting metallurgical plants in New Jersey and Eastern Pennsylvania. Production of iron and steel, zinc, copper, lead and non-ferrous alloys. Students meet instructor about one week before opening of fall term. For men expecting to register for 3·01 or 3·12.

3·11. Advanced Metallurgical Calculations (A). Reactions involved in various metallurgical operations, with special reference to their thermal values. Calculations of heat balances and furnace efficiencies; critical study of the results with a view to suggesting improvements in design or operation of apparatus.

3·12. Metallurgy: Iron and Steel. Production of wrought iron, pig iron, steel and alloy steels. Design and engineering operations incident to iron and steel manufacture and economic advantages of the various processes. Lectures supplemented by plant visits, covered by reports and seminars.

3·16. Advanced Metallurgy: Iron and Steel (A). Class work, conferences, plant visits and library work, supplementing 3·12.

3·20. Metallurgical Thermodynamics (B). Thermodynamics emphasizing those portions especially 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 (B). 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.

3·30. Metallography. General methods in the study of metals and alloys, construction and interpretation of equilibrium diagrams and relations between the constitution of alloys and their physical properties. The iron-carbon diagram with its application to the heat treatment and the use of steel and cast iron. Laboratory exercises, with microscopic examination of a series of typical non-ferrous and ferrous alloys. Williams and Homerberg, *Principles of Metallography.*

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

Metallurgy Continued

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. Constitution, properties, heat treatment, selection and uses of steel, cast iron and other iron-base alloys. Equilibrium diagrams, phase transformations, grain size, hardenability and surface hardening.

3·33. Industrial Physical Metallurgy (B). Lectures and laboratory conferences with 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). Subjects within the general field of physical metallurgy, such as stable and metastable alloy systems, ternary phase diagrams, diffusion, phase transformations and precipitation phenomena, theories of metal hardening, and the physics of hardenability. Particular attention paid to the more recent publications on these topics.

3·38, 3·39. Advanced Physical Metallurgy. Fundamental properties of metals and alloys with particular reference to materials used in torpedo construction. (Restricted to selected U. S. Naval Officers only.)

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. (Restricted to Courses XIII-A and XIII-B only.)

3·394. Metallurgy. Structure, properties, and applications of non-ferrous metals and alloys. Phase diagrams, plastic deformation, recrystallization, heat treatment, corrosion resistance, and other important properties. Brief summary of production methods for the more important non-ferrous metals. Heyer, *Engineering Physical Metallurgy;* Williams & Homerberg, *Principles of Metallography*. (Restricted to selected U. S. Naval Officers only.)

3·395. Metallurgy. Structure, properties, and applications of iron, steel, and cast iron. Heat treatment, surface hardening and corrosion and heat resistant properties. Brief review of production of iron and steel. Heyer, *Engineering Physical Metallurgy;* Williams & Homerberg, *Principles of Metallography*. (Restricted to selected U. S. Naval Officers only.)

3·40. Corrosion and Heat Resisting Alloys (B). Electrochemical theories of corrosion. Discussion of typical corrosion behavior of engineering materials at high and low temperatures. Industrial techniques, such as electroplating, anodizing, painting, and other surface treatments employed to ameliorate corrosion.

3·41. Industrial Non-Ferrous Alloys. Mechanical properties, heat treatment, selection and uses of brass, bronze, bearing metals, alloys of aluminum, magnesium and other non-ferrous metals.

3·42. Powder Metallurgy (B). Physical and chemical methods for the production of metal powders. Pressing and annealing of alloy powder compacts and resulting properties of the finished compact. Problems of adhesion, diffusion, recrystallization and grain growth as they apply to this field. Present industrial applications of powder products.

3·422. Powder Metallurgy Laboratory (B). Laboratory work and conferences with powder metallurgy practice and its application to industrial problems.

3·50. X-ray Metallography (B). Use of X-rays in the study of metals. Radiographic examination of metal parts, as well as the X-ray diffraction study of atomic and granular structures of metals, and their relations.

3·51. Physics of Metals (B). Modern theories of the metallic state resulting from a study of 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 structures. Experimental methods of obtaining information in this field. Laboratory work in the form of short research problems.

3·60. Ferromagnetism (A). Outstanding properties of ferromagnetism materials, their interpretation, and the application of ferromagnetism to the investigation of the physical structure of metals.

3·61. Atomic Arrangements in Alloys (A). Applications of statistical mechanics and thermodynamics to alloys. Brief introduction to the fundamental concepts, and applications which seem of most interest to the class. Problems of order and disorder in alloys, ferromagnetism, phase changes and nonequilibrium states.

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.

3·65. Theory of the Solid State (B). A semi-quantitative presentation of the modern concept of solids with particular reference to metals. Electronic configuration of the elements and the manner in which these ideas can lead to an understanding of binding energies, specific heats, thermal expansion, and the magnetic and electrical properties of metals.

3·70. Ceramics (B). Introduction to the more advanced ceramic subjects. Selection of ceramic materials, molding, drying and burning, as well as the physical properties of finished products. Commercial processes carried out on a small scale.

3·71. Optical Ceramics (B). Methods of petrography applied to the study of ceramic products and raw materials, such as clay, cement, glass, porcelain, refractories, etc.

3·73. Fundamental Ceramic Processes (A). Forming, drying and burning of clay articles, such as whitewares, refractories, terra cotta, etc. Principles involved in the manufacture and use of glass, cements and abrasives. Principles of kiln and furnace design with practical examples.

3·74. Physical Properties of Ceramic Products (A). Methods of determining the properties of finished ceramic articles. Influence of manufacturing methods on these properties with effective methods of control.

3·75, 3·76. Special Problems in Ceramics (A). Advanced work in this field. Time devoted to lectures, conferences, assigned readings, or laboratory work.

3·81. Mineral Dressing I. Introduction to the dressing of ores, coals and mineral substances from the unit-process point of view. Emphasis on the principles involved in the severance, separation and aggregation of particulate materials, and on the relationship of these principles to physical and chemical laws and to sound engineering design. Processes including crushing, grinding, screening, classification, gravity concentration, float-and-sink separation, flotation, amalgamation, magnetic separation, thickening, filtration, and sintering. Gaudin, *Principles of Mineral Dressing*.

3·82. Mineral Dressing II. The flotation process and its broad applications. Gaudin, *Flotation*.

3·83T. Mineral Dressing III (B). Crushing and grinding. Fundamentals of size distribution and size reduction of particulate solids.

3·84T. Mineral Dressing IV (B). Fundamentals of separating particulate solids according to differences in specific gravity.

3·86T. Quantitative Mineragraphy. Mineralogical study of ores and minerals from the point of view of their dressing or subsequent processing. Ores or minerals studied in polished section, thin section, as loose grains or as polished briquettes. Emphasis on quantitative and dimensional aspects of textural and structural relationships.

3·87T. Ore Testing (B). Practice in choosing concentration methods for specific ore samples, in developing laboratory dressing technique, and in preparing reports.

Metallurgy Continued

3·88T. Mineral Dressing Practice (B). Principles of arrangement, location, and operation of mills; mill costs, general economics of dressing operations, typical flowsheets, and fundamentals of design. Richards and Locke, *Textbook of Ore Dressing.*

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 Ore Dressing.*

3·90. Advanced Mineral Dressing (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.

3·902. Advanced Mineral Dressing Laboratory (A). Continuation of 3·901.

ARCHITECTURE AND PLANNING

Subjects 4·00 to 4·99

4·031, 4.032. Freehand Drawing. Problems in the understanding of form and space, their coördination, and their graphic expression. Basic figure construction and anatomy; rapid drawing direct from the human figure. Eight weeks' work at the Boston Museum of Fine Arts in studying and analyzing the design of architectural and sculptural forms.

4·041, 4·042. Freehand and Color. Selection and use of appropriate graphic techniques for study in, and representation of, building materials and other elements of architectural design. Four weeks of each term spent in figure sketching.

4·051T, 4·052T. Freehand and Color (B). A continuation of 4·042. More advanced problems in design and materials with special reference to architectural application. Attention is given to graphic expression of the relationship of building to land. A limited part of each term is spent in advanced figure drawing.

4·053, 4·054. Freehand Drawing (A). Continuation of 4·052. Problems of an advanced nature fitted to the needs of the individual student. Open only to graduate students or others who demonstrate fitness for advanced work.

4·07. Shop. Working experience with commonly used materials to develop familiarity with their qualities and the influence of these qualities on their application in design. Use of hand and power tools to inculcate techniques required in future subjects for making quick and accurate architectural models or full-scale furniture designs.

4·10. Architectural Illumination. Solution of small problems in architectural design chosen to illustrate the influence of illumination requirements on architectural form. Collaborative work with professional students of architecture on advanced problems involving illumination in buildings.

4·41. Fine Arts. Illustration and analysis of typical artistic productions, to stimulate the habit of observation, and to make the student sensitive and discriminating in his artistic preferences. Sufficient history to place significant periods and masters. Classwork in common for all; outside work specialized, as students prefer, in any of the fine arts. Demonstration in the Graphic Arts, and practice for students desiring it.

4·451, 4·452. History of Architecture. Illustrated lectures comprising a general survey of the Architecture of all periods, supplemented by reference reading, theme writing, and conferences.

4·461, 4·462. European Civilization and Art (B). History of culture, mainly that of Europe. The main currents of science and philosophy, with emphasis upon literature, sculpture and painting. Lectures, readings, and reports.

4·50. 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.

4·52. Office Practice (A). Office practice in the office of a city or regional planning agency, the work required in research or design being of an advanced nature.

4·541, 4·542. Housing Seminar (A). Open only to a limited number of mature students, and not given if there are less than five registrants. General introductory evaluation of the housing problem; intensive critique of concepts and relationships in housing from social, technical, economic, and administrative points of view; historical survey beginning with the 1914 legislation in Europe, with special critical attention directed to contemporary solutions in Europe and the United States; consideration of present social and economic trends and their future implications to housing. Fortnightly, exercises, each student presenting a portion of the subject selected for that exercise, his presentation being based upon extensive reading offered by a large bibliography. Oral presentations supplemented in all cases by written reports. Serious library work.

4·59. Government and Public Administration. Structure of local and state governments; powers and duties of local authorities; general survey of the field of public administration, including the relationship of administrative agencies to the legislative and judicial branches of government; general principles of municipal finance; long-term programming and financing of public works.

4·60. Planning Legislation and Administration (B). Survey of past and present legislation relating to city planning and housing; general powers and duties of local authorities; typical acts relating to planning and housing in the United States and abroad; modern tendencies in legislation; other legal aspects of planning, such as zoning laws, building codes, private deed restrictions, etc. Administrative problems of planning commissions and zoning boards of appeal; organization and administration of planning projects in state, county, region, and city; securing citizen and official interest and sanction.

4·62. Site Planning and Construction. Primarily for students in City Planning, including problems in site planning with emphasis on the relations to physical conditions, landscape construction, and costs. Use of contour maps, layout of roads, pedestrian circulation, grouping of buildings, surface and subsurface drainage, utilities, community services, efficiency of land use, details of construction and costs of management (public and private). Major portion of the subject devoted to preparation of site and utility plans for a specific project.

4·621. Site Planning and Construction (B). Contains all of the subject matter of 4·62, presented primarily for advanced students in Architecture.

4·641. Principles of City Planning. 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. Thomas Adams, *Outline of Town and City Planning.*

4·651, 4·652. Theory and Practice of City Planning. Advanced problems of city and regional planning, together with modern methods of dealing with them. Collateral reading, written reports, and round table discussions.

4·661, 4·662. City Planning Research (A). Selected topics in the field of city and regional planning. Supervised study, with conferences, readings, and reports but without lecture hours.

Architecture and Planning Continued

4·672. City Planning Design. Research into the social, economic, and physical structure of a community, followed by the design of functional elements such as areas for residence, commerce, and recreation.

4·681. City and Regional Planning. Practical application of city and regional planning theory to towns, cities, and regions, including problems of replanning and redevelopment in existing communities. Individual problems, supplemented by group projects worked out in collaboration, and preliminary and final reports.

4·682. City and Regional Planning. Continuation of 4·681.

4·683. City and Regional Planning (B). Continuation of 4·682.

4·691. Advanced City and Regional Planning (A). Continuation of 4·683.

4·692. Advanced City and Regional Planning (A). Continuation of 4·691.

4·721, 4·722. Architectural Design. Investigation of requirements and determination of solutions for building problems selected from many fields of human activity (habitation, education, health, recreation, government, religion, industry, merchandising, and transportation). Relationship of buildings to physical and social environment, technique of organizing spaces of different kinds in relation to each other, climate and orientation, and selection of appropriate materials and construction. Individual and collaborative work.

4·731, 4·732. Architectural Design. Continuation of the planning studies initiated in the previous year. At least one problem in each term carried to an advanced stage of analysis to give facility in the adaptation of a building to its site, to apply structural methods and calculations, and to investigate typical details such as windows, copings, stairways. Numerous short problems emphasizing methods of dealing with specific conditions in planning or the use of materials.

4·741, 4·742. Architectural Design. Consolidation of previous design experience. Problems affording an opportunity to study particular conditions encountered in larger buildings, such as: circulation, control, and safety of crowds, accommodations for vehicles and freight, and the use of elevators, and special equipment. Presentation of one detailed problem in the second term, with studies of structure, assembly of materials, heating and ventilating, sanitation, acoustics, electricity, and illumination.

4·751T. Architectural Design (B). Problems emphasizing basic community needs in housing, recreational, commercial, and educational categories, and inviting speculation as to the future possibilities for adequate solutions to these problems. Disposition of groups of buildings on new sites with analysis of economic considerations.

4·761, 4·762. Architectural Design (A). Research, development of program, and design of buildings with particular attention to thorough consideration of social, economic, and technical influences and integration of these factors in the solution of the problem. Site plans, considered in their architectural and engineering aspects; and collaborative projects with graduate students in City Planning.

4·78. Planning Principles. Principles underlying all good planning such as the logical relation to one another of the different parts of a building, the arrangement of proper lighting and circulation, axial development and balance.

4·811. 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. W. H. Lawrence, *Notes on the Analysis and Design of Elementary Structures; Mimeograph Notes.*

4·812. Structural Analysis. Continuation of 4·811 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. *Mimeograph Notes.*

4·98. Thesis Research (A). Investigation leading to student's choice of a thesis subject and organization of the essential data into a complete statement of his program.

CHEMISTRY

Subjects 5·00 to 5·99

Inorganic Chemistry

undergraduate subjects

5·00. Entrance Chemistry. Lectures, recitations and laboratory given during the summer to cover the entrance recommendation in chemistry.

5·01, 5·02. General Chemistry. Fundamental principles of chemical science and descriptive chemistry of the more common elements and their important compounds. Publication by M. I. T. Staff, *General Chemistry;* Latimer and Hildebrand, *Reference Book of Inorganic Chemistry.*

5·03. Chemistry. *General:* Consideration of inorganic chemical principles such as atomic and molecular structures, electrolytes, reactions in solutions, ionization, chemical equilibrium, light metal alloys, corrosion of metals. *Lubricants:* Petroleum and its products, including certain organic concepts, production, characteristics, standard tests, interpretation of data. *Plastics:* Composition, manufacture, properties, limitations, particularly as applied to airplane construction. Briscoe, *General Chemistry for Colleges, Third Edition;* Simonds, *Industrial Plastics, First Edition;* Government Printing Publications: *Significance of Tests on Petroleum Products; Federal Specifications for Lubricants and Fuel Oils.* (Restricted to selected U. S. Naval Officers only.)

5·061, 5·062. Advanced Inorganic Chemistry (B). 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, throughout the course.

graduate subjects

5·071, 5·072. Special Topics in Inorganic Chemistry (A). Selected subjects, varying from year to year, presented by the members of the class and the staff, 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.

5·08. Advanced Inorganic Laboratory (A). Typical research methods, including such procedures as employment of high vacuum technique, conduct of operations in inert atmospheres and in non-aqueous media, isolation of compounds of the rarer elements, etc. Reference to the original literature required for experimental details.

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 macro scale of a large number of solutions and solids, including alloys, pigments, minerals, slags and miscellaneous commercial products. Preparation for quantitative analysis, correlating and systematizing much of the information already obtained in general inorganic chemistry. Noyes and Swift, *Qualitative Chemical Analysis.*

Chemistry Continued

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.*

5·12. Quantitative Analysis. Discussion of principles of volumetric and gravimetric analysis with detailed attention to the solution of stoichiometric problems. Laboratory work consisting of quantitative analysis by volumetric and gravimetric methods of typical natural and commercial products, and covering acidimetry, the permanganate and iodimetric processes, precipitation methods and gravimetric methods. Considerable emphasis on the development of careful laboratory technique. Hamilton and Simpson, *Calculations of Quantitative Chemical Analysis;* Talbot, *Quantitative Chemical Analysis.*

5·13. Quantitative Analysis. Continuation of 5·12. A correlative study of analytical chemistry for the identification and determination of the more common constituents. Analysis of silicates, minerals, ores and alloys including electrolytic and electrometric methods, and when possible, an original study of some special analytical problem. Gas analysis.

5·141. Analytical Chemistry. Instrumental methods of analysis. Chemical applications of the microscope, including microchemical qualitative analysis, spot tests, and identification of crystalline material by the polarizing microscope. Use of the spectrograph, spectrophotometer, polariscope, polarograph, colorimeter, and refractometer.

5·35. Applied Chemistry. Theoretical principles underlying the causes and prevention of corrosion. Critical examination from the corrosion viewpoint of the composition of numerous industrial alloys and the chemistry of protective coatings such as: paints, varnishes, lacquers and inhibitors. Speller, *Corrosion — Causes and Prevention.*

Organic Chemistry

undergraduate subjects

5·41. Organic Chemistry I. Comprehensive survey of the chemistry of carbon compounds, including study of the basic principles and most important classes of the acyclic, isocyclic and heterocyclic divisions. Emphasis on systematic nomenclature, general synthetic methods, and characteristic reactions, with appropriate attention to practical applications of organic compounds in science and industry.

5·414. Organic Preparations. Fundamental unit processes and techniques of synthetic organic chemistry; experimental study of typical reactions of organic classes.

5·416. Organic Preparations. Examples of synthetic techniques in organic chemistry, and experimental study of typical reactions of organic classes, culminating in a short special synthetic problem.

5·417. Quantitative Organic Analysis. Practice in the determination of carbon, hydrogen, nitrogen, halogens and sulfur by semi-micro combustion methods.

5·42. Organic Chemistry II. Development of the general synthetic and analytical methods of organic chemistry with particular emphasis upon bifunctional and polyfunctional organic compounds and their derivatives, carbohydrates fats, proteins, dyestuffs, pharmaceuticals, etc. Further emphasis on basic principles coupled with substantial amplification and extension of fundamental theories and methods as applied to acyclic, isocyclic and heterocyclic divisions.

5·424, 5·426. Identification of Organic Compounds. Fundamental methods of identification of organic compounds of known structure. Test of acquired proficiency in methods of procedure by rigorous identification of assigned "unknowns," and by execution of a special experimental problem in the field of organic qualitative analysis.

5·428. Organic Chemistry Laboratory. Practice in the fundamental techniques of organic chemistry. Emphasis on synthesis and identification of simple organic compounds, as well as experimental study of the typical reactions of the more important classes of compounds. Primarily for students majoring in biology and biological engineering, and those intending to enter medical school.

5·43. Organic Chemistry III (B). Consideration of selected classes of organic compounds from a viewpoint more mature than is possible during the first year of study of the subject. Special emphasis on the chemistry of organic compounds containing nitrogen and/or sulfur. Full study of the Beilstein classification of organic compounds.

5·44. Organic Chemistry IV (B). Consideration of the application of the theory and practice of organic chemistry with special attention to currently important industrial processes and products.

graduate subjects

5·51. Functional Groups in Organic Chemistry (A). Consideration of the most important functional groups with special emphasis upon their introduction and characteristic behavior, especially as influenced by their molecular environment and other conditions.

5·52. Reactivity, Mechanism and Structure (A). Theory and factors which govern the reactivity of organic compounds, and the present state of knowledge of the mechanism of reactions. Molecular structure and the influence of resonance.

5·55. Identification of Organic Compounds (A). Consideration of systematic methods for the unequivocal identification of organic classes and individual organic compounds. Emphasis on methods of establishment of structure and of differentiation between compounds having closely similar properties.

5·561. Chemistry of Heterocyclic Compounds (A). Chemistry of the various heterocyclic ring systems. Methods of preparation. Activity of functional groups in heterocyclic systems, compared with that in the aromatic and aliphatic systems.

5·562. Carbohydrates (A). Stereochemistry, configuration, structure, derivatives, and reactions of carbohydrates with reference to industrial and biological applications of such knowledge.

5·565. Terpenes (A). Acyclic, monocyclic and bicyclic terpenes, sesquiterpenes and polyterpenes and their chemical interrelationships.

5·566. Amino Acids and Proteins (A). Isolation, identification and synthesis of amino acids and organic chemistry of proteins.

5·568. Natural Products (A). Chemistry of vitamins, hormones and related natural products of biological importance.

5·581, 5·582. Advanced Organic Laboratory (A). Theory and practice of laboratory technique, including practice in micro manipulation, fractionation of a drop, vacuum fractionations, molecular distillations, and use of special apparatus.

5·591, 5·592. Recent Advances in Organic Chemistry (A). Consideration, in each term, of a group of four or five topics of current interest and significance in organic chemistry or closely allied fields. Appropriate development of each of these topics as a unit by means of three lectures by various members of the staff. Different unit topics in each academic year.

Physical Chemistry

undergraduate subjects

5·61. Physical Chemistry I. Atomic weights, elementary thermodynamics, properties of gases, liquids and crystals, ideal solutions, transference and conductance of ionized solutes, thermochemistry, homogeneous equilibrium. Millard, *Physical Chemistry for Colleges.*

5·611. Physical Chemistry Laboratory I. Laboratory coördinated with the topics of 5·61.

5·612. Physical Chemistry Laboratory I. Abridgment of 5·611.

Chemistry Continued

5·62. Physical Chemistry II. Continuation of 5·61. Change of equilibrium with temperature, heterogeneous equilibrium, phase equilibrium, kinetics of chemical reactions, free energy of chemical changes, potentials of electrolytic cells.

5·621. Physical Chemistry Laboratory II. Laboratory coördinated with the topics of 5·62.

5·622. Physical Chemistry Laboratory II. Abridgment of 5·621.

5·63. Introduction to Thermodynamics (B). Fundamental definitions and concepts; first and second laws of thermodynamics with applications to chemical systems, ideal and real gases, ideal and real solutions, partial molal 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*.

5·64. Introduction to Radiation Chemistry (B). Structure of atoms as inferred from results of experiments: deflection of charged particles in electric and magnetic fields, interaction of matter with charged particles or neutral particles of high velocity; emission and absorption of radiation. Discussion of these results and the periodic table in terms of the quantum theory. Transition to the study of molecular structure provided through the concepts presented.

5·65. Kinetics of Chemical Reactions (B). Introduction to kinetic theory of gases with special emphasis on the calculation of collision frequencies; theoretical and experimental aspects of the kinetics of homogeneous reactions in gaseous and liquid systems. Hinshelwood, *Kinetics of Chemical Change*.

5·66. Surface and Colloid Chemistry (B). The structure of surfaces; surface and interfacial tensions, including solid-fluid interfaces; absorption, 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.

GRADUATE SUBJECTS

5·71T. Physico-Chemical Experimental Techniques (A). Unit experiments designed to illustrate principles and research techniques in the following fields, among others: production, control, and measurement of pressures, temperatures and temperature differences in various ranges from very low to very high; measurement of mass and volume; determination of physical properties of fluid mixtures; measurements of electromotive force, current, and resistance; determination of energy, intensity and wave length of radiation; production of and determination of the properties of molecular, ionic and electronic beams.

5·72T. Radiation Chemistry (A). Review of atomic spectra in terms of energy levels, followed by a brief introduction to the mechanics of molecular motion. The spectra of diatomic and polyatomic molecules are used to derive the molecular constants and to distinguish between possible structures of molecular species. Ultraviolet emission and absorption spectra, infra-red absorption spectra, and Raman spectra provide the data used.

5·73. Advanced Radiation Chemistry (A). Modern statistical methods for calculating macroscopic properties such as free energy, entropy, and heat capacity which require a knowledge of the *miscroscopic* properties of molecules. These properties such as bond strengths, internuclear distances, atomic angular distribution, nuclear spin, and dissociation energies are derived from spectroscopic data. The mechanics of molecular motion are considered, and with the aid of the quantum theory, the relation of molecular constants to spectroscopic constants is derived. The primary reactions of photochemistry are interpreted in terms of the spectra.

5·74. Statistical Mechanics (A). Introduction to the principles and methods of statistical mechanics, with applications to physico-chemical problems. Thermodynamic properties of ideal gases, real gases, crystalline solids, and liquids. Mayer and Mayer, *Statistical Mechanics*.

5·75, 5·76. Chemical Thermodynamics (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.

5·77. Kinetic Theory (A). Development of the kinetic theory of gases from the modern standpoint with applications to laboratory problems involving gases. Kennard, *Kinetic Theory of Gases*.

5·79. Physical Chemistry of High Polymers (A) Physical and chemical properties of substances of high molecular weight, considered from a fundamental viewpoint. Molecular structure of natural and synthetic high polymers; thermodynamics, kinetics, and mechanism of polymerization reactions; thermodynamic and mechanical properties of polymers and their solutions. Emphasis on general behavior, rather than specific practical applications.

RESEARCH

5·90. Special Problems in Chemistry (A). Directed research and study of special chemical problems. For graduate students only.

5·911, 5·912. Journal Meeting in Inorganic Chemistry (A). Discussion of recent publications on topics of interest to the inorganic chemist. Scope of these topics generally somewhat more limited than those given in 5·071 and 5·072, although the report is expected to include a brief review of the field related to the particular paper chosen for discussion.

5·913, 5·914. Journal Meeting in Organic Chemistry (A). Discussion of current journal publications in organic chemistry by graduate students and staff members.

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).

5·943, 5·944. Research Conference in Organic 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

6·00T. Principles of Electrical Engineering (Electric Circuits). Limitations of circuit theory; idealizations inherent in symbolic representation by means of circuit elements; steady-state alternating-current theory for linear circuits, including polyphase systems; complex function loci; transient behavior of linear and nonlinear circuits; electric-circuit representation of electromechanically coupled systems. *Electric Circuits*, by Members of the Department Staff.

6·01T. Principles of Electrical Engineering (Magnetic Circuits and Transformers). Properties of magnetic materials; magnetic circuits; transformers for power and communications circuits; polyphase systems. *Magnetic Circuits and Transformers*, by Members of the Department Staff.

6·02T. Principles of Electrical Engineering. Engineering electronics including the internal phenomena of vacuum and gas tubes, and the analysis of circuits containing such tubes; single-phase and polyphase rectifiers, amplifiers, oscillators, modulators, and demodulators. *Applied Electronics* by Members of the Department Staff.

6·03T. Principles of Electrical Engineering (B). Polyphase synchronous and induction machines, single-phase

Electrical Engineering Continued

alternating-current motors, synchronous converter. Lawrence, *Principles of Alternating Current Machinery, Third Edition.*

6·04. Principles of Electrical Engineering (B). General survey of transmission-line problems, calculation of line constants, short-line solutions, skin effect, corona, insulator stresses and insulation break down, hyperbolic-function solution of long-line problems, graphical methods, circle diagrams, transients, system stability, solution of networks. Woodruff, *Principles of Electric Power Transmission*, 2d *Edition.*

6·05. Principles of Electrical Engineering. Resistance and resistance networks; associated electrical measurements laboratory experiments; orientation lectures, educational films. *Electric Circuits*, by Members of the Department Staff.

6·11. Principles of Electrical Engineering. Brief discussion of vacuum-tube characteristics and a treatment of elementary circuits containing such tubes. Detailed consideration of audio-frequency amplifiers followed by a short discussion of tuned amplifiers, oscillators and the application of nonlinear elements in modulation and detection. Elementary theory and study of the operating characteristics of motors, generators, and power transformers.

6·16. Electricity. Electricity rate structures and schedules; wires and safe wiring practice; d-c and a-c generators; transformers; electronic devices and rectifiers; d-c and a-c motors; motor control equipment; batteries. This subject treats the foregoing equipment as components of the modern building and the principles involved as the concern of the designer. Applications in heating, ventilating, air-conditioning, lighting, refrigeration, elevators, conveyers, communications, signal systems, protection of person and property, therapeutics and other services to occupants of the buildings are studied as separate or combined devices. Elevators are treated as a 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.

6·18. Fundamentals of Electrical Engineering. Fundamental principles of electric and magnetic circuits and the application of these principles to the theory and performance of direct- and alternating-current machines. Presentation of the basic elements common to the electrical field, illustrated and amplified by association with engineering applications laid out as the first part of a two-term program with electronic and other aspects of electrical engineering considered during the second term subject. Classroom construction supplemented by experimental work in the electrical-engineering laboratories.

6·181. Electrical Engineering. Similar to 6·18. (Restricted to selected U. S. Naval Officers only.)

6·19. Fundamentals of Electrical Engineering. Continuation of the two-term program begun in 6·18. Electron-tube parameters and equivalent circuits, theory of simple amplifier, oscillator, rectifier, photoelectric-cell, and gas-filled tube circuits, and brief survey of electrical-measurement and -control techniques.

6·191. Electrical Engineering. Similar to 6·19. (Restricted to selected U. S. Naval Officers only.)

6·20. Electronic Control and Measurement (B). Analysis and design principles of electronic devices for control and measurement in engineering, as applied to phototube devices, voltage regulators, water-level controls, spot-welder controls, sensitive wattmeters, voltmeters, ohmmeters, high-speed recording instruments, stroboscopes, flash-photography apparatus, etc. Detailed consideration of the following subjects: grid current and its effect in high-impedance circuits; amplifiers with direct, resistance-capacitance, push-pull and degenerative coupling; methods of frequency conversion to facilitate amplification or measurement; trigger circuits; and negative-resistance oscillators. Emphasis on importance of the nonlinear properties of electron tubes either as limitations or as useful characteristics.

6·211. Applications of Electricity to Industry (B). Scientific basis for modern applications of electricity in industry. Sources of energy. Analysis of power production in United States. Choice of system. Elements of electrical energy costs. Distribution of energy within the plant. Principles of electric heating, including energy conversion to heat, heat transfer, heating and cooling of metals, resistance heating, arc furnaces, low-frequency and high-frequency induction furnaces.

6·212. Applications of Electricity to Industry (B). Mechanical, thermionic and photo-electric applications. Duty cycles. Operating characteristics of motors. Controller design and application, including types, methods of acceleration and retardation, protective devices. Essentials of connecting motor to load. Principles of moving fluids and solids. Problems in the application of motors, electron tubes and photo-electric cells.

6·221, 6·222. Electric Power Generation (B). Economics and technique of electric power generation. Study of the generating station as a unitary instrument for the conversion of energy. Generation with an appropriate degree of reliability at minimum total cost. Effect of the characteristics of the load curve on cost of generation. Thermal efficiency and commercial economy of various heat cycles. General layout of the generating station. Calculation of fault currents and the operation of protective devices. Division of load among generating units for minimum cost. The interrelation between steam and hydro generation. By-product generation. Joint operation of industrial and central-station plants. Energy storage systems.

6·23. Electrical Implementation (B). Principles underlying electrical methods of measurement, operation, and control in problems involving devices, processes, and systems of nonelectrical as well as electrical nature. Comprehensive case studies selected from such topics as dynamic performance of electromechanical systems of moving-conductor, moving-iron, piezoelectric and magneto-strictive types; electrothermal systems; elementary theory of automatic control; switching systems; the design point of view, including use of physical similitude, optimizing of performance, and minimizing of costs. Emphasis upon use of electric-circuit analogies and models.

6·251. Electric Machinery Design (B). Transformers and induction motors. Materials of construction, methods of construction, calculation of electrical characteristics, eddy-current losses in the windings, and influence of various factors of design on manufacture and operation of machines.

6·252. Electric Machinery Design (B). Design of synchronous and direct-current machines. Continuation of 6·251, but also complete within the term.

6·26. Electric Insulation (B). Fundamental laws of electric insulation and their application. Comprehensive introduction aimed at a general orientation in the field. Vacuum, gas, liquid and solid insulation discussed principally from the point of view of the behavior of electrons and ions, atoms and molecules in producing the dielectric properties of engineering insulating materials. Experimental demonstration with some of the lectures.

6·27. Principles of Illuminating Engineering. Introductory and broad survey of the whole field of illuminating engineering. Classroom work, problems, and laboratory investigations dealing with light sources, photometric units and measurements, vision, and lighting design. A foundation for advanced subjects. Moon, *The Scientific Basis of Illuminating Engineering.*

6·271, 6·272. Principles of Illuminating Engineering (B). Detailed treatment of particular phases of the subject matter of 6·27. Calculation of illumination from point sources with symmetric and asymmetric distributions, calculation of illumination from surface sources, the unit sphere method, the contour integral method, applications to daylighting and built-in artificial lighting. Photochemical theory of vision, data on the visual thresholds and application to lighting design. Design of lighting systems, reflectors, and glassware. Moon, *The Scientific Basis of Illuminating Engineering.*

Electrical Engineering Continued

6·281. Principles of Wire Communications (B). Electrical transmission characteristics, as a function of frequency, of long lines with distributed constants in the steady state, distortion and its correction, communications transformers, insertion loss, networks, loading, filters, balancing networks, repeaters and carrier-current systems.

6·293. Principles and Applications of Radar (R). (Restricted to selected U. S. Army Officers only.)

6·294. Principles and Applications of Radar (RB). (Restricted to selected U. S. Army or Naval Officers only.)

6·295. Principles and Applications of Radar (RB). (Restricted to selected U. S. Naval Officers only.)

6·30. Principles of Electrical Communications. Fundamental principles for the solution of electric circuit problems in the Communications field, including the following topics: Fourier series and Fourier integrals and their use in analysis and synthesis; introduction to network synthesis with emphasis upon the reactive case; equivalent and impedance-transforming networks; effect of small amounts of incidental dissipation; single- and double-tuned circuits and other simple types of coupling networks.

6·311. Principles of Electrical Communications (B). Theory and applications of vacuum tubes and their associated circuits as elements of communications systems. Nonlinear operation of tubes, amplifiers, feedback systems, oscillators, amplitude and frequency modulators, demodulators, converters, and power supplies. Cathode-ray tubes and circuits. Brief consideration of typical radio transmitters and receivers.

6·312. Principles of Electrical Communications (B). Detailed studies of various radio communications systems. Analysis of transmitters and receivers for amplitude and frequency modulation services with reference to design problems. Short-wave transmitters and receivers. Ultrahigh-frequency generators including velocity-modulation devices and magnetrons.

6·321. Principles of Electrical Communications (B). Discussion of the propagation of voltage and current on transmission lines in the sinusoidal steady state; significant features of low- and high-frequency applications; properties of almost lossless lines; impedance transforming properties of lines; transmission line charts; use of lines as coupling networks and as resonators; introduction to the theory of wave filters and corrective networks.

6·322. Principles of Electrical Communications (B). Physical aspects of vector analysis and of Maxwell's field equations; discussion of the problems of electrostatics, magnetostatics, and dynamics to show reasons for introducing concepts of scalar electric and magnetic vector potential functions; retarded potentials; plane waves in dielectrics and conductors; skin effect; the concept of skin depth and the calculation of effective resistance; Poynting's theorems; reflection and refraction of plane waves; propagation of waves along infinite conducting planes; rectangular wave guides; the radiating dipole; the linear antenna; antenna impedance; antenna arrays and radiation patterns.

6·331, 6·332. Electrical Communications Laboratory (B). Study of experimental methods in the solution of communications problems. Theory and use of modern laboratory instruments. Study of vacuum tubes and their circuits, artificial lines, and other networks, radio frequency and acoustical measurements. Correlation of physical behavior and theory of operation. Practice in designing and constructing components of communications systems.

6·34. Electrical Communications Laboratory (B). Special undergraduate work in vacuum-tube circuits, audio-, radio-, and ultrahigh-frequency measurements and acoustics arranged to meet the needs of the individual. Opportunity for acquiring experience in design, construction, and testing of components of communications systems.

6·40. Elements of Electrical Engineering. Applications of the general principles of the electric and magnetic circuit and electronics to the generation, distribution and utilization of direct- and alternating-current power. Applications based upon modern industrial problems involving motor drive, illumination, automatic control, rectification, measurement and communication with continuous attention to the economic justification for each solution. Hudson, *Engineering Electricity, Third Edition.*

6·43. Electrical Engineering. Fundamental theory of direct-current and magnetic circuits, magnetic and electric fields. Fundamentals and characteristics of direct-current machinery, with emphasis on the selection of machinery and control equipment as affected by torque requirements and duty cycles imposed by the load. Timbie and Bush, *Principles of Electrical Engineering, Third Edition;* Kloeffler, Brenneman, and Kerchner, *Direct-Current Machinery.* (Restricted to Courses XIII-A and XIII-B only.)

6·44. Electrical Engineering. Continuation of 6·43 on direct-current machinery, with experimental work in the Electrical Machinery Laboratory. Fundamental theory of alternating-current circuits, with comprehensive problems illustrating the theory and its applications. Kloeffler, Brenneman, and Kerchner, *Direct-Current Machinery;* Lawrence, *Principles of Alternating Currents, Second Edition; Instructions for Students in Electrical Engineering Laboratories, Eleventh Edition.* (Restricted to Courses XIII-A and XIII-B only.)

6·45. Electrical Engineering (RB). Theory and characteristics of transformers, synchronous machines and induction machines, with emphasis on selection of alternating-current machinery and control equipment as affected by torque requirements and duty cycles imposed by the load. Lawrence, *Principles of Alternating-Current Machinery, Third Edition; Instructions for Students in Electrical Engineering Laboratories, Eleventh Edition.* (Restricted to Course XIII-A only.)

6·46. Electrical Engineering (RB). Elementary theory of electronic devices and their applications in circuits for measurement and control purposes, with emphasis on amplifiers and rectified-power supplies. *Applied Electronics* by members of the Department Staff. (Restricted to Course XIII-A only.)

6·48. Electrical Equipment of Buildings. Design of electric wiring, lighting and elevator systems for buildings. Cook, *Electric Wiring.*

6·501, 6·502. Electrical Engineering Seminar (A). Designed to give graduate students experience in the preparation and presentation of technical papers, and to present to the students and staff of the Department, both at the meetings and by means of the file of completed Seminar papers which is maintained in the Vail Library, the history of developments which are of special interest to electrical engineers.

6·511. Electric Power Circuits (A). Theory of symmetrical components and application to electric power systems operating under unbalanced conditions. Theory of equivalent circuits with application to component parts of power networks. Calculation of resistance, inductance and capacitance of transmission lines for currents of the different sequences. Analysis of single and multiple faults. Comprehensive treatment of electric power systems in the steady state. Lyon, *Applications of Symmetrical Components;* Edith Clarke, *Circuit Analysis of A-C Power Systems.*

6·512. Electric Power Circuits (A). Transients on long lines. General theory of travelling waves, followed by a consideration in detail of reflections and refractions at junction points, circuit discontinuities and terminals, effect of resistance, inductance and capacitance in series and in parallel with the line, the effect of choke coils, etc. Lightning and its effect on transmission lines. Review of laboratory and field test methods and apparatus. Principles and practice involved in lightning protection of lines. Ruedenberg, *Elektrische Schaltvorgänge;* Bewley, *Traveling Waves on Transmission Systems.*

6·515. Power Systems Laboratory (A). Power-network analysis using the network analyzer (an alternating-current calculating board). Problems including those relating to steady-state operation; to symmetrical and unsymmetrical faults; and to steady-state and transient stability. Problems preferably submitted by the student.

6·516. Power System Analysis (A). Studies of the technical problems which arise in the operation of major transmis-

Electrical Engineering Continued

sion systems and in planning for system expansion and interconnection. Discussion of theoretical aspects of the problems and application of methods of analysis to the study of representative modern power systems on the M. I. T. Network Analyzer. Problems concerned with both normal steady-state operation and operation during and immediately following fault conditions; such as, steady-state power and reactive-power flow and its control in large systems; voltage regulation and the maintenance of voltage levels; interconnection of generating units within a station and its effect on system reliability and on relaying and circuit-breaker duties; steady-state and transient stability and power limits and their effects on system operation and design; frequency variations and tie-line power swings; and the action and effects of governors, excitation systems, and damper windings.

6·521, 6·522. Advanced Alternating-Current Machinery (A). Analysis of more intricate electrical problems met in the operation of alternating-current machinery; such as effect of unbalanced conditions on the operation of synchronous and induction machines; eddy currents in laminations, solid rotors, and conductors of direct-current and alternating-current machines; harmonic analysis of the magnetic density existing in the air gap of synchronous and induction machines including the effect on generated e.m.f., torque, and vibration; transient conditions due to the sudden alteration of the electric circuits or to the sudden variation of the shaft load of synchronous and induction machines, particularly the effect of sudden short circuit on the current and torque and the conditions which arise while pulling into step and phase swinging. Facilities available in the machine-transients laboratory for supplementary experimental work.

6·531, 6·532. Power System Economics (A). Determination of demand, energy and customer components of cost of electric power. Allocation of demand costs. Study of load curves, load, diversity, loss and demand factors, load duration and peak percentage curves. Analytical studies of prediction of peak demand and energy output. Theory of incremental heat rates and their application to load division. Incremental loading of generating stations including effect of losses in transmission circuits. Rate structures, Hopkinson and Wright demand rates, off-peak rates, power-factor and coal clauses. Increment costs. Cost of energy losses in a power system. Economics of power-factor costs, correction and conductor sizes. Problems in interconnection studies and methods of operation. Cost, economic functions and value of hydro power. Firm capacity. Rate bases, depreciation, financial and operating statistics and forms of organization, problems in public utility economics and management. Relation between load, capacity and service continuity. Economics of radial distribution, primary and secondary networks.

6·541. 6·542. Electric Power Generation (A). Economics and technique of electric power generation. Study of the generating station as a unitary instrument for the conversion of energy. Generation with an appropriate degree of reliability at minimum total cost. Effect of the characteristics of the load curve on cost of generation. Thermal efficiency and commercial economy of various heat cycles. General layout of the generating station. Calculation of fault currents and operation of protective devices. Division of load among generating units for minimum cost. Interrelation between steam and hydro generation. By-product generation. Joint operation of industrial and central-station plants. Energy storage systems.

6·551, 6·552. Railroad Electric Traction (A). Electrical and mechanical principles and economic considerations relating to railway electrification. Mechanics of traction, calculation of speed-time curves, train resistance for conventional design, light-weight, and stream-lined equipment as a function of weight and speed, energy consumption and power demand, analysis of motor characteristics, design and control as applied for traction purposes, analysis of motive-power equipment, steam, diesel-electric and electric as applied to traction purposes, power-distribution circuits, factors affecting substation rating and spacing, equivalent circuits for power distribution for analytical purposes or network-analyzer representation, calculations of short-circuit and ground currents, power costs and transportation economics. Study of the foregoing as regards electrification in particular and transportation in general.

6·561. 6·562. Advanced Network Theory (A). Discussion of the methods of network synthesis and their applications to the design of networks for prescribed driving-point or transfer characteristics including such networks as wave filters, attenuation or phase equalizers, coupling networks for wide-band or feedback amplifiers, etc. Theoretical development beginning with an enlargement of the more elementary methods of network analysis out of which are established the properties of physical driving-point impedance functions and the necessary conditions for the physical realizability of a prescribed impedance or of a set of impedance functions characterizing a network with several terminal-pairs. Discussion of synthesis procedures including a variety of methods pertinent to the design of nondissipative and dissipative networks with one and two terminal-pairs, with consideration of various methods of obtaining equivalent networks and of the collaterally useful concept of the duality. Discussion of pertinent properties of analytic functions of a complex variable.

6·571, 6·572. Principles of Illuminating Engineering (A). Latest researches in physiological optics and their applications to lighting, vector field method of calculating illumination, and design of lighting equipment. Moon, *The Scientific Basis of Illuminating Engineering.*

6·58. Transients in Linear Systems (A). Formulation from physical considerations, of differential equations of circuit and field problems in electrical, mechanical, thermal and acoustical systems which permit of linear treatment; analogies; mathematical studies of transient disturbances in these systems, using the Laplace transformation method as a means of solving the differential equations. Requisite background in complex variable theory for use of the method.

6·585. Applications of Integral Equations in Electrical Engineering (A). Applications of integral equations to various problems in electrical engineering, such as problems of electrostatics, skin effect, interreflections of radiant energy, and vibrations. Particular attention devoted to the solution of integral equations by approximating the kernel and by use of various numerical and graphical methods.

6·586. Engineering Applications of Field Theory (A). Engineering treatment of methods for the solution of Laplace's equation and their practical applications. A supplement to the usual electric-circuit theory (one space dimension) by developing methods for two and three dimensions. Byerly, *Fourier Series and Spherical Harmonics.*

6·59. Communications Laboratory (A). Work on a substantial problem or selected group of problems in consultation with a member of the staff who is particularly qualified in the field. For students with a mature independence of attack and investigatory ability. Conferences, with opportunity for detailed criticism and discussion.

6·60. Mathematical Analysis by Mechanical Methods (A). Methods used in the mechanization of mathematical processes, particularly those involving continuous variables. Development and illustration of the principles of existing equipment. Computation, treated as an engineering problem, with attention to design and economic limitations.

6·601. Special Applications of Mechanized Mathematics (RA). (Restricted to selected U. S. Naval Officers only.)

6·605. Servomechanisms (A). Dynamical principles of closed-cycle automatic control systems with emphasis on the quantitative study of system behavior. Stability requirements transient and steady state response to arbitrary forcing function, and the transfer loci method of predicting design data.

6·606. Servomechanisms (A). Servomechanism theory embodying analysis and quantitative design of a number of automatic control systems. Electric, hydraulic, electro-electronic, and electro-hydraulic servo-mechanisms investigated with the aid of supporting applied electronics, electrical machinery, fluid mechanics, and fluid machinery theory as applied to servomechanisms. Quantitative measurements and evaluations of servomechanism performance in the laboratory.

Electrical Engineering Continued

6·607. Servomechanisms Laboratory (A). Quantitative investigation of design and test of closed-cycle systems. Program varying to meet particular needs of the student. More profound problems recommended in comparison to unrelated minor studies.

6·61. Generation and Utilization of Super-Voltages (A). Principles and techniques involved in the production, measurement, and utilization of very high voltages. Analysis of direct-current electrostatic, alternating-current, and impulse-voltage sources. Theory and characteristics of high voltage insulating media with emphasis on compressed gases and high-vacuum insulation. Physical properties of high energy X-rays and their production for medical and industrial use. Cathode rays, neutrons and radiations from artificially radioactive materials. Trends in the development of high-voltage power for transmission. Analysis of methods of generation and conversion for direct-current power systems.

6·62. Principles of Electrical Communications (A). Thermionic gaseous conduction and photo-electric tubes and their associated external networks. Linear and nonlinear amplifiers, amplitude and frequency modulators, regenerative and super-regenerative circuits and oscillators.

6·621, 6·622. Radio Lines, Antennas and Propagation (A). Those parts of the radio system that effect transmission of energy between transmitting apparatus and receiving apparatus. First term — theory and application of radio-frequency wave guides of various types; resonant cavities. Second term — theory and practice of antennas for broadcast, short wave, and microwave services, including applications to air navigation. Engineering aspects of radio wave propagation. General principles, derived from electromagnetic theory, followed by application to practical problems.

6·627. Patents and Their Relation to Science and Engineering (A). Engineering significance of patents. Nature of patents, machinery incidental to obtaining them, their effects in industry considered by means of typical cases. Appeals, interferences, court litigations treated by actual illustrations, ranging from simple to highly technical in character. Does not pretend to cover patent law, but leads to an understanding of the working of patent law. Free use of mathematics, physics, chemistry, and electricity.

6·628. The Patent Background of Electrical Communications in the United States (A). Patent background of communications systems of this country and, to an extent, of other countries. Discussion of background in relation to corporate development of several large communications organizations. Emphasis on growth of electronic art including vacuum tubes and tube circuits; growth of telephone and telegraph. Regulatory legislation in the communications field.

6·631. Engineering Electronics (A). Electrokinetic theory of gases, including free paths, mobility, diffusion, ionization, recombination and space-charge effects. Potential distributions between electrodes immersed in a gas, and theory and characteristics of glow, spark and arc discharges. Application to rectifiers, grid-controlled arc tubes, circuit breakers and lightning arresters. Cobine, *Gaseous Conductors.*

6·632. Engineering Electronics (A). Engineering application of electronic apparatus. Current, voltage, and energy considerations in circuit interruption involving arcs. Mercury arc rectifiers and associated circuits. Electric welding arc. Inversion and other special applications. Cobine, *Gaseous Conductors.*

6·64. Applications of Atomic Physics in Electrical Engineering (A). Knowledge of atomic physics necessary for understanding a majority of the modern devices used by electrical engineers. Important electrical apparatus like gas- and dry-rectifiers, vacuum- and barrier-layer photocells, electrolytic condensers, lightning arresters, piezo-electric resonators, etc. discussed in this subject from the standpoint of: How are they made? Why do they work? Under what circumstances do they fail? Supported by experiments. Designed to bring an understanding of the atomistic phenomena involved, of the limitations imposed by them, and of the research problems facing us today.

6·651, 6·652. Electric Power Distribution (A). Theoretical principles of electric power distribution. Distribution system in theory. Calculation of power-system short-circuit transients. Limitation of short-circuit currents, maintenance of voltage, and the control and transfer of power. Theory of electric power cables, dielectric properties, calculation and limitation of sheath currents. Low-voltage and medium-voltage distribution networks. Interlacing of primary cables, load division and transformer spacing. Theory of relays, methods of obtaining selectivity and their applications. Load characteristics, economic problems in electric distribution, allocation of demand costs, determination of cost of energy loss and rate structures.

6·661, 6·662. Principles of Electric Machine Development (A). Various types of electric machines and apparatus and calculation of their characteristics. Eddy-current loss in rectangular wire windings in transformers and generators. Theory of measurement of core loss with poor wave form. Allowable overloads for transformers. Heat resistivity, free convection and radiation. Slot harmonics in induction motors and choice of slot numbers. Reactance and temperature rise of bus-bars. Inductance, magnetic field strength and mechanical force of round coils in air. Flux-plotting. Usual methods of calculation including the potential method. Graphical flux-plotting. Unbalanced magnetic pull in rotating machines. Eddy currents in round wires, tubular conductors and induction furnaces and solutions by means of Bessel functions.

6·663, 6·664. Aircraft Electrical Systems and Machines (RA). Problems arising in the design, coördination, and operation of d-c and a-c electric power and control apparatus and distribution systems for use in aircraft, emphasis being placed on basic fundamentals rather than specific present-day techniques. Comparison of d-c and a-c systems; steady-state and transient analysis of these systems; discussion of basic problems in the design of electrical machinery for use in aircraft; and brief discussion of the basic theory of automatic control devices and servomechanisms. Machine characteristics, determined in the laboratory and used in the study of representative aircraft systems on the M. I. T. Network Analyzer. (Restricted to selected U. S. Army Officers only).

6·671, 6·672. Vibrations (A). Theory of vibration of mechanical systems including certain acoustical and hydraulic problems. Complex-notation method generally used. (Short preliminary instruction in this method for students from other courses while the Electrical Engineering students work on more purely electrical problems. Thereafter, the two groups united.) Forced, transient, and self-induced vibration. Single and multiple degrees of freedom. Analogies between electrical and mechanical systems. Nonlinear systems. Application to mechanical devices, machines, and structures. Vibration measurements and corrections. Use and limitations of models, mechanical and electrical. Noise in machines, its causes and control. Control of temperature oscillations. The tide and an analysis of tidal power possibilities. Stresses in bus-bars and bus-bar supports. Inertia effects in high-speed mechanisms.

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.

6·681. Special Problems in Fire Control (RA). (Restricted to selected U. S. Naval Officers only.)

6·69. Sound in Electrical Communications (A). Principles and apparatus involved in the production, measurement, transmission and reproduction of sound by electrical means. Laboratory measurements of sound fields and performance of receivers and transmitters.

6·73. Advanced Electrical Measurements Laboratory (A). Advanced work of the nature of that given in 6·75, and 6·76, the choice of problems being suited to the individual student.

Electrical Engineering Continued

6·74. Advanced Electrical Engineering Laboratory (A). Laid out in accordance with the needs of the individual student, special problems on direct and alternating-current machinery being selected.

6·75. Electrical Engineering Laboratory. Measurement of the properties of linear circuit elements and their behavior in circuits; measuring methods and equipment; and investigation of the characteristics of magnetic materials and transformers. *Instructions for Students in the Electrical Engineering Laboratories. Eleventh Edition*, 1943.

6·76. Electrical Engineering Laboratory. Characteristics of electronic devices and their use in engineering applications, including rectifiers, thyratron control circuits, amplifiers and oscillators.

6·77. Electrical Engineering Laboratory. Characteristics and fundamentals of direct-current machinery. Ricker and Tucker, *Electrical Engineering Laboratory Experiments, Fourth Edition;* Kloeffler, Brenneman, and Kerchner, *Direct-Current Machinery; Instructions for Students in Electrical Engineering Laboratories, Eleventh Edition*, 1943.

6·78. Electrical Engineering Laboratory. Polyphase circuits, symmetrical phase components, transformer, synchronous generator, synchronous motor, three-phase induction motor. Ricker and Tucker, *Electrical Engineering Laboratory Experiments, Fourth Edition; Instructions for Students in Electrical Engineering Laboratories, Eleventh Edition*, 1943.

6·781. Electrical Engineering Laboratory. Polyphase circuits, symmetrical phase components, power transformer, synchronous generator, synchronous motor, single-phase and three-phase induction motors, and power rectifiers. *Textbooks same as for* 6·78.

6·79T. Electrical Engineering Laboratory. Characteristics of single-phase induction motors, synchronous converters and power rectifiers, special purpose alternating-current machinery, characteristics of power transmission lines. *Textbooks same as for* 6·78.

6·80. Electrical Engineering Laboratory (B). For Electrical Engineering students who desire work in addition to that included in any one of subjects 6·75, 6·76, 6·77, 6·78 or 6·79**T**, and for any other students requiring a special program. Arranged to suit the requirements of the individual student.

6·81. Electrical Engineering Laboratory. Choice of work from a broad selection of topics dealing with methods of measurement of the electrical and magnetic properties of metals. *Instructions for Students in the Electrical Engineering Laboratories, Eleventh Edition*, 1943.

6·82. Electrical Engineering Laboratory. Experiments designed to illustrate the operating characteristics of common types of direct- and alternating-current motors and generators and transformers; experiments with elementary vacuum and gaseous-tube circuits. Ricker and Tucker, *Electrical Engineering Laboratory Experiments, Fourth Edition; Instructions for Students in Electrical Engineering Laboratory, Eleventh Edition*, 1943.

6·83. Electronic Engineering Laboratory. Choice of work by the student, subject to the counsel of his instructor, from a broad selection of topics having to do with the application of electronic devices to measurement and control purposes in engineering: amplifiers, voltmeters, trigger circuits, relaxation and phase-shift oscillators, voltage regulators, phototube devices, and thyratron applications.

6·84. Electrical Implementation Laboratory. Choice of work by the student, subject to the counsel of his instructor, from a broad selection of the topics listed for 6·23.

6·85. Electrical Engineering Laboratory. Ten exercises designed to familiarize students with the elements of electrical measurements and with the characteristics and fundamental principles of operation of the ordinary types of electrical machinery and control apparatus. Ricker and Tucker, *Electrical Engineering Laboratory Experiments, Fourth Edition; Instructions for Students in Electrical Engineering Laboratories, Eleventh Edition*, 1943.

6·89. Electrical Engineering Laboratory. Eight laboratory exercises similar in subject matter to those of 6·85. *Textbooks same as for* 6·85.

6·901—6·904. General Electric Industrial Practice. Practical work done by the coöperative students in testing, manufacture, engineering and research in plants of the General Electric Company located in Lynn, Schnectady, Pittsfield, 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.

6·911—6·914. Boston Edison Public Utility Practice. Work done by coöperative 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.

6·941—6·944. Bell System Communications Practice. Work done by coöperative students in the manufacture of communication equipment at Kearny, N. J., and in its installation and maintenance in a Bell Telephone operating company, including at least one term's work devoted to research and development of communication and electronic apparatus at the Bell Laboratories in New York City.

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 coöperative 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.

BIOLOGY
FOOD TECHNOLOGY

Subjects 7·00 to 7·99

7·01, 7·02. General Biology, I and II. Introduction to the study of plant and animal organisms, including man, with consideration of their structure, function, development, heredity, and interrelationships (classification, evolution, distribution). First term — presentation of a general survey of the above subjects. Second term — a more detailed presentation, with particular reference to botany, including plant physiology, and invertebrate zoölogy. Laboratory work integrated with the lectures and recitations throughout the course.

7·03. Genetics (B). Discussion of the facts and theories of heredity and their relation to the present state of biological theory in general.

7·11. Embryology. Classroom and laboratory work on the development of animals from the germ cells to the organ systems.

7·12. General Cytology (A). Fundamental cytolog of mitosis, meiosis, spermatogenesis, and genetic mechanics, together with the morphology of secretory, excretory, contractile, absorptive, and conducting cells; activities of cells and cell structures in physical chemical terms. Application of methods of modern cytology in the laboratory with emphasis on study of living material.

7·14. Comparative Anatomy. Comparative gross anatomy of vertebrates and essential histology of the organs, with the structures partly dissected out by students and partly demonstrated by the instructor. Classification and general zoölogy of vertebrates.

7·19. General Physiology I (B). Physical chemical basis for the structure and colloidal properties of protoplasm.

Biology and Food Technology Continued

7·20. General Physiology II (B). Fundamental processes which characterize cells and tissues, including permeability phenomena, cell division, growth of cells and organisms, metabolism, contractibility and motility, irritability, glandular secretion, and excretion.

7·211. General Physiology Laboratory I(B). Laboratory coördinated with the topics of 7·19.

7·212. General Physiology Laboratory II(B). Laboratory coördinated with the topics of 7·20.

7·22. Chemistry of Nutrition (B). The needs of man and animals for calories, carbohydrates, fats, proteins, amino acids, minerals, and vitamins.

7·222. Chemistry of Nutrition Laboratory (B). Analysis for nutrients of representative foods by chemical, colorimetric, fluorometric, and microbiological techniques.

7·23. 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.

7·24. 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.

7·301. Bacteriology. Biology, biochemistry, and biophysics of bacteria with emphasis on the study of selected types. Laboratory work including use of various methods for studying bacteria, and studies to determine effect of physical and chemical agents on bacteria. Zinsser and Bayne-Jones, *A Textbook of Bacteriology.*

7·31. Biology of Bacteria. Bacteriology as a biologic science, stressing the fundamental principles and pure science aspects of the subject. Laboratory work including the basic techniques for studying bacteria, with use of selected types. Salle, *Fundamental Principles of Bacteriology.*

7·321, 7·322. Advanced Bacteriology (A). Reports and discussions on bacterial physiology and growth, including nutrition, energetics, respiration and anaerobiosis, growth factors, temperature effects, bacterial variation, and use of statistical measurements in quantitative bacteriology. In the second term, laboratory problems and demonstrations including bacterial dissociation, filtration techniques, viruses, and special problems.

7·361. Industrial Microbiology. Theory and practice involved in fermentation processes, and industrial and economic applications of microbiology in agriculture and manufacture of biochemical preparations. Industrial alcohol, vinegar, acetone, butyl alcohol, glycerin, fermentation acids, and applications in the leather and food industries.

7·371, 7·372. Advanced Industrial Microbiology (A). Current theories of the mechanisms of fermentations, and 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, enzyme products, lipids, sterols, and other substances; and relation of certain biological agents to the textile, timber and leather industries. Prescott and Dunn, *Industrial Microbiology;* Smith, *Industrial Mycology;* Bernhauer, *Gärungschemisches Praktikum.*

7·39. 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 advances in food packaging, and relation of bacteria thereto.

7·42. Chemistry of Foods. Analytical methods, fundamental basis of nutrition; extent, character and legal status of food adulteration. Woodman, *Food Analysis.*

7·701, 7·702. Technology and Chemistry of Food Supplies. 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.*

7·711. Technology of Food Products (B). 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.*

7·712. Technology of Food Products (B). A continuation of 7·711 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.*

7·721, 7·722. 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. Clayton, *Colloid Aspects of Food Chemistry and Food Technology.*

7·791, 7·792. Food Technology Seminar (A). Presentation of recent advances in food technology and research and analysis of the fundamental principles involved.

7·80. Biochemistry (B). Experiments illustrating basic principles of biochemical procedure as applied in various fields without special emphasis upon clinical aspects of physiological chemistry. Lectures on the nature of chemical processes in plants and animals with special attention to the metabolism of foodstuffs and the nature of protoplasms.

7·81. Enzymology (A). Quantitative study of enzyme reactions, their products, and the conditions governing activity.

7·82. Advanced Biochemistry (A). Technique for biochemical analyses and bio-assays, based on the recent literature.

7·831, 7·832. Biochemistry of Micro-organisms (A). Emphasis on quantitative aspects of the metabolic activities of micro-organisms. 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. Biophysics I (A). Optical methods useful in biochemical and biological research. Techniques used in photography, spectrography, microscopy (including ultra-violet and electron microscopy), polarization optics, and X-ray diffraction.

7·86. Biophysics II (A). Isotopic tracers, surface chemistry, the ultracentrifuge, electrophoresis, and other physical equipment and techniques applicable to biological and biochemical problems. Biological effects of radiant energy.

7·87. Spectroscopy of Biological Materials (A). Spectroscopic methods applied to biological and biochemical problems, with emphasis on visible and ultraviolet absorption spectrophotometry and photochemical techniques. Infra-red, Raman, fluorescence, and emission spectra are considered briefly.

7·871. Spectroscopy of Biological Materials Laboratory (A). Laboratory work coördinated with the topics of 7·87.

Biology and Food Technology Continued

7·881. Biophysics Laboratory I (A). Laboratory coördinated with the topics of 7·85.

7·882. Biophysics Laboratory II (A). Laboratory coördinated with the topics of 7·86.

7·91, 7·92. 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.

PHYSICS

Subjects 8·00 to 8·99

General Physics

8·00. Entrance Physics. Entrance requirement in Physics. No laboratory work is given.

8·01. Physics (Mechanics). Fundamental laws of point and rigid body mechanics. Free use of elementary calculus.

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. Supplements the student's training in amount necessary to cover the requirements of 8·01 and 8·02. Free use of calculus.

8·02. Physics (Mechanics and Heat). Lectures, laboratory and recitations. Divided into two parts: (*a*) Mechanics of continuous media preceded by a study of gravitational field of force and orbital motion. (*b*) The first and second laws of thermodynamics and elementary kinetic theory of gases.

8·03. Physics (Electricity). Introduction to the fundamental laws of electricity and magnetism and their applications. Electrostatics, steady currents and magnetic fields, and time-varying electric and magnetic fields. Quantitative work throughout, with free use of calculus, both in the theory and applications.

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. Supplements the student's training in amount necessary to cover the requirements of 8·03 and 8·04. Free use of calculus.

8·04. Physics (Electricity, Optics and Modern Physics). Continuation of 8·03, approximately one-third of the subject bringing to a conclusion the study of electricity. Discussion of electromagnetic waves leads to optics; devoted to both geometrical and physical optics. Quantitative character of 8·03 continued and free use of calculus.

8·05. Vibration and Sound (B). First part: a study of the dynamics of vibrating bodies; coupled oscillators, strings, membranes and plates. Second part: a study of the transmission and radiation of sound. Properties of loudspeakers and microphones treated, and the characteristics of speech and hearing discussed.

8·051. Special Problems in Acoustics (A). Advanced problem in acoustics or vibrations with assigned reading and consultations.

8·052. Experimental Acoustics (B). Laboratory subject in acoustics, including measurements on acoustical absorbing materials, calibration of loudspeakers and microphones, recording and analysis of noise, vibration analysis, and experiments in supersonics and in physiological acoustics.

8·053. Architectural Acoustics. Study of the acoustical design of rooms and buildings. Experiments will accompany many of the principal topics; measurement of sound, reverberation, absorption coefficients, room resonance, vibration isolation, sound transmission, and insulation.

8·061. Intermediate Physics (Thermodynamics and Kinetic Theory). Physics of intermediate grade, material somewhat more advanced than 8·01–8·04. First and second laws of thermodynamics with applications to properties of gases, change of state, and chemical equilibrium. Elementary kinetic theory, Maxwell distribution of velocities, and the Maxwell-Boltzmann formula.

8·062. Intermediate Physics (Electronics). Continuation of 8·061. Electron ballistics, theory of electron emission, Fermi-Dirac distribution, Schottky effect, high field emission, secondary emission, photoelectric effect, Townsend discharge, glow discharge, arc discharge, rectifiers and filters.

8·09. Physical Measurements. Introduction to experimental physics with emphasis on laboratory manipulation. Glass blowing, microsoldering, vacuum technique, evaporation of metals and assembly of optical systems. Application of the techniques to physical measurements. Selected experiments on heat, electricity, light, X-rays, gas kinetics and properties of matter.

8·11. Experimental Physics (B). Methods of analyzing experimental problems to determine suitable methods of achieving a desired result, in the design and use of experimental equipment. Case system used with reference to the entire field of pure and applied experimental physics. Experiments of semi-research character develop initiative, resourcefulness, and familiarity with modern experimental technique.

Optics and Photography

8·15. Photography. Elementary subject primarily an elective for students not in Course VIII.

8·152. Advanced Photography. Advanced laboratory subject. Determination of the various characteristics of photographic materials and practice in photographic technique.

8·161. 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.

8·162. Optical Measurements. Principles, methods and manipulation of optical instruments.

8·164. Optics (RB). Fundamental principles of geometrical, physical, and physiological optics with special reference to their military applications. (Restricted to selected U. S. Army Officers only.)

8·173. Color Measurements (B). 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.

8·183. Special Problems in Optics (A). Experimental work in the optics laboratory, of special investigations not thesis work.

Physics Continued

Electronics

8·202. Electronics Laboratory. Intermediate electrical and electronic measurements.

8·21. Electronic Phenomena (A). Introduction to modern electron theory and an elementary treatment of Maxwell-Boltzmann and Fermi-Dirac statistics with applications of these theories to thermionic and photoelectric emission from metals and to gas discharge phenomena.

8·212. Experimental Electronics (A). Theory and use of modern experimental appparatus as applied to electronic investigations. Experiments with the Compton quadrant electrometer, the FP-54 vacuum tube, "Electrometer," the cathode ray oscillograph and the thyratron, as well as experiments of a fundamental nature on thermionic emission, photoelectric effect, and gas discharge phenomena.

8·215. Special Problems in Electronics (A). Advanced problem in electronics, with assigned reading and consultation.

X-Rays and the Structure of Matter

8·26. Molecular Structure (A). Electric and optical properties of molecules, gases and liquids. Theory of polar molecules, refraction, scattering of light and Kerr effect. (Alternate years.)

8·27. X-rays and Crystal Physics (B). 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 theory of X-ray diffraction and its application to the study of the structure of matter. Introduction to crystal chemistry. Application of space group theory to crystal structure determination. Diffraction in perfect and imperfect crystals. Diffuse scattering. Fourier treatment of X-ray diffraction, and the Patterson-Harker method of analysis. (Alternate years.)

8·29. Quantum Theory of the Solid State (A). Motion of electrons in a periodic potential field. Methods of calculation of the elastic properties of solids. Discussion of electric conductivity of the magnetic and optical properties of solids, and of the structure of alloys. (Alternate years.)

8·30. Special Problems in Crystal Physics (A). Advanced problem in X-ray diffraction or crystal physics, with assigned reading and consultation.

Atomic Structure and Spectroscopy

8·311. Atomic Structure. Electron and ion beams, and scattering of alpha-particles, electrons, and light by atoms. The corpuscular nature of light and the wave nature of the electron. The Bohr theory of atomic structure and the vector model of the atom. Radioactivity and nuclear structure.

8·312. Atomic Structure Laboratory. Continuation of 8·09 with application of the laboratory techniques to the study of selected topics in modern physics such as absorption and emission spectra, inelastic impacts of the first and second kind, resonance radiation, fluorescence, critical potentials, gamma ray absorption and artificial radioactivity.

8·32. Line Spectra (A). Characteristics of atomic spectra and their description in terms of quantum numbers, their interpretation in terms of current theories of atomic structure, and their use in explaining the chemical properties of the elements.

8·343. Special Problems in Spectroscopy (A). Experimental work in the Spectroscopy Laboratory, of special investigations not thesis work.

Nuclear Physics

8·411. Nuclear Physics (B). Principal fields of atomic nuclei, building each up from its beginnings to the present. Treatment is primarily factual, experimental results being correlated with those given by current theories. Lectures are supplemented by laboratory work with the latest types of apparatus. Properties of stable nuclei; isotopes, nuclear moments, mass and charge; radioactive transformations; mathematical theory of statistics and fluctuations; properties of alpha rays, gamma rays, electrons and positrons.

8·412. Nuclear Physics (B). Continuation of 8·411 considering the nuclear spectra of alpha, beta, gamma rays and nuclear energy levels; nuclear force fields and scattering of alpha rays, protons, neutrons and electrons; excitation and transmutation of nuclei; artificial radioactivity; cosmic rays; applications of nuclear techniques to chemistry, biology, geology and other fields.

8·43. Theory of Nuclear Structures (A). Current theories of the structure of atomic nuclei. Calculation of nuclear binding energies and collision reactions. Nature of internuclear forces. Theory of radioactive decay. (Alternate years.)

8·44. Applied Radiochemistry (A). Applications of radioactive elements to studies in chemistry, biology, medicine, metallurgy, etc. Extensive survey of such applications included to indicate the scope of field and to suggest new ways to apply radiochemical techniques. Laboratory work will demonstrate special problems involved in applied radiochemistry and will furnish practice in preparation, application, and detection of radioactive materials.

8·441, 8·442. Special Problems in Nuclear Physics (A). Experimental work on radioactivity, nuclear bombardment, and general nuclear research, of special investigations not thesis work.

Theoretical Physics

8·461. Introduction to Theoretical Physics I (Mechanics) (B). Mechanics of particles, planetary motion, rigid bodies, vibrating particles, vibrating strings and membranes, elasticity and hydrodynamics. Use of Lagrange's equations and generalized coördinates, ordinary and partial differential equations, Fourier series, and vector analysis.

8·462. Introduction to Theoretical Physics II (Electromagnetic Theory) (B). 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.

8·463. Introduction to Theoretical Physics III (A). Wave mechanics and quantum theory, classical and quantum statistics, structure of atoms and molecules, and the properties of matter.

8·491. Methods of Theoretical Physics (A). Coördinates and develops methods used in solving problems in electrostatics, hydrodynamics, heat flow, diffusion, wave motion, wave mechanics, etc. Equations governing these phenomena developed and effects of boundary conditions on solutions studied. Green's functions, eigenfunctions, variational methods, and conformal transformations discussed. (Alternate years.)

8·512. Statistical Mechanics (A). Statistical mechanics with applications to physical problems. (Alternate years.)

8·521. Quantum Mechanics (A). Modern atomic theory. Dirac operator method developed, and theories of electron spin and interaction of radiation and matter discussed. Atomic and molecular spectra, collision processes and other topics. (Alternate years.)

8·56. Electromagnetic Wave Theory (A). Radiation theory, electromagnetic boundary-value problems, propagation in dispersive media with application to the ionosphere. Application of Fourier and Laplace transform theory to field equations. (Alternate years.)

8·60. 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

10·17. INDUSTRIAL CHEMISTRY. Industrial aspects of fuels, combustion and furnaces through the solution of numerous problems. Lewis and Radasch, *Industrial Stoichiometry.*

10·18. INDUSTRIAL CHEMISTRY. Industrial chemical processes studied from the point of view of both the chemical 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 standard types of apparatus and a general survey of the field obtained. Extensive problem work.

10·21T. INDUSTRIAL CHEMISTRY (B). Continuation of 10·18. Industries dealing with amorphous solids, including glass, ceramics, leather, paints, textiles, paper, rubber, etc.

10·25. INDUSTRIAL CHEMISTRY (A). Industrial stoichiometry and the industrial chemistry of more important chemical industries. 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 (B). Evolution of a chemical process from the idea as originally formulated through the successive stages of laboratory development to the design and equipment of the necessary plant.

10·26T. INDUSTRIAL CHEMICAL LABORATORY (B). Laboratory development of a chemical process illustrating the integrated application and utilization of chemical principles and methods in solving industrial problems. The materials involved are analyzed and relevant physical and chemical characteristics measured. Reaction equilibria and rates are determined, side reactions investigated and methods of process control explored. Experimental results are studied and interpreted to bring out the full technical significance of all chemical information available. Discriminating and effective presentation of conclusions is developed through oral and written reports.

10·27. INDUSTRIAL CHEMICAL LABORATORY (A). Experience in methods of attack upon typical industrial chemical problems, necessitating brief laboratory investigation. Problems of current industrial interest and emphasis upon the interpretation of experimental results and their effective presentation in a series of group conferences.

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, thermal control of chemical reactions, and the like. Development of second law and its elementary applications.

10·29. CHEMICAL ENGINEERING (B). 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. Attention to high pressure operations, particularly the influence of pressure on thermal effects and chemical equilibrium.

10·30. ENGINEERING EQUIPMENT. For students selecting the Chemical Engineering Practice Option, 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 the determination of the operating characteristics of such equipment under plant conditions.

10·31, 10·32. CHEMICAL ENGINEERING (B). Basic principles underlying the unit operations of chemical industry. Discussion of fundamental problems in flow of heat. Analysis of the operation of evaporation, distillation, drying, humidification, filtration, subdivision of solids, hydraulic classification and similar topics. Emphasis on quantitative relationships illustrated by the solution of numerous problems. Walker, Lewis, McAdams and Gilliland, *Principles of Chemical Engineering.*

10·311. HEAT TRANSFER (RB). Fundamentals of conduction, convection, and radiation of heat, with applications to problems arising in practice. (Restricted to selected officers of the U. S. Navy and Coast Guard only.)

10·33. ANALYTICAL TREATMENT OF CHEMICAL ENGINEERING PROCESSES (A). Conservation of matter and energy, the laws of equilibrium, and reaction rate. Problems of diffusion requiring certain mathematical techniques. Training in setting up ordinary and partial differential equations corresponding to specific physical situations, and presenting methods available for their solution, including various graphical constructions. Sherwood and Reed, *Applied Mathematics in Chemical Engineering.*

10·38. EXPLOSIVES PLANT ENGINEERING (R). Survey of the fundamentals of physical chemistry and chemical engineering, followed by application of these subjects to the industrial operations involved in the manufacture of ordnance material with particular reference to propellants and high explosives. (Restricted to selected U. S. Army and Naval Officers only.)

10·39. THEORY OF INTERIOR BALLISTICS (R). Theories underlying the ignition and combustion of propellants in the gun and that of the motion of the projectile along the bore. Applications to the design of guns and ammunition. (Restricted to selected U. S. Army and Naval Officers only.)

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.

10·41. DISTILLATION (A). Basic principles of distillation, as applied to binary mixtures, both of complete and limited miscibility and to multicomponent systems. Problems including batch and continuous simple distillations, steam distillations, vacuum and pressure distillation, rectification, heat recovery and the like. Special attention to graphical methods.

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.

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, *Absorption and Extraction.*

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. Empirical, but dimensionally sound approach to the problem. Extensive use of graphical methods. Trends of present development. McAdams, *Heat Transmission.*

10·52. CHEMICAL ENGINEERING II (A). Offered for graduates of other schools whose training in chemical engineering differed from that given in 10·31 and 10·32. Emphasis on basic theories in flow of fluids and flow of heat. Application to problems of advanced character. Attention to recent developments in chemical engineering.

10·53. CHEMICAL ENGINEERING DESIGN (A). Open only to students completing the field work of Course X-A. Design of a complete plant, from the viewpoint of both chemical engineering and economics.

Chemical Engineering Continued

10·54. 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.

10·55. Economic Balance (A). Shorter subject of the same character as 10·54.

Applied Chemistry

10·62. Applied Chemical Thermodynamics (A). Energy relations of chemical processes. Equilibria and thermal effects in heterogeneous and homogeneous systems, and technique in utilization of data in interpretation and practical control of chemical reactions.

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.

10·65. Catalysis and High Pressure Processes (A). Principles involved in the use of high pressures and catalysts in certain chemical reactions, such as the synthesis of ammonia, synthesis of mixtures of aliphatic compounds, alcohols and hydrocarbons from water gas, hydrogenation of coal and oils, cracking of mineral oils, etc.; discussion of industrial applications, equipment requirements, and opportunities for research.

10·661. Introduction to 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.

10·662. Colloid Chemistry (A). A continuation and extension of 10·661, with attention to recent developments in surface reactions, gel formation, and their technical significance.

10·663. Introduction to Applied Colloid Chemistry (A). Fundamentals of colloid chemistry. Arranged primarily for X-A students, but may be taken by other graduate students unable to attend courses in colloid chemistry during the first term.

10·673. Colloid Chemistry Laboratory (A). Training a limited number of men in the use of special instruments such as stalagmometers, bubble pressure pipettes, and surface and interfacial tensiometers. Including the laboratory technique of dialysis, electro-dialysis, cataphoresis, modern microscopic technique, and micro-dissection, as well as the theoretical background pertaining to these methods.

10·674. Colloid Chemistry Laboratory (A.) Continuation of 10·673.

10·68. Corrosion (A). Selection of equipment for use in chemical engineering processes. Emphasis on resistance to corrosion and theories of corrosion and methods of prevention.

10·69. Plastics and Other High Polymeric Substances (A). Survey of the chemical and physical properties and molecular structure of organic and inorganic high polymeric substances. Emphasis on specialized colloid chemical and physical methods of investigation necessitated by the unique properties of this class of materials. Correlation of theoretical considerations of structure with properties of practical industrial importance.

FUEL ENGINEERING

10·70. Principles of Combustion (A). Open to students wishing to specialize in the engineering rather than the chemical phase of fuel engineering. Emphasis on the application of fundamental principles in combustion reactions, including physical and organic chemistry of particular importance in fuel engineering. Problems illustrating the quantitative application of these principles in fuel processing and utilization.

10·71. Fuel Engineering (A). For students with an adequate background of physical and organic chemistry and thermodynamics. Mechanism of the combustion reactions, and application of combustion principles to problems of design or use of equipment for fuel processing and utilization.

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. Quantitative design and layout of several furnaces, retorts or still-settings.

10·76. Seminar in Radiant Heat Transmission (A). Theory and derivations incident to heat transfer in furnaces, including general law of total radiation in its differential form, its applications to radiation between finite solid surfaces with evaluation for special shapes of engineering importance, the law of spectral energy distribution of radiation, its application to radiation from luminous and non-luminous gases, powdered coal flame radiation, and optical pyrometry.

10·79. Automotive Fuels (A). Discussion of refinery technology, particularly cracking; the mechanism of combustion in Otto and Diesel cycle engines; the relation of "engine knock" to chemical structure of a fuel; thermodynamics of engine cycles, allowing for dissociation; the volatility of motor fuels; gum in gasoline; theory of bearing lubrication. Problems and comprehensive report required on some motor fuel subject.

School of Chemical Engineering Practice

10·81. School of Chemical Engineering Practice — Bangor Station (A). Emphasis on the study of electrolysis, drying, humidification, evaporation, absorption and causticization. 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. Offered from July through December and from February through May.

10·82. School of Chemical Engineering Practice — Parlin Station (A). Distillation, heat transfer, fluid flow, handling of corrosive materials, plant layout, and industrial chemical operations such as those employing catalysis and high pressure. Conducted at the Cellulose Products plant of Hercules Powder Company in Parlin, New Jersey. Offered from July through December and from February through May.

10·83. School of Chemical Engineering Practice — Buffalo Station (A). Flow of fluids, flow of heat and combustion, the work extending over a wide field. Quantitative studies are made and tests run on coke ovens, blast furnace stoves, gas producers and the like. Experimental work on flow of heat, flow of fluids, absorption and other unit studies of chemical engineering is carried out in connection with the recovery of light oil and ammonia from coke oven gas. Conducted at the Lackawanna Plant of the Bethlehem Steel Company. Offered from July through December and from February through May.

10·84. School of Chemical Engineering Practice — Bangor Station. Similar to 10·81. Given during the second period of the academic year.

10·85 School of Chemical Engineering Practice — Parlin Station. Similar to 10·82. Given during the second period of the academic year.

10·86. School of Chemical Engineering Practice — Buffalo Station. Similar to 10·83. Given 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.

10·911, 10·912. Research Conferences (A). Regular conferences are held with research students by the Staff of the Laboratories of Chemical Engineering in which the work is conducted.

10·991, 10·992. Seminar in Chemical Engineering (A). Offered primarily for post graduate students on thesis or preparing for the oral examination for the Doctor of Science degree.

GEOLOGY

SUBJECTS 12·00 TO 12·99

12·011T. MINERALOGY. Blowpipe analysis, followed by an intensive laboratory study of the common non-silicate minerals, developing the student's ability to identify the common minerals on sight. Warren, *Determinative Mineralogy;* Hurlbut, *Dana's Ma nual of Mineralogy.*

12·012. MINERALOG.. Continuation of 12·011, covering a study of the common silicate minerals. Warren, *Determinative Mineralogy;* Hurlbut, *Dana's Manual of Mineralogy.*

12·05. MINERALOGICAL SEMINAR (A). Presentation and discussion of literature bearing on certain phases of theoretical mineralogy. (Alternate years.)

12·06. MINERALOGICAL RESEARCH (A). Supervised research on some mineralogical or crystallographic problem, with the intention that each investigation will result in a publication.

12·15. PETROGRAPHY. Laboratory work on thin rock sections, using the polarizing microscope. Some lectures on the occurrence and genesis of rocks and rock minerals. Confined to igneous and metamorphic rocks. Harker, *Petrology for Students;* Tyrrell, *Principles of Petrology;* Rogers and Kerr, *Optical Mineralogy.*

12·161, 12·162. PETROLOGY SEMINAR (A). Discussion of the composition and fabric of igneous and metamorphic rocks. Assigned reading, exercises, and reports.

12·17. ADVANCED PETROGRAPHY (A). Methods and instruments used in petrological research. Arranged to suit the requirements of individual students, and may include mechanical fractionation methods; Rosiwal analysis and staining techniques; mineral identification using X-ray powder photography and Universal stage methods; statistical analysis with X-rays and the Universal stage.

12·20. ELEMENTARY CRYSTALLOGRAPHY. Basic subject dealing with classical concepts of crystallography important in the study of mineralogy metallography, chemistry and optical crystallography, and including symmetry, crystal classes, crystal systems, indices crystal forms, habit, twinning, parting, cleavage, isomorphism, and polymorphism. Laboratory study of crystal models to acquaint the student with a working knowledge of important crystal forms.

12·23. OPTICAL CRYSTALLOGRAPHY. Optical properties of crystals with special reference to the identification of crystalline substances with the aid of the polarizing microscope. Larsen and Berman, *Microscopic Determination of the Nonopaque Minerals (U. S. Geological Survey Bulletin 848);* Buerger, *Optical Identification of Crystalline Substances.*

12·24. THEORETICAL CRYSTALLOGRAPHY (B). 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.

12·26. X-RAY CRYSTALLOGRAPHY (A). Theory and methods of determining the unit cells and space groups of crystals, including lattice geometry, simple aspects of X-ray diffraction theory useful in crystallographic investigations, rotating- and oscillating-crystal methods. Weissenberg method, de Jong-Bouman method, precession method, determination from X-ray data of lattice type, unit cell, and space-group, and precision determination of cell dimensions. (Alternate years.) Buerger, *X-ray Crystallography.*

12·27. CRYSTALLOGRAPHIC RESEARCH (A). Supervised research on some crystallographic problem.

12·301, 12·302. GENERAL GEOLOGY. Geological processes, including the nature and origin of rocks and minerals, the surficial processes and results of erosion and deposition, and the development and evolution of plants and animals as determined from the fossils in the rocks. The first term devoted to physical geology — minerals, rocks, and the geologic work of streams, oceans, glaciers, and the wind. The second term devoted to a brief study of structural geology, followed by historical geology. Lectures, laboratory demonstrations and work on specimens and maps, and field trips to points of geologic interest in the vicinity.

12·321. ENGINEERING GEOLOGY. Geology adapted to the needs of engineers. Ries and Watson, *Elements of Engineering Geology.*

12·322. ENGINEERING GEOLOGY (B). Relations of geology to engineering problems, with reviews of actual cases.

12·36. ECONOMIC GEOGRAPHY OF THE WORLD. Basic geography of the lands and seas of the world. Resources of significance in world-economy — their nature, location, extent, the trade routes, ports, etc., that forward them to their destination.

12·37. GEOMORPHOLOGY (B). Fundamental principles of geomorphology. Constructional land forms — plains, plateaus, mountains and volcanoes — are first examined and classified. Consideration of cycles of erosion, caused by diverse eroding agencies in each class of constructional land form; and the various types of destructional land forms which erosion produces; thus developing the histories of valleys, of glacial and aeolian land forms, and of shore lines leading to the final intergradation of the destructional with constructional land forms. Opportunity for voluntary field work.

12·38. ADVANCED GEOMORPHOLOGY (A). Critical study of the several theories of geomorphological principles; illustrated by special problems, varying from year to year in accordance with the chief interests of the students. Opportunity for research in geomorphology; and voluntary field work.

12·39. REGIONAL GEOMORPHOLOGY OF THE EARTH. Comprehensive subject on the surface-forms of the world. Forms of all lands in terms of the processes that shaped them; including the continents, the continental and oceanic islands, and the geomorphology of all sea-floors. Emphasis upon cause and process and upon comparison between homologous regions.

12·40. ECONOMIC GEOLOGY (B). Occurrence and origin of ore deposits. Lindgren, *Mineral Deposits, Fourth Edition.*

12·41. ECONOMIC GEOLOGY LABORATORY (B). Training in the determination of ore minerals and their relationships in hand specimens and in polished sections. Laboratory results are correlated with the geological occurrence of the ores. Laboratory supplement to 12·40.

12·42. APPLIED ECONOMIC GEOLOGY (B). Application of geology to: prospecting for new ore bodies, geophysical prospecting, alluvial prospecting, diamond drill core interpretation, mine sampling and ore estimation. Discussion of methods of underground geological mapping. (Alternate years.)

12·431, 12·432. ADVANCED ECONOMIC GEOLOGY LABORATORY (A). Study of specimens or suites of specimens from mineral deposits; metallographic or petrographic work.

12·433, 12·434. ADVANCED ECONOMIC GEOLOGY SEMINAR (A). Seminar including reading and reports based upon the literature of ore deposits.

12·44. ECONOMIC GEOLOGY OF FUELS (B). Geology of natural gas, petroleum and coal, adapted to the needs of engineers.

12·511, 12·512. PALEONTOLOGY. The past life of the earth, studied through a comparison with living plants and animals. Shimer, *Introduction to the Study of Fossils, Second Edition.*

12·52. ADVANCED PALEONTOLOGY (A). Laboratory work and assigned reading upon the Invertebrata or upon some aspect of stratigraphic geology.

12·53. INDEX FOSSILS (A). Determination of the geologic age of rock formations in North America through a study of their included organic remains. Shimer and Shrock, *Index Fossils of North America.*

12·54. MICROPALEONTOLOGY (A). Fossil microscopic plants and animals.

12·55. ADVANCED ORGANIC EVOLUTION (A). Various phases in the evolution of plants and animals.

Geology Continued

12·581. Sedimentation (B). Survey of the chief types of sediments and sedimentary rocks with discussions on the environmental conditions under which they are formed and deposited. Twenhofel, *Treatise on Sedimentation;* Grabau, *Principles of Stratigraphy;* and Hatch, Rastall, and Black, *The Petrology of Sedimentary Rocks.*

12·582. Sedimentation (A). Consideration of the important primary and secondary chemical and physical characteristics of sedimentary rocks, supplemented by microscope work in the laboratory, and by occasional field trips. Twenhofel, *Treatise on Sedimentation;* Grabau, *Principles of Stratigraphy;* and Hatch, Rastall, and Black, *The Petrology of Sedimentary Rocks.*

12·60. Glacial Geology (B). Glaciers, and glacial periods. Origin and motion of glaciers together with the landforms resulting from glacial action. Causes and history of ice-ages considered as a contribution to the geologic history of the earth.

12·63. Physical Geology Seminar (A).

12·64. Geology of North America (A). Geological history of each province beginning with the present physiography of the continent, including the stratigraphy, orogeny and igneous intrusives and extrusives and their influence upon the present structure and topography of the continent. (Alternate years.)

12·66. Research (B). For students desiring special library, laboratory or field work on geologic problems.

12·671, 12·672. Problems in Geology Seminar (A). Seminars in alternate weeks, devoted to major problems in geology, of fundamental rather than special interest, which merit special or detailed consideration. Members of the staff will collaborate, each taking charge of those seminars which deal with subjects within his special field. Each session will consist of a lecture followed by group discussion.

12·701, 12·702. Structural Geology (B). Original or 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 significance. The second term is largely devoted to laboratory and field work.

12·71. Advanced Structural Geology (A). Nature, significance, and causes of structural features produced by earth deformation.

12·80. Geology of Coal and Petroleum (B). Contrast of origin and stratigraphy of coal, oil shale and petroleum and consideration of geology and economics of the major fuel deposits. Elementary treatment of physical principles in underground fluid equilibrium and flow, and of methods used in estimating reserves in oil fields.

12·81. Advanced Geology of Petroleum (A). Structural and stratigraphic relations of oil fields with special emphasis on those in the United States. Application of the principles deduced from selected regions leading to location of new oil fields, proposed by the class and critically examined in conference.

12·851, 12·852. Advanced Theoretical Geophysics. (A). Selected topics in terrestrial physics: age of rocks; thermal problems; seismology and elastic problems; problems in crustal mechanics; figure of the earth and gravitational problems. Jeffreys, *The Earth.*

12·86. Elements of Seismology (B). A general introductory survey. 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. (Alternate years.)

12·87. Introduction to Geophysical Prospecting (B). Orientation subject to acquaint the student with the geophysical prospecting methods as a geological tool. Discussion of the principles, possibilities and limitations of the methods, and the nature of the problem of interpreting the observational data.

12·91. Elements of Mining (B). Mining history, terminology, and fundamentals of practice. including prospecting, exploration, drilling, shaft sinking, drifting, explosives blasting, timbering, haulage, hoisting, ventilation, drainage, mining law, health and safety.

12·92. Mining Methods and Practice (B). Continuation of 12·91. Mining systems, costs, engineering and administration. Mining of metals and non-metallics by open-pit and underground methods, with attention concentrated on adaptability, choice, and practical operation of representative methods of mining.

12·94. Mineral Economics (B). Economic aspects of mineral resources of the world, production and consumption. Effects of distribution, political control, monopolies, tariffs and cartels on availability of raw materials. Attention directed to economic planning, self-sufficiency, nationalism, strategic minerals, over-production and secondary metals.

12·95. Mine Valuation (A). Methods of examination and principles of valuation of principal types of mineral properties to equip student with the theory of valuation and its practical application. Emphasis on sampling, sampling calculations, estimation of ore, costs, selling prices, markets, and profits, the interest rate, depletion and taxation.

12·96. Mineral Economics Seminar (A). Discussions of more advanced phases of mineral economics.

For description of the following see Division of General Studies.

G9. Geology.

G28. Economic Geography.

G29. Topography in the World War.

NAVAL ARCHITECTURE AND MARINE ENGINEERING

Subjects 13·00 to 13·99

13·01, 13·02. Naval Architecture (B). Geometry of the ship, principle of flotation, load line, capacity, tonnage, stability, buoyancy and stability in damaged condition, trochoidal waves, strength calculations, rolling and other ship oscillations, resistance, propellers, propulsion, powering, steering and launching. Rossell and Chapman, *Principles of Naval Architecture;* Taylor, *Speed and Power of Ships.*

13·021. Naval Architecture. Resistance and powering of ships, influence of form and coefficients on resistance; powering and propulsion, propeller design, influence of hull on action of propeller; steering and maneuvering; rolling, pitching and yawing. Rossell and Chapman, *Principles of Naval Architecture.*

13·03, 13·04. Naval Architecture and Ship Design (A). 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. Original design of a merchant ship is carried out by each student.

13·10. History of Warship Design (B). Evolution of modern warships from the introduction of the use of steam machinery for propulsion and iron and steel for hulls; evaluation of the good and bad features of design from battle experience and the effects of technical developments on the military efficiency of warships.

13·11. Structural Design of Warships (A). Stresses in a warship and the design of strength members to support these stresses. Types of loading and other conditions affecting the nature and magnitude of stresses; consideration of the

Naval Architecture and Marine Engineering Continued

strength of simple and built-up structural members; riveted and welded connections; girders, compression members, strength of plating in compression and under fluid loading and the design of shell, framing, bulkheads and decks. Hovgaard, *Structural Design of Warships.*

13·12. Theory of Warship Design (RB). 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 only.)

13·13. Theory of Warship Design (RA). Stresses in a warship and the design of strength members to support these stresses. Hovgaard, *Structural Design of Warships.* (Restricted to Course XIII-A only.)

13·14. Protection and Armament (A). Considerations involved in the design of the military equipment of warships, battery, magazines and ammunition supply systems; structural design of foundations for gun mountings; design of armor protection and protection against underwater explosions.

13·15. Theory of Warship Design (RA). Principles and procedures to be followed in the preparation of the preliminary design of warships and the design of armor protection. Manning, *Basic Design of Ships.* (Restricted to Course XIII-A only.)

13·16. Theory of Warship Design (RA). Considerations involved in the design of the military equipment of warships and in the design of protection against underwater attack; design of ventilation and air-conditioning systems. (Restricted to Course XIII-A only.)

13·17. Basic Design of Naval Vessels (A). The principles and procedures to be followed in the preparation of the preliminary design of warships. Manning, *Basic Design of Ships.*

13·21. Warship Design (RB). Work in the drawing room which includes fairing a set of lines for a warship from preliminary design data; calculations for and drawing of displacement and other curves, cross curves of stability and curves of statical stability. (Restricted to selected officers of the U. S. Navy and Coast Guard only.)

13·22. Warship Design (RB). Work in the drawing room which includes calculations for and preparation of a curve of floodable length and the general arrangement plans of a warship. (Restricted to selected officers of the U. S. Navy and Coast Guard only.)

13·23. Warship Design (B). Work in the drawing room which includes calculations for and preparation of a curve of floodable length and the general arrangement plans of a warship.

13·24. Warship Design (RA). Work in the drawing room which includes calculations and drawings for the general strength investigation of a warship; structural plans of midship section and a transverse bulkhead and shell expansion plan. (Restricted to Course XIII-A only.)

13·25. Warship Design (RA). Work in the drawing room which includes preparation of structural plans of the strength deck of a warship, the stem and bow framing or sternpost and after framing and propeller strut and the transverse strength calculation of a warship. (Restricted to Course XIII-A only.)

13·26. Warship Design (RA). Work in the drawing room which includes the preparation of the necessary plans and calculations for the preliminary design of a warship; preparation of the structural plan of a gun foundation. (Restricted to Course XIII-A only.)

13·27. Warship Design (A). Work in the drawing room which includes calculations and drawings for the general strength investigation of a warship; structural plans of midship section and a transverse bulkhead and shell expansion plan.

13·28. Warship Design (A). Work in the drawing room which includes preparation of structural plans of the strength deck of a warship, the stem and bow framing or sternpost and after framing and propeller strut and the transverse strength calculation of a warship.

13·29. Warship Design (A). Work in the drawing room which includes the preparation of the necessary calculations and plans for the preliminary design of a warship; preparation of the structural plan of a gun foundation.

13·34. Ship Construction. Structural arrangements of ships; general arrangements of ships of various classes; hull systems, including fire, drainage, sanitary, oil and ventilation systems; hull fittings and equipment, including anchor handling, steering gear, cargo and boat handling equipment.

13·341. Hull Engineering. The principles involved in the design and installation of hull auxiliary machinery, hull fittings and hull systems. The lectures also cover the principles and methods of preparing the general arrangement plans of a warship.

13·40. Elementary Ship Construction. Types of ships, geometry of ship form, general and structural arrangements of ships, propelling machinery, and the operation of shipyards. Some attention is also given to the construction of wooden vessels and sailing yachts. Manning, *Manual of Ship Construction.*

13·42. Ship Drawing. Fairing a set of lines from given offsets; preparation of a body plan for calculations; calculations for and drawing curves of form and stability curves; calculations for and preparation of floodable length curve and launching curves. Rossell and Chapman, *Principles of Naval Architecture.*

13·421. Naval Architecture Drawing. Work in the drawing room which includes fairing a set of lines for a warship from preliminary design data; calculations for and drawing of displacement and other curves, cross curves of stability and curves of statical stability. Russell and Chapman, *Principles of Naval Architecture.*

13·45T. Ship Design (B). Lectures on structural design of ships; nature of stresses in the ship girder, shipbuilding materials, strength of individual members of ship structure; design of riveted and welded joints, design of shell and inner bottom plating, framing, decks and bulkheads. Methods of design; estimate of displacement, form, stability and power required and preliminary strength and weight calculations. Drawing room work on making of general arrangement plans, diagrammatic plans of hull systems, and longitudinal strength calculation.

13·46T. Ship Design. Lectures on the basic design of ships. Preparation of the following structural plans in the drawing room: midship section, shell expansion, a main transverse bulkhead and deck in way of cargo hatches; and the preliminary estimate of displacement of a new design. Manning, *Basic Design of Ships.*

13·47. Ship Design. Calculations for and drawing a floodable length curve, load line calculation, general arrangement plans of cargo ship with particular attention to cargo handling arrangements, midship section plan for cargo ship and diagrammatic plan of bilge and ballast system.

13·52. Marine Engineering. Steam and Diesel machinery; fuels, combustion, boilers, reciprocating engines, turbines, auxiliary machinery and steam power plant layouts. Diesel and oil engines, motor ship auxiliaries; types of engines, fuel injection and combustion, valve gears, supercharging, oil engine fuels, and Diesel electric drive. Chapman, *The Marine Power Plant.*

13·54. Marine Engineering (B). Topics in dynamics and stress analysis. Dynamics of the crank-connecting rod mechanism; stresses in connecting rods; the balance of rotating and reciprocating machines; elementary vibration theory; torsional vibration in internal combustion engines and marine reduction gears; vibration of ships; dynamics of governors and flywheels; mechanical similitude and other related topics.

13·55. Marine Engineering. Following a brief review of nozzle and blade design the important dimensions of several turbines are computed and their principal features compared with other modern turbines. Effects of superheat, increased pressure, vacuum; types of auxiliary drive and heat balance of the marine steam plant. Discussion of critical speed blade strength, and design of reduction gears.

Naval Architecture and Marine Engineering Continued

13·56. Marine Engineering. 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; boilers, main engines, auxiliaries and auxiliary systems.

13·57. Marine Engineering. The marine steam power plant as applied to naval vessels; fuels, boilers, propelling machinery and auxiliaries and steam power plant layouts.

13·58. Diesel Engineering (B). Types of Diesel engines with particular reference to naval applications; basic design problems; fuel injection and combustion; valve gears and other mechanical details; super-charging; Diesel-electric drive; gas turbine cycles and gas turbine and Diesel engine combinations.

13·61, 13·62. Marine Engineering Design (B). Calculations and preliminary design of main propelling units for a steamship; determination of sizes of auxiliaries; machinery layout; diagrammatic arrangements of principal piping systems; application of modern heat transfer formulas; propeller design, and other marine engineering problems.

13·64. Marine Engineering Design. Calculations and preliminary layout of the power plant for a naval vessel.

13·71, 13·72. Naval Engineering (A). Modification of 13·75 and 13·76, arranged for students in Course XIII-B.

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 transverse vibration of uniform beams; 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 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; non-linear systems; self-sustained oscillation.

13·75, 13·76. Naval Engineering (RA). Various types of steam and Diesel propelling machinery and auxiliaries. A machinery layout made in the drafting room for a specified ship, involving the basic design of boilers, propelling machinery, gears, condensers, auxiliaries, shafting and propellers. Attention to fuels, lubrication, feed heating systems, heat balances, estimates of performance, analyses of trials, etc. Comparison of the various types of propelling machinery and auxiliaries. (Restricted to Course XIII-A only.)

13·78. Propeller Theory and Experimental Research (A). Discussion of modern ideas of propeller action based on air-foil theory; cavitation; interactions of hull and propellers; various available methods of design.

13·79. Propeller Design (RA). Momentum and blade element theories of propeller action. Propeller testing procedure. Methods of presenting propeller test data. Application of theories and test data to the design of ships' propellers. Strength of propeller blades. (Restricted to Course XIII-A and Navy Torpedo Engineers only.)

13·791. Propeller Design (A). Similar to 13·79.

13·81, 13·82. Ship Operation (B). Engineering and economic aspects of ship operation, various items making up the operating disbursements and incomes; calculations for operating expenses and profits on various trade routes, comparison of different types of fuels and machinery for different sizes of ships and various lengths of voyage; influence of size of ship and speed on operating expenses; turn-around and port expenses; cubic and dead-weight ships; the design of cargo and passenger vessels from the owner's point of view; tonnage measurements, fuel conservation, repairs and maintenance; study of present and future trade routes, cargo movements, and factors influencing ocean freight rates. Coastwise, inland water transportation and interrelation of land and marine transportation. Problems in cargo and passenger ship operation.

13·83. Ports and Port Facilities. Functions, layouts and facilities of ports and passage of cargo through ports; piers, quays, roadstead ports; transit sheds; shipside cranes, warehouses, lighters; movement of cargo to and from hinterland, port belt line railroad, road vehicles and roadways, inland water craft, feeder line vessels; study and comparison of world ports and their cargoes, facilities and hinterlands; port administration, port planning and port charges; port competition; marine passenger terminals; coördination of inland transportation with ocean shipping.

13·84. Cargo Handling and Stowage. Methods of cargo transfer between ship and shore; handling of bulk and liquid cargoes; cargo handling equipment; cargo transfer through deck hatches, the longshoremen's gang, cycle of operation, types of slings; movement of cargo between shipside and transit shed, transit shed vehicles; design of the ship from the point of view of cargo handling, hatches, booms, winches and rigging; cargo transfer through side ports; conveyors and elevators; costs and speeds of cargo transfer; essential requirements in the stowage of cargo, palletized cargo, cargo stowage plans; refrigerated cargoes, cargo ventilation; factors making for rapid turn-around and reduction of cargo handling costs; longshore labor problems. Presentation and discussion of a paper by each student on an assigned port. Trips to the waterfront to observe cargo handling and to visit various types of cargo ships.

METEOROLOGY

Subjects 14·00 to 14·99

14·01. 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*.

14·02. Descriptive Meteorology II. Continuation of 14·01, covering the general circulation of the earth's atmosphere; the secondary circulations, both tropical and extra-tropical, 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*.

14·14. 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.

14·30. 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. Microclimatology. Effect of climate on human life. Climatic changes. Haurwitz and Austin, *Climatology*.

14·31. Regional Climatology (B). 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*.

14·43. Synoptic Meteorology I (B). Principles of weather map analysis; the meteorological elements and their conservatism, classification of air masses, North American air mass properties, formation and characteristics of fronts,

Meteorology Continued

frontal disturbances, basis of upper air analysis, tropical hurricanes. Required reference reading.

14·44. Synoptic Meteorology II (B). 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. Petterssen, *Weather Analysis and Forecasting.*

14·45. Synoptic Meteorology III (A). Analysis of the field of motion with reference to divergence, convergence and vertical motion; fronts and frontogenesis; cyclone waves and structure of moving cyclones; survey of quantitative methods for the construction of surface and upper air prognostic charts. Petterssen, *Weather Analysis and Forecasting.*

14·50. 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.

14·51. Synoptic Laboratory I (B). Analysis of weather maps. Application of practical rules for extrapolating the movement and development of pressure systems. Practice forecasting for selected stations.

14·52T. Synoptic Laboratory II (B). Analysis of weather maps and practice weather forecasting for selected stations, together with practice in special airways forecasting, utilizing the teletype line sequences.

14·53. Synoptic Laboratory III (A). Continuation of 14·52T. Advanced methods of analysis and forecasting with special emphasis on the use of aerological diagrams, cross sections, upper air charts, etc.

14·60. Thermodynamics of the Atmosphere. Review of classical thermodynamics. Thermodynamics of the atmosphere with special emphasis on the role of water vapor. Atmospheric statics. Theory and construction of the common thermodynamic diagrams used in meteorology.

14·61. Dynamic Meteorology I (B). Effects of the earth's rotation on motion. Simple atmospheric motions: geostrophic wind, gradient wind, thermal wind, and isallobaric wind. Surfaces of discontinuity. Equation of continuity. Pressure variations, convergence and divergence. Haurwitz, *Dynamic Meteorology.*

14·62T. Dynamic Meteorology II (B). 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.*

14·64. Dynamic Meteorology III (A). Advanced treatment of the dynamics of atmospheric motion, including a detailed study of atmospheric turbulence. Solution of the simpler problems connected with the wave theory of cyclones and with the study of large scale atmospheric motions.

14·65. Dynamic Meteorology IV (A). Continuation of Dynamic Meteorology III, placing emphasis on the problems arising because of the spherical shape of the earth. Atmospheric tides.

14·67. Graphical Analysis (B). Applications of graphical algebra and calculus to scalar and vector fields. V. Bjerknes, *Dynamic Meteorology and Hydrography II.*

14·70. 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.

14·72. Physical Meteorology (A). More detailed study of radiation theory as applied to the atmospheric heat balance; structure and composition of the stratosphere with special reference to the ozone layer. Theory of the visual range; physical theory of atmospheric condensation and precipitation processes.

14·83. Oceanography (B). 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.*

14·91, 14·92. Meteorological Seminar I, II (A). Weekly reviews and discussions by staff members and students, of recent meteorological contributions published in current periodicals, and of original research.

14·911, 14·912. Meteorological Seminar I, II (A). Same as 14·91.

14·95. Special Problems in Meteorology (A). Reading, consultation and original investigation on meteorological problems.

BUSINESS AND ENGINEERING ADMINISTRATION

Subjects 15·00 to 15·99

15·11. Introduction to Business Management (B). Functions and methods of business. Corporate organization, finance, accounting, production, marketing, with emphasis on interrelations between these functions. Considers business problems in the order they would be encountered in a new business: survey for a new venture; promotion, organization; personnel; operation; control; expansion or liquidation. (Not open to Course XV; may be taken as elective in other Courses.)

15·20. Ocean Shipping Administration. Ocean services and traffic agencies and their organizations; rate and traffic agreements; ocean shipping documents; ocean rates and regulation; marine insurance; and admiralty law.

15·25. Industrial Traffic Management (A). Organization and operation of an industrial traffic department. Industrial aspects of freight classifications, rate structures, routes, carrier-shipper relations, common carrier liabilities, general and special services, national and state common carrier regulations and protective insurance. Types of transportation agencies such as rail, water, air, motor truck, mail, parcel post and express. Seminar discussions and conferences conducted by traffic managers from representative industries.

15·30. Personnel Management. Personnel management 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.

15·41. Finance (B). Principles of financial organization and management. Modern business corporation; instruments and agencies used in finance — corporate securities, investment banking and exchanges; problems of internal financial control. Specific cases illustrating principles and affording opportunity for individual analysis.

15·42. Financial Problems (B). Selected topics in the fields of corporate and personal finance. Case studies in internal financial administration of industry providing opportunity to apply the principles developed in 15·41 to concrete situations. Major part of subject devoted to problems in personal finance, including consideration of investment, insurance and taxation.

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

Business and Engineering Administration Continued

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. Familiarity with use and interpretation of financial reports as an essential business tool. Brief consideration of double-entry bookkeeping. Problems inherent in the typical financial statements. Form and content of balance sheets and of profit and loss statements considered; problems of surplus, depreciation and valuation. Introduction to methods of statement analysis. Reports and accounting policies of actual companies form the basis for discussion. (Not open to students below third year.)

15·51. Industrial Accounting (B). Application of accounting control to industry. Principles of cost analysis as applied to problems of manufacturing, distribution and administration. Teaching material from a wide variety of business situations.

15·52. Accounting. Introduction to elements of accounting. Preparation and structure of representative financial reports to stockholders and creditors examined for use and significance.

15·55. Problems in Accounting Policy (A). Consideration of case problems involving accounting policy approached from administrative viewpoint. Application of analytical methods to financial data. Nature and determination of income, asset valuation, presentation of net worth, consolidated statements.

15·58. Problems in Accounting Control (A). Scope of accounting function with emphasis upon duties and responsibilities of controller. Records systems and extent to which various actual systems meet desired requirements. Periodic reports, budgets, costs, cash control, internal control, intercompany and branch control, machine accounting, taxes and other special problems, including relation of controller to stockholders and to public bodies.

15·61. The Law of Contracts (B). Law of contracts. Rules applicable to formation of contracts, their performance and discharge and also rights of third parties in contracts. Rules applicable to special kinds of contracts such as agency, sales and negotiable instruments.

15·62. The Law of the Market (B). Rights and liabilities of buyers and sellers of goods and also rules of law applicable to customary methods by which purchases and sales financed. Uniform law of sales and uniform law of negotiable instruments.

15·63. Industrial Law (B). Legal aspects of social control of industry through governmental agencies. Constitutional powers and limitations of Federal and State authorities, and trends of administrative law, past, present, and probable. Relationship between government and business as evidenced by rules and regulations which are currently developing, considered with especial emphasis upon financial, production, and marketing problems arising therefrom. Law relative to inventions and their management, commonly called patent law.

15·64. Patent Law (B). Legal aspects of patents, copyrights, and trade-marks. Detailed discussion on what constitutes patentable invention; methods by which a patent may be obtained; its protection after issuance against infringement; rights obtained under copyright laws of the United States; and trade-mark laws of both the United States and the several states.

15·65. Labor Law (B). Fundamental legal principles underlying formation and operation of labor unions, limitations upon right to strike and right of boycott, and control of union activities through administrative governmental agencies.

15·70. Production. Basic treatment of manufacturing process. Factory organization and personnel; fabricating and assembling sequences; productive facilities, their selection, arrangement and coördination; product design; purchasing; internal and external transport of materials; inspection; stores; and salvage. Plant visits and reports.

15·71. Production (B). Application of principles of scientific management to production control; material control; standardization and simplification; design and administration of wage systems; new product control; industrial conversion and management engineering techniques.

15·72. Technique of Executive Control (B). Survey of the means by which line executive deals with working group. Nature of executive responsibilities and methods of supervision, devices for stimulating desire of employee to improve quantity and quality of his work; ways of collaborating with other executives and functional specialists. Common executive difficulties with subordinates, associates, and superiors.

15·73. Management Laboratory (B). Work Simplification and Time Study. Technique of motion study in simplification and standardization of manual work. Process charts, micro-motion and principles of motion economy, proper workplace 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. Use of stop watch for rate setting includes such topics as selected times, leveling factors, fatigue study, allowances, base-rate evaluation.

15·74. Advanced Management Laboratory (B). Advanced techniques in work simplification, motion study, and time 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, coördination with suggestion systems, and maintenance of progress schedules and records of waste elimination.

15·75. Manufacturing Analysis (A). Formation of analytical sequences of appraisal of management methods in manufacturing. Evaluates such factors as process, facilities, operating methods, organization, control structures, incentives. Analyzes specific activities of such functions as purchasing, storage, traffic, research, design, inspection, salvage and maintenance.

15·76. Mass Production Methods (B.) Principles and advantages of direct-line method of manufacture, production engineering and preliminary work necessary to set up fabrication and assembly lines, and control systems used to maintain flow of production along various lines throughout plant. Reading assignments, problems from actual war plants, plant visits, and small term projects constitute required work.

15·81T. Marketing and Reports. Broader social and economic aspects as well as managerial problems involved in marketing operation. Product policy, selection of channels of distribution, brand policy, advertising and sales promotion, customer relationships and problems of price structure. Major emphasis on marketing of manufactured consumer goods, with some attention given to marketing of industrial goods and agricultural products. Instruction primarily by problem method, supplemented by reading assignments and conferences with marketing executives. Written and oral reports on various aspects of marketing.

15·82. Sales Promotion Strategy and Methods (B). Overall strategy involved in use of various sales promotional methods to secure consumer and trade acceptance of 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 with brief consideration of principles of salesmanship. Administrative control of sales operations and role of price policy as it affects promotional problems. Several discussion sessions with marketing executives.

15·83. Marketing Research: Field Surveys (B). Basic principles and techniques in marketing research. Original field study by class, each student making a substantial number of field interviews. Training of student to analyze a problem in its components, secure facts necessary for its solution, interpret data, and prepare suitable written report.

15·84. Marketing Research: Sales Analysis and Potentials (B). Sources of information and techniques used in analyzing sales activities and in measuring market poten-

Business and Engineering Administration Continued

tials. Characteristics and usefulness of variety of sources of market data. Emphasis on market for manufactured products including both industrial and consumer goods. Class projects involving analysis of sales records, of product use reports and of buying power indices and other measures of market opportunities. Stress on use of existing data.

15·86. New Product Appraisal and Development (A). 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 coördination between production, research, marketing, financial and other company departments affected by product decisions. Problems on transferring new products from development stage to regular production, package design, testing market acceptability, and planning introductory sales campaigns. Much of case material from direct contact with business executives actively engaged in product development and evaluation.

15·88. Marketing Seminar (A). Administrative and policy-making level of marketing problems, including coördination of promotional, distribution, product, and price policies; critical appraisal of sales planning and control methods; long range planning of marketing activities and appraisal of effects of governmental controls.

15·92. Industrial Problems (B). With collaboration of operating executives, government representatives and military officials, field of managerial activities and problems currently shouldered by industrialists surveyed. Field interviews, conferences, classroom presentations, case problems and discussions serve to reflect interdependence of marketing and contract-procurement, finance, accounting, production and labor, and interrelations of the going business as a whole with government and public.

15·94. Contemporary Problems Seminar (A). Contemporary industrial and economic issues. Preparation includes assignments to current periodicals as well as text references. Development of facility in appraisal of current trends; stimulation of interest in business relationships with government, labor and public; experience in discovering key factors influencing contemporary events. Guests (faculty members or industrialists) participate.

15·95. Special Problems 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 fieldwork, and reports.

15·96. Administrative Theory and Practice (A). Consideration of initial problems confronting 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 business administrator to subordinates, investors, vendors and customers, associates, community, government and public. Comparison of administrative procedure in old and established organizations *vs.* newly organized companies. Review of underlying principles leading to continuity of administrative tenure. Administrative methods in political and military areas differentiated from those in industrial fields.

15·97. Seminar in Business Administration (A). Consideration of basic aspects of administrative responsibilities in relation to industrial development, operation and control. (Open only to qualified graduate students of other departments.)

Graduate Thesis (A). Original research in field of business administration. Purpose of such work is to ascertain student's ability to make a contribution to existing knowledge.

AERONAUTICAL ENGINEERING

Subjects 16·00 to 16·99

16·01, 16·02. Introduction to Aeronautical Mechanics (B). Dynamics applied to the various phases of aeronautical engineering. Presentation of dynamics of particles, fluids and solid bodies as branches of one comprehensive subject. Fixed and moving reference systems; impulse and momentum, work and energy; center of gravity theorems; kinetic theory of gases; fluids as continuous media; fundamental equations of fluid motion; Bernoulli's equation for compressible and incompressible fluids; jet propulsion; stream function and velocity potential; adaptation of streams to given boundaries; boundary layers and streamlining; lift on rotating cylinders; conformal transformation; lift and moment on airfoils in two-dimensional flows; start of circulation; airfoils in three dimensions; Fourier Series; viscosity; dimensional analysis; kinematics and kinetics of rigid bodies in three dimensions; gyro instruments; oscillations of linear systems with one degree of freedom; forced motions — resonance; oscillations of systems with several degrees of freedom; determinants and their use in the treatment of homogeneous simultaneous equations.

16·03. Aerodynamics — Non Viscous Fluids (A). Continuation of the aerodynamics part of 16·02. Review of general equations of fluid motion, potentials, circulation, vorticity, Bernoulli equation of energy. Deeper treatment of circulation generation, complex potentials, Blasius equations of force and moment, Kelvin's equation of energy, virtual mass, two-dimensional wing theory, conformal transformations via M. I. T. charts, three-dimensional wing theory, Lotz method, fuselage theory, interference effects, gust mechanics, Karman trails and wind tunnel wall corrections.

16·032. Aeronautical Mechanics. Vector Analysis and aerodynamical applications, fluid kinematics and flow description, stream and velocity potential functions, dynamic equations for a perfect fluid, solution by scalar and vector methods, properties of elemental and combined flows, two-dimensional problems, use of complex numbers in flow descriptions, conformal transformation complex integration, Blasius Equations, Kutta-Joukowski Theorem, lift and pitching moment on an infinite wing. Prandtl-Tietjens, *Fundamentals of Hydro- and Aero-Mechanics;* Phillips, *Vector Analysis;* Glauert, *Airfoil and Airscrew Theory.* (Restricted to selected U. S. Naval Officers only.)

16·033. Aeronautical Mechanics. Viscous fluids, Navier-Stokes Equation and special solutions, Prandtl Boundary Layer Theory, skin friction, Helmholtz Vortex Theory, the three-dimensional airfoil, induced velocity, angle of attack, drag, lift distribution, least induced drag tapered and twisted airfoils, chordwise and spanwise load distribution, tunnel-wall effect, compressible fluids. Texts same as 16·032. (Restricted to selected U. S. Naval Officers only.)

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, Schlechting 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.

16·06. Introduction to Wing Flutter (B). Introduction to theory of wing flutter and methods of computing flutter speeds.

16·061. Flutter Mechanics (A). Discussion of the flutter problem and of theoretical and experimental procedures for solving it.

Aeronautical Engineering Continued

16·07. Aerodynamics — Compressible Fluids (A). Brief review of compressibility literature. Method of invariant energy, application of M. I. T. compressibility charts to problems in compressible flow, critical Mach numbers, shock wave mechanics, compressibility burble.

16·08. Advanced Topics in Aeromechanics (A). Problems of practical importance not included in 16·03 and 16·04. Attention to the mechanics of airplane spin and of wing and tail flutter, and of air flow at compression speeds to advanced phases of boundary layer phenomena as they affect burbling, problem of sound reduction and vibration damping directed toward greater passenger comfort.

16·10, 1610T. Applied Aerodynamics (B). Application of aerodynamic theory to airplane design and aircraft propellers. Warner, *Airplane Design, Vol. I;* Weick, *Aircraft Propeller Design.*

16·102. Aerodynamics (Performance). Atmosphere, steady flight, dynamic loads, applied wing theory, parasite drag, propeller characteristics, equilibrium of engine, propeller and airplane, performance, (speed, climb, cruising, range takeoff), performance by chart. E. P. Warner, *Airplane Design-Performance, Second Edition;* Fred E. Weick, *Aircraft Propeller Design.* (Restricted to selected U. S. Naval Officers only.)

16·11. Airplane Performance (B). Discussion of the combinations of characteristics of airplane, propeller, and engine as they affect the performance of the airplane. Warner, *Airplane Design, Vol. I;* Weick, *Aircraft Propeller Design.*

16·13. Airplane Stability and Control (B). General theory of longitudinal and lateral stability, controllability and maneuverability of airplanes.

16·132. Aerodynamics. Fundamental definitions, the forces and moments of the entire plane, the equations of motion, the moments of the wing, the moment of the tail, downwash, C.G. location, C.G. for N.S., locked control stability, free control derivatives, motion in the longitudinal plane. Lateral motion, directional stability, spiral and directional divergence, dynamic stability equations, force and moment derivatives, maneuverability, controllability, three-dimensional motion, spins. Diehl, *Engineering Aerodynamics;* Stalker, *Principles of Flight;* Wood, *Technical Aerodynamics;* Warner, *Airplane Design: Aerodynamics.* (Restricted to selected U. S. Naval Officers only.)

16·14. Airplane Design Problems (B). Preparation of design proposals including preliminary design of an airplane to meet a specific performance and C.A.A. minimum requirements in performance, stability and control.

16·16. Power Plant Performance and Installation (B). General principles underlying the relationships between altitude, power output and fuel consumption of aircraft engines. Principles of heat tranfer applied to radiators and aircooled engines. Internal aerodynamics including drag or thrust due to cooling airflow, engine airflow and exhaust jets. Power plant vibration and vibration isolation.

16·161. Engine Installation. Engine performance under altitude conditions, engine cowling and cooling, engine mounting, engine accessories. (Restricted to selected U. S. Naval Officers only.)

16·17. Airplane Design Practice (B). Preparation by each student of a weight estimate, balance diagram, and general arrangement drawing of a training airplane and solution of certain stress analysis problems according to C.A.A. requirements.

16·172. Airplane Design. Preparation of equipment list, weight estimate, balance diagram, and three-view drawing of a typical small airplane such as a training airplane. Use made of this design for the stress analysis required in 16·173. Texts required in 16·212; Teichmann, *Airplane Design Manual;* CAR 04; CAM 04; certain Navy Specifications. (Restricted to selected U. S. Naval Officers only.)

16·173. Airplane Design. Analysis of the front wing beam and the fuselage structure of the airplane designed in 16·172 for the loads in the high angle of attack flight condition. Timoshenko, *Strength of Materials, Vol. I and II;* Niles and Newell, *Airplane Structures, Vol. I and II;* Sechler and Dunn, *Airplane Structural Analysis and Design;* Teichmann, *Airplane Design Manual; ANC 5; CAR 04; CAM 04; Navy Specifications.* (Restricted to selected U. S. Naval Officers only.)

16·18. Airplane Design Practice (RA). Detail design problems associated with installation, operation and servicing of aircraft armament. Emphasis is placed on the effects which armament installations have upon airplane performance and upon the structural elements by which they are supported. (Restricted to selected U. S. Army or Naval Officers only.)

16·20. Structures. Outer forces, reactions, shears and bending moments, influence lines, slopes and deflections of beams by elastic weights and moment areas, the three-moment equation and method of moment distribution, design of simple beams, and analysis of trusses by algebraic and graphical methods. Niles and Newell, *Airplane Structures.*

16·201. Structures. Parts of 16·20 and 16·21, plus additional topics. Combined stresses; the ellipse and circle of stress; strain rosettes and principal stresses in bending, or bending and torsion; the ellipse and circle of inertia; the three moment equation with applications to beams, frames or crankshafts; centers of twist; influence lines; moment distribution for beams on elastic supports and for beam-columns; strain energy and Fourier's series for displacement curves; impact loads; Castigliano's Theorem; redundant trusses; curved beams and tubes; thin plates and shells, cylinders and spheres; effects of stress concentration. Timoshenko, *Strength of Materials, Vol. I and II;* Niles and Newell, *Airplane Structures, Vol. I and II.* (Restricted to selected U. S. Naval Officers only.)

16·21. Structures (B). Analysis of unsymmetrical beams; beams having partially or totally "ineffective" material in their cross sections; beams having shear-resistant or tension-field web plates; torsion, or torsion and bending, on simple sections; fittings and connections; simple columns and compression members composed of sheet and stiffeners; beam-columns by the generalized three-moment equation and by the generalized method of moment distribution; deflections of beams and trusses by virtual work and by Castigliano's Theorem. Niles and Newell, *Airplane Structures.*

16·212. Structures. Parts of 16·21 and 16·22, plus additional topics. Metal spars with shear-resistant or tension-field webs; columns and struts of variable section; tubes under external pressure; rectangular plates under edge compression and normal loads; design of trusses, wings and space frames; graphical methods for truss analysis; deflection of beams and trusses by virtual work, by elastic loads; the Williot-Mohr diagram; beam-columns; stability of statically indeterminate structures; flat sheet instability; thin walled columns; sheet-stringer and other skin-stressed structures. Timoshenko, *Strength of Materials, Vol. I and II;* Niles and Newell, *Airplane Structures, Vol. I and II;* Sechler and Dunn, *Airplane Structural Analysis and Design: ANC* 5. (Restricted to selected U. S. Naval Officers only.)

16·22. Aircraft Structures (B). Applications of the methods of least work and deflections to the analysis of indeterminate structures, the elements of the analysis of space framework, the use of methods of analysis currently employed in the design of all-metal aircraft and a consideration of the assumptions used in the determination of design load factors and load distributions specified for use on commercial airplanes. Niles and Newell, *Airplane Structures.*

16·22T. Aircraft Structures (B). Applications of methods of least work and deflections to the analysis of indeterminate structures; analysis of curved beams and rings, distribution of shear and effects of shear lag in stressed-skin structures; principles of the methods for determining the stability of systems of members and introduction to the equation of elasticity as applied to isotropic and anisotropic materials. Laboratory work on calibration and use of strain gages, with applications to actual wing structures, drop testing of a hydraulic shock strut, determination of the elastic axis of an airplane wing, and similar experimental investigations. Niles and Newell, *Airplane Structures,* and notes.

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

Aeronautical Engineering Continued

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.

16·33. Meteorological Observations. Observation, recording and coding of weather data; use and maintenance of station instruments; teletype circuit operation and procedure.

16·34. Aircraft Instruments (B). Lectures, problems, and laboratory exercises comprising a survey of aircraft power-plant, flight and navigation instruments and meteorological instruments. An elective for students not specializing in instruments and a background for the more advanced problems treated in 16·42.

16·37. Instrumentation (RA). Adaptation of 16·41. (Restricted to selected U. S. Army and Naval Officers only.)

16·38. Instruments (RA). Adaptations of portions of 16·42. (Restricted to selected U. S. Army and Naval Officers only.)

16·39. Instruments Laboratory (RA). Laboratory exercises to accompany the lecture material of 16·37. (Restricted to selected U. S. Naval Officers only.)

16·40. Instruments Laboratory (RA). Laboratory exercises to accompany the lecture material of 16·38. (Restricted to selected U. S. Naval Officers only.)

16·41. Instrumentation (A). Principles of instrument analysis with emphasis on dynamic performance. Development of generalized methods applicable to instrument problems from the theory of one-dimensional systems.

16·42. Aircraft Instruments (A). Detailed dynamic analysis of various aircraft flight instruments using the methods developed in 16·41.

16·43. Instruments Laboratory (A). To be taken simultaneously with 16·41. Application of principles developed in 16·41 to typical instrument problems.

16·44. Meteorological Instruments (B). Lectures on methods and instruments used to obtain meteorological data, and on the fundamental principles involved. Laboratory exercises on calibration of typical anemometers, meteorographs and radiometeorographs. Field exercises on the measurement of upper air temperatures, humidities and wind velocities; reduction and plotting of meteorological data in suitable form for synoptic and dynamic studies.

16·45. Special Problems in Aeronautical and Meteorological Instruments (A). Problems of interest to properly qualified individual students in consultation with the instructor.

16·46. Vibration Measurements (A). Methods and instruments used to obtain and interpret data on mechanical vibrations are studied. Lectures and laboratory exercises devoted to consideration of the possibilities and limitations of mechanical, optical and electrical instruments for measuring vibrations. Electromagnetic, piezoelectric, carbon and wire resistance pickup units. Use of cathode ray and electromagnetic oscillographs for making visual observations and photographic records from internal combustion engines and other sources of vibration. Analysis of complex vibratory motions into harmonic components, illustrated by laboratory exercises.

16·47. Instrument Design Practice (A). Designs of typical instrument components with emphasis on methods of fabrication used in the instrument field.

16·48. Instrument Design Practice (A). Continuation of 16·47, the student carrying out the design and construction of a working model of a complete instrument.

16·50. Rotating Wing Aircraft (B). Discussion and problems of the rudiments of design of rotating wing aircraft.

16·501. Rotating Wing Aircraft (A). Discussion of problems of performance evaluation, control and stability, vibration and design, as applied to rotating wing aircraft.

16·52. Aircraft Propeller Design (A). Study in class and drafting room of aircraft propeller design including aerodynamics strength and vibration problems.

16·53. Advanced Airplane Engine Design (A). Advanced problems in the design of airplane engines, including drafting room layouts.

16·60. Advanced Aeronautical Problems (A). Individual advanced work by properly qualified graduate students. Problems selected in consultation with the instructor.

16·62. Aerodynamic Laboratory (B). Methods and equipment used for research in aerodynamics.

16·621. Aerodynamics (Wind Tunnel). Lectures including theory and use of wind tunnels, measuring equipment, wall effects, fundamentals of flight testing. Laboratory including determination of simpler forces and moments for performance, control and stability analysis. (Restricted to selected U. S. Naval Officers only.)

16·63. Aerodynamic Laboratory (B). Continuation of 16·62 including additional practice in the laboratory. Class discussions emphasizing solution of special problems in the wind tunnel and flight.

16·75. Construction Details of Aircraft (B). Detail design of the airplane structure, and power plant installation.

16·81. General Aeronautics (B). 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.

16·83. Aeronautical Engineering. Review of theory of flight and introductory aerodynamics and performance with supplementary lectures by men prominent in aeronautics to acquaint the student with the scope and problems in the various fields of aeronautics. (Restricted to selected U. S. Naval Officers only.)

16·84. Aeronautical and Production Engineering. Designed to acquaint the student with Management Engineering in general and Navy Shore Station management in particular, as regards Accounting, Labor Relations, Supervision, Production, Leadership and Efficiency, by introducing the student officers to the regulations concerning the hiring, supervision, and management of civilian employees and the labor relations connected therewith. Organization and management of Production Divisions of Navy Yards. Intended to familiarize the student officer with modern production practices and problems in order better to equip the officers whose future may involve production and material inspection, by means of a series of eight lectures covering the field of plant organization, selection and coördination of production facilities, process sequences and product routing, procurement store, personnel problems; inspections, waste and salvage controls and plant maintenance. (Restricted to selected U. S. Naval Officers only.)

BUILDING ENGINEERING AND CONSTRUCTION

Subjects 17·00 to 17·99

17·22. Building Construction. Construction of Third Class Buildings, with particular reference to the residence. Assembly of various materials commonly used in such construction discussed together with proper relationship and sequence ordinarily used in the field. Consideration of the use of new materials. Class discussions and problem analysis in drafting room. *Department Notes.*

17·31. Building Construction. Second Class Buildings, including combinations of wood and masonry, or exposed steel, wood and masonry, in semi-fireproof or heavy timber construction. Foundation problems, exterior walls, interior frames and floor systems, and an integration of all factors into the finished building, studied same as in 17·22. *Departmental Notes.*

Building Engineering and Construction Continued

17·32. Building Construction. Construction of First Class Buildings, special reference to those with reinforced concrete and structural steel frames. Heavy foundations, shoring, relation of frame to exterior walls, floor arches, interior partitions, mechanical equipment, electrical services and architectural balance studied same as in previous courses in Building Construction. *Departmental Notes.*

17·33. Building Construction. Continuation of Third Class buildings, and application of Second Class construction to light construction. Building and zoning codes and their restrictions upon Housing studied and more rational approaches to flexible public controls for low-cost construction discussed and analyzed. Modern systems, materials and services for home construction coördinated with economic effects. Costs as affected by labor policies and field procedures analyzed. *Departmental Notes and Collateral Reading.*

17·34. Building Construction. Application of principles of mass production to Housing. Various proposals for low-cost housing analyzed and possibilities for development of mass production procedures using structural and wall and floor panels explored. Development of plans on a modular basis with maximum of interchangeability and demountability. Effects of materials on details and methods.

17·40. Estimating and Job Management (B). Two of the important functions exercised by the builder, consideration of basic units into which each estimate is divided, together with a breakdown of such units into man-hours and materials required. Lectures and discussions on job planning, contract relations, labor relations, safety in construction and business aspects of contracting. Pulver, *Construction Estimates and Costs.*

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.

17·45. Construction Problems (B). 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.

17·52. Structural Problems. First part: establishment of a connection by graphical and analytical methods between the study of applied mechanics and structural theory. Graphical analysis actually illustrating stress distribution and affording a more visual concept of stress analysis. This procedure applied to forces, homogeneous and nonhomogeneous beams of wood and steel and reinforced concrete, trusses and masonry piers and arches. Latter part: an application of these studies to structural design in timber, including analysis of compound beams, trussed girders, floor frames of wood, roof trusses and details, timber and concrete-filled columns, and other details common to heavy timber construction. Wolfe, *Graphical Analysis;* Fuller and Johnston, *Applied Mechanics, Vol. II;* Voss and Varney, *Wood Construction.*

17·53. Structural Design (B). Structural design of reinforced concrete building frames, including development of the theory of design, consideration of specifications, and design of solid and ribbed slabs, beam and girder frames, flat-slab systems and columns. Design of footings and retaining walls including discussion of soil pressures. Peabody, *Design of Reinforced Concrete Structures.*

17·531. Advanced Reinforced Concrete Design (A). Retaining walls. Deflection and bending stiffness. Torsional stresses and stiffness. Continuous frame analysis, including irregular spans and members of variable thickness, and continuous frames in three dimensions. Members curved in the horizontal plane, such as bow girders. Members curved in the vertical plane, such as arches.

17·532. Advanced Reinforced Concrete Design (A). Effect of shrinkage and plastic flow. Prestressed members. Plastic theory of design. Special design problems such as balcony frames, ribbed barrel arches, chimneys, elevated tanks, and domes.

17·54. Structural Design (B). Design of structural steel building frames, including design of typical floor-arch systems, rolled and built-up beams and girders, design of details, truss analysis, columns and foundation problems. Special attention to general steel framing in its relation to architectural details and application of structural design to shoring and underpinning. Voss and Varney, *Steel Construction.*

17·542. Advanced Structural Steel Design (A). Welded frames and wind bracing. Elastic frame analysis for welded and riveted frames. Torsion of structural shapes, members curved in horizontal or in vertical plane. Special problems involving balcony framing, elevated structures, arches and domes.

17·56. Structural Design. Structural design of simplified frames in steel and reinforced concrete. Theory of design of slabs, beams, columns and footings for light occupancy buildings. Engineering procedures for design and preparation of working drawings for such buildings. Abbrevation of work given in 17·53 and 17·54. Peabody, *Design of Reinforced Concrete Structures;* Voss and Varney, *Steel Construction.*

17·71. Materials. Mechanical and physical properties of wood in relation to growth, major and minor-structure and other characteristics which influence its use in the construction and engineering fields. Volume changes, moisture content, preservative treatment, wood products, identification, and selection of species for various uses. Fundamental properties and uses of plastics, and basic characteristics of paints and fabrics used in construction. *Wood Handbook;* Leighou, *Chemistry of Engineering Materials; Departmental Notes.*

17·72. Materials. Geological origin, sources and composition of masonry materials together with their conversion into usable building forms. Fundamental properties of clays and clay products, cements and lime, concrete aggregates, mortars, natural and cast stone, gypsum products and various masonry specialties used in construction. *Departmental Notes.*

17·73. Materials. Alloy diagrams and their interpretation. Consideration of the more important non-ferrous alloys and a more detailed discussion of ferrous metals, their properties and heat treatment. Chemistry of corrosion and welding theory and practice. Williams and Homerberg, *Principles of Metallography; Departmental Notes.*

17·77. Special Problems in Building Materials (A). For graduate students whose previous training fits them to undertake research in connection with the physical behavior of building materials, and effect of physical and chemical properties of the constituents of the materials on this behavior.

GRAPHICS

Subjects D1 to D99

D11. Engineering Drawing. Instruction in correct use of drafting instruments and materials. Practice in lettering. Theory of projection drawing. Drawing in orthographic, isometric, oblique and perspective projection. Practice in dimensioning, making of dimensioned freehand sketches of machine parts and accurate detail and assembly drawings from sketches. Tracing in ink and pencil on cloth or paper of finished drawings. French, *Engineering Drawing.*

D12. Descriptive Geometry. Fundamental concepts of descriptive geometry, including reference systems, representation of point, line and plane; fundamental problems of position, of perpendicularity and of measurement. Solutions of

Graphics Continued

fundamental problems checked by methods of analytic geometry. Various surfaces and solids, their sections, developments and intersections. Application of descriptive geometry to certain problems arising in engineering practice. Especial emphasis on ability to visualize problems, and processes involved in their solution. *Notes on Descriptive Geometry.*

D31. NOMOGRAPHY. Nomographic method of solving equations in three or more variable and its application to scientific and engineering data. Functional scales, network charts, simple nomographic relationships derived from plane geometry.

ECONOMICS AND SOCIAL SCIENCE

SUBJECTS Ec1 TO Ec99

Ec11. ECONOMIC PRINCIPLES. Economic analysis concentrating on forms of business organizations; determination and behavior of costs and prices; distribution and exchange; theory of money, international trade, and influence of technological and other changes on volume of production and employment. Use of business cases in study of costs, and integration of practical problems with analysis.

Ec12. INDUSTRIAL ECONOMICS. Examination of particular American industries with special attention to degree of monopoly and competition; means of restoring competition; patent question; regulation of public utilities; public policy in relation to private enterprise; impact of business cycle. Tools of analysis learned in preceding subject in Economic Principles applied in case studies.

Ec15. ECONOMIC PRINCIPLES. Covers same ground as Ec11. Restricted to graduate students for whom it is especially designed.

Ec17, Ec18. 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.

Ec19. MATHEMATICAL APPROACH TO ECONOMICS (A). Use of mathematical methods in all fields of economics.

Ec23. POSTWAR PROBLEMS (B). Economic problems involved in maintaining national income and employment under conditions likely to prevail after the war.

Ec24. SCHOOLS OF ECONOMIC THOUGHT (A). Economic ideas developed by different groups of economists in recent times.

Ec26. BUSINESS CYCLES (A). Statistical, historical, and theoretical examination of determinants of income, production and employment. Modern methods on problems of analyses, forecasting, and control.

Ec28, Ec29. ECONOMICS OF TECHNOLOGICAL CHANGE (B). Factors influencing development of industrial research and technology and economic effects of technological change on investment and business cycle. Role of government in promoting technological progress in this country and abroad.

Ec32. ECONOMIC STATISTICS. Frequency distributions, averages, index numbers, time series, simple correlation, and elementary analysis of variance.

Ec33. ADVANCED STATISTICS (B). Advanced statistical problems (such as theory of variance, small sample techniques) which are of particular importance for psychological and group phenomena.

Ec37. ADVANCED ECONOMIC STATISTICS (A). Special topics in economic statistics.

Ec38. INDUSTRIAL STATISTICS (B). Application of statistical principles to (1) design and analysis of laboratory and factory experiments, (2) process and final inspection and (3) control of quality of industrial output.

Ec39. STATISTICAL INFERENCE (B). Probability distributions, their origins and properties; sampling theory; statistical estimation; testing of simple hypotheses. Exposition is mathematical.

Ec40. MONEY AND BANKING. Forms of money and credit, credit instruments and institutions, commercial banking, price levels, monetary and banking policies.

Ec47. INVESTMENT FINANCE (A). Investment securities, corporate promotion, business expansion, working capital requirements, business failure and corporate reorganization examined from points of view of business executive and of investor. (Not open to Course XV students.)

Ec48. INVESTMENT ANALYSIS (A). Investment characteristics of enterprises and methods of analyzing their securities. Corporate reports and their interpretation. Investment canons and their limitations.

Ec49. PUBLIC FINANCE (B). Examination of expenditures and revenue systems of federal and local governments in the United States, and a study of effects of various fiscal policies and methods upon social and economic development of the community.

Ec50. BANKING AND FINANCE (B). Recent credit trends including international banks, government agencies, housing finance, and other timely topics.

Ec54. CORPORATIONS (B). For students whose professional interest may be in scientific or engineering fields, but who desire some knowledge of corporate organization and finance and social and political problems of business. (Not open to Course XV students)

Ec56. PROBLEMS IN INDUSTRIAL ECONOMICS (B). Economic problems faced by small and large enterprises, and public policies developed to meet these problems under conditions of competition and monopoly.

Ec57, Ec58. INTERNATIONAL RELATIONS. Basic factors in world politics, foundations of national power; influence of geography; relative power positions of the Great Powers; formation and execution of foreign policy; conduct of international affairs; plans for settlement of the war and establishment of a new world organization; and relationship of technology and international affairs.

Ec59. INTERNATIONAL ECONOMICS (A). International Economic equilibrium and operation of adjusting mechanisms as they are affected by recent national policies with respect to trade, finance, money, and exchange.

Ec60. LABOR RELATIONS. Development of labor movement, growth and present status of labor legislation, and broad economic questions raised by these trends. Major concrete questions of labor relations as they are encountered in industry today — wage determination, seniority and layoff methods, grievance procedure, technological changes, union-management coöperation, etc.

Ec65. INDUSTRIAL RELATIONS (B). Students will analyze and discuss case situations in current industrial relations.

Ec66. SEMINAR IN INDUSTRIAL RELATIONS (A). Constructive participation in developing "situational thinking" as a distinctive approach to industrial relations.

Ec67, Ec68. SEMINAR IN LABOR PROBLEMS (A). Labor problems in the United States.

Ec70. INTRODUCTORY PSYCHOLOGY. Systematic approach involving a dynamic concept of the whole human being, as developed from the practice of therapists who solve daily the problems of real life, backed by an increasing amount of experimental evidence. An attempt to answer at the level of practical everyday living the commonest questions of normal youth, "Why do we behave as we do? How can we understand ourselves and those with whom we associate?"

Ec71, Ec72. MOTIVATION AND PERSONALITY DEVELOPMENT (B). Aspects of the development of the individual which influence his adult relations to his fellows and his culture. Special emphasis on modern motivational theory.

Ec721. PSYCHOLOGY OF PERCEPTION AND ACTION (A). Problems of action, verbal expression and social perception. Stress on the relation to work efficiency, to interviewing procedures and to performing certain social functions (role playing).

Economics and Social Science Continued

Ec731, Ec732. Introduction to Group Psychology (B). A basic orientation to a systematic theory of group life: group structure and functioning, group interaction, group ecology, the relation between individual and group. Stress on the relation to industry, public administration, nutrition and other applied fields.

Ec735. Advanced Group Psychology (A). Group Psychology on a more advanced level with specific problems, such as leadership of different types and capacities and leadership training for different purposes.

Ec75, Ec76. Laboratory in Research Methods (A). Basic experimental and observational techniques in individual and group problems; scientific methods of evaluation.

Ec77. Seminar on Topological Psychology (A). Scientific representation of psychological "force fields."

Ec781, Ec782. Social Psychology of Change (A). Conditions of change and constancy in individual and group life; factors determining the degree and permanence of change. Emphasis on practical methods of producing desired changes.

Ec791, Ec792, Ec793, Ec794. Advanced Psychological Seminar (A). Available to students after one year of graduate work and dealing with current research — an opportunity to participate in developing new concepts and theories.

Ec80. American Government. Governmental process in United States viewed historically and functionally. Development of American system in relation to changes that have taken place in political ideas in this country and abroad.

Ec82. Government Control of Industry (A). Relationship of state to economic activity. Attention centered on the United States, but comparison made with medieval guild control, policies of mercantilism and with contemporary foreign systems.

Ec83. 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.

Ec85, Ec86. Land Economics (B). Principles of classification and utilization of urban and rural land. Policies of conservation and control of land and their effects on social development.

Ec88. Building Economics. Social, political, industrial, and economic factors affecting the location, construction, financing, and marketing of buildings — with emphasis on low cost housing.

Ec91, Ec92. Economic Seminar (A). Special social problems or economic problems of particular industries. (Open to graduate students only.)

Ec93, Ec94. 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.

Ec95, Ec96. Social Science Seminar (A). Reading, discussion, and case work relating to non-economic aspects of human behavior and human relations in the perspective of modern social and industrial conditions.

For description of the following subjects see Division of General Studies.

G75. Human Relations.
G76. Human Relations.

ENGLISH AND HISTORY

Subjects E1 to E99

E1. Entrance English.

E11. English Composition. Principles of effective written and oral communication. Particular attention to logical organization of papers and talks and to precise and coherent expression of facts and opinions. Numerous papers and speeches required.

E12. English Composition. Continuation of E11.

E21, E22. United States in World History. Position of the United States in world civilization. Covers not merely evolution of American political and social institutions as such, but also ways in which growth of the United States has influenced and been influenced by developments and forces in the rest of the world. Arrangement of material topical, rather than strictly chronological or national. Economic, social, and governmental institutions and trends dealt with much more fully than the narrative details of history. The first term covers the period 1600–1870; the second term, the period from 1870 to the present time.

E25. English Composition. Students who in the collective judgment of members of the Department of English and History have failed in E22 to meet certain standards of expression and therefore have received a Composition D 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.

E33. Report Writing. Practice in writing simple memoranda, business letters, and comprehensive scientific reports. Search of literature of subjects pertaining to thesis in Chemistry, arrangement of material, and its presentation in oral and written report form. (Open to Course V students only.)

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. Emphasis on written reports and on oral presentation before committees.

E41, E42. History of Thought. Traces historical connection between present day ideas, and theories of great thinkers in science, philosophy, government, and economics. The first term covers the period 1200–1789, the second term, the period from 1789 to present time.

E43, E44. Western World Literature. Comprehensive view of some of the writings of outstanding western world authors. Only men in the first rank are dealt with, and their works are studied with the object of showing their place in world literature. The first term begins with classical Greek literature and ends with the age of enlightenment, the second term, covers from the age of enlightenment to present time.

E46. Introduction to Music. Approach to the understanding of musical development. Many musical illustrations in the classroom. Lectures and outside reading to give simply and clearly the knowledge needed by an intelligent listener.

E51, E52. Seminar in Economic and Industrial History (A). An historical study of the economic concepts and institutions which have governed the production and distribution of goods since the Middle Ages. Particular attention given to the evolutionary character of economic institutions and to the development of modern industrial organizations. Two full year subjects in Social Science will be required as preparation for admission to the subject.

For description of the following see Division of General Studies.

G1. History of Science.
G2. History of Science.
G7. Problems of Modern Philosophy.
G12. Seminar in Biography.
G38. Public Speaking.
G39. Reading Seminar.
G67. Principles of Debating.
G68. Principles of Debating.

HUMANITIES AND SOCIAL SCIENCES

DURING each regular academic year, in addition to required courses in mathematics, science, engineering, and modern languages, undergraduate students are expected to carry one course in the general field of the humanities and social sciences. In the second half of the third year and in the fourth year a limited number of options are permitted. The list of options may be modified or extended from year to year.

HUMANITIES I

FIRST YEAR

First Term	E11	English Composition	3–5
Second Term	E12	English Composition	3–5

HUMANITIES II

SECOND YEAR

First Term	E21	U. S. in World History	3–5
Second Term	E22	U. S. in World History	3–5

HUMANITIES III

THIRD YEAR

First Term	Ec11	Economic Principles	3–5
Second Term	Ec12	Industrial Economics	3–5
(Choice of	Ec60	Labor Relations	3–5
one)	Ec70	Psychology, Introductory	3–5

HUMANITIES IV

FOURTH YEAR

First Term	(1) 4·41	Fine Arts	3–5
(Choice of	(2) Ec57	International Relations	3–5
one)	(3) E41	History of Thought	3–5
	(4) E43	Western World Literature	3–5
Second Term	(1) E46	Music, Introduction	3–5
(Choice of	(2) Ec58	International Relations	3–5
one)	(3) E42	History of Thought	3–5
	(4) E44	Western World Literature	3–5

It is expected that a student will desire to follow the same field through both terms.

E11, E12. ENGLISH COMPOSITION. Principles of effective written and oral communication. Particular attention to logical organization of papers and talks and to precise and coherent expression of facts and opinions. Numerous papers and speeches required.

E21, E22. UNITED STATES IN WORLD HISTORY. Position of the United States in world civilization. Covers not merely evolution of American political and social institutions as such, but also ways in which growth of the United States has influenced and been influenced by developments and forces in the rest of the world. Arrangement of material topical, rather than strictly chronological or national. Economic, social, and governmental institutions and trends dealt with much more fully than the narrative details of history. The first term covers the period 1600–1870; the second term, the period from 1870 to the present time.

Ec11. ECONOMIC PRINCIPLES. Economic analysis concentrating on forms of business organization; determination and behavior of costs and prices; distribution and exchange; theory of money, international trade, and influence of technological and other changes on volume of production and employment. Use of business cases in study of costs, and integration of practical problems with analysis.

Ec12. INDUSTRIAL ECONOMICS. Examination of particular American industries with special attention to degree of monopoly and competition; means of restoring competition; patent question; regulation of public utilities; public policy in relation to private enterprise; impact of business cycle. Tools of analysis learned in the preceding subject in Economic Principles applied in case studies.

Ec60. LABOR RELATIONS. Development of labor movement, to growth and present status of labor legislation, and to broad economic questions raised by these trends. Major concrete questions of labor relations as they are encountered in industry today — wage determination, seniority and layoff methods, grievance procedure, technological changes, union-management coöperation, etc.

Ec70. INTRODUCTORY PSYCHOLOGY. Systematic approach involving a dynamic concept of the whole human being, as developed from the practice of therapists who solve daily the problems of real life, backed by an increasing amount of experimental evidence. An attempt to answer at the level of practical everyday living the commonest questions of normal youth, "Why do we behave as we do? How can we understand ourselves and those with whom we associate?"

4·41. FINE ARTS. Illustration and analysis of typical artistic productions to stimulate the habit of observation, and to make the student sensitive and discriminating in his artistic preferences. Sufficient history to place significant periods and masters. Classwork in common for all; outside work specialized, as students prefer, in any of the fine arts. Demonstration in the Graphic Arts, and practice for students desiring it.

Ec57, Ec58. INTERNATIONAL RELATIONS. Basic factors in world politics, foundations of national power; influence of geography; relative power positions of the Great Powers; formation and execution of foreign policy; conduct of international affairs; plans for settlement of the war and establishment of a new world organization; and relationship of technology and international affairs.

E41, E42. HISTORY OF THOUGHT. Traces historical connection between present day ideas, and theories of great thinkers in science, philosophy, government, and economics. The first term covers the period 1200–1789, the second term, the period from 1789 to present time.

E43, E44. WESTERN WORLD LITERATURE. Comprehensive view of some of the writings of outstanding western world authors. Only men in the first rank are dealt with, and their works are studied with the object of showing their place in world literature. The first term begins with classical Greek literature and ends with the age of enlightenment, the second term covers from the age of enlightenment to present time.

E46. INTRODUCTION TO MUSIC. Approach to the understanding of musical development. Many musical illustrations in the classroom. Lectures and outside reading to give simply and clearly the knowledge needed by an intelligent listener.

GENERAL STUDIES

SUBJECTS G1 TO G99

THIS section includes subjects of a general and essentially non-vocational character which are offered for the purpose of giving the student an opportunity of broadening his education. When the coördinated program in the humanities and social sciences is in full effect, these studies will be *optional electives without credit*. So far as possible, the subjects offered in any term, and the hours and methods of instruction will be planned to meet the needs of students who request subjects of this type. The list will accordingly be modified from time to time.

G1. HISTORY OF SCIENCE. History of science from its beginnings. Babylonians and Egyptians, development and decline of Greek Science; transmission of science into Western Europe; science of the Renaissance. Centers around the physical and biological sciences, with reference to technical arts and sciences. Emphasis on the development of scientific spirit and method. Illustrated by lantern slides.

G2. HISTORY OF SCIENCE. Continuation of G1 covering history of various sciences to the end of the eighteenth century. Nineteenth century science along the two lines of its most

General Studies Continued

important development — geology, biology, and theory of evolution; chemistry, physics, and atomic nature of matter. Illustrated by lantern slides. (Either G1 or G2 may be taken independently.)

G7. Problems of Modern Philosophy. The self and the will.

G8. History of Philosophy. General survey of modern philosophy from the time of Descartes.

G9. Geology. Consideration of the forces now modifying the earth and its inhabitants, and history of changes produced by these forces throughout the past, upon the earth and its life. Shimer, *Introduction to Earth History.*

G12. Seminar in Biography. Preparation and oral presentation of papers based upon lives and works of some of the world's most important philosophers, scientists, and statesmen. Opportunity for round table discussion of questions to which each generation must seek its answers.

G28. Economic Geography. Seas and land masses of the world, with geography of human races, with the world's resources in mineral wealth and its resources of plant and animal origin; also with distribution of commodities, with manufactured products, with economic basis of world trade and with national control of raw materials.

G29T. Topography in the World War. Influence of topography in directing military objectives considered in every theatre of the world war, and influence of topography in defense for areas which may reasonably become involved.

G38. Public Speaking. Designed, through practice and criticism, to afford knowledge of principles of public speaking and, to extend the range of student's intellectual interests.

G39. Reading Seminar. Opportunity to read good books under direction. Readings will be chosen from a selected list of interesting and important works of past and present. Each student's selection, given unity of interest in a period or a subject. Written critical reviews, oral presentations, and group discussions. Group limited to fifteen students.

G581. G582. Elementary Russian. Elementary grammar; practice in reading Russian. Enables a good student by the end of year to read scientific articles in Russian, also laying the foundation for continued study of the language.

G67. Principles of Debating. In addition to discussion of fundamentals of argumentation and debating, a public question with important economic and political significance is selected for study and analysis. Individual instruction in collection of material and in oral presentation of conclusions. Class open to a selected group of students, after consultation with instructor, on basis of capacity and interest in debating and public speaking.

G68. Principles of Debating. Psychology of persuasive speech, separate assignments in argumentation, public speaking methods, and audience psychology being correlated to this end. One-half the subject devoted to the theory of persuasive speech; remainder devoted to training of student in practical application of this theory. Each student to write and deliver (on a recording machine) two examples of "persuasive speech." Robert Oliver, *The Psychology of Persuasive Speech.*

G75. Human Relations. Fundamental object a realization of necessity for good method in dealing with human relations, as well as grounding in what constitutes good method. Such basic influences as aptitudes, habits, attention, understanding, desires, and prejudices analyzed and applied to typical situations which arise in employment. Illustrative problems taken from actual cases with emphasis on that structural analysis which characterizes good method. Except by special permission of instructor, only juniors and seniors may elect the subject.

G76. Human Relations. Continuation of G75 which applies fundamentals already learned to job interviews, hiring, discipline cases, problems in coöperation, industrial conflict, etc. Case demonstrations of actual situations in which selected students act as executives presented in the classroom; the person taking the part of employee is brought in from industry and the technique of students handling the situation subsequently discussed, often by actual business men familiar with the original situation. Except by special permission of instructor, only juniors and seniors may elect the subject.

G79T. Comparative Political Institutions. Various theories of government viewed historically and comparatively. Modern trends as evidenced by Fascism, Communism, Socialism and the changes in constitutional democratic government discussed in detail in relation to social and economic changes.

MODERN LANGUAGES

Subjects L1 to L99

SEVERAL courses are offered in both French and German; two in Spanish, one in Italian, one in Russian. Those in French and German are of Elementary, Intermediate and Advanced grade. In the Elementary and Intermediate subjects a careful foundation is laid for reading, writing and speaking the foreign language. Great care is taken to secure a good pronunciation, a mastery of the working essentials of grammar, a reasonable vocabulary for the expression of common ideas, training of the ear, and a broad reading vocabulary. The reading texts include scientific matter, fiction, drama, historical or descriptive works of a nature to open up to the student the genius, institutions and social organization of the country studied. Part of the work consists of assignments for written translation of articles from recent foreign journals selected by each student according to his individual interests and needs. Occasional illustrated lectures are given to supplement the class exercises and stimulate interest.

The elective courses in Spanish and Italian are parallel to the courses in French and German. They give a training in pronunciation, essentials of grammar, and reading of varied matter. On completion a student should be able to make intelligent contact with the foreign country, be able to read correspondence and translate reading matter of moderate difficulty. In all subjects the foreign language is used as far as practicable in the classroom.

L11, L12. Elementary German. Necessary foundation for German language for scientific and litarary purposes. Fulfills entrance requirements in Elementary German. Training in pronunciation, elementary grammar, acquisition of useful vocabulary, reading of varied matter, some of which deals with science, and individual written translations from recent scientific works. Texts (subject to modification): Cowden and Van Eerden, *Introduction to College German;* Sepmeier, *Hans und Liese;* Gerstäcker, *Irrfahrten;* Wizinger, *German Science Readings.*

L21, L22. Intermediate German. Systematic review of grammar, miscellaneous prose and individual written translations from recent scientific works. Trains students to read understandingly any ordinary newspaper or magazine article of a literary or popular scientific nature, to understand simple spoken German, and to express simple thoughts in German. Texts (subject to modification): Curts, *Readings in Scientific and Technical German;* Zeydel, *First Course in Written and Spoken German;* Kästner, *Drei Männer im Schnee.*

L31. Intermediate German. Required in Course V. Reading of selected texts and individual assignments of articles in recent chemical journals.

L41. Advanced German. For premedical students.

L51, L52. Elementary French. Necessary foundation for French language and literature, or for scientific studies. Fulfills the entrance requirement in Elementary French. 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 spoken French; also individual written translations from recent scientific works. Reading of some technical

Modern Languages Continued

French included in second term. Texts (subject to modification): Fraser and Squair and Carnahan, *Standard French Grammar;* Hills and Dondo, *La France;* Maupassant, *Six Contes Choisis;* Eve Curie, *Madame Curie;* one short play.

L61, L62. Intermediate French. Continuation of grammar, pronunciation, and useful conversational forms; reading of matter dealing with French geography, history, and industrial activity; some standard modern authors; reading of scientific French; individual written translations from recent scientific works.

L81, L82. Elementary Spanish. Pronunciation, elementary grammar (first term), graded reading matter. Practice in conversation, composition (second term). Texts (subject to modification): Hills, Ford, Rivera, *Brief Spanish Grammar for Colleges;* Castillo and Sparkman, *Graded Spanish Readers;* Valdes, *Los Puritanos;* Galdós, *Doña Perfecta;* the New York newspaper *La Prensa.*

L83, L84. Intermediate Spanish. Brief grammar review, conversational forms, composition and letter writing; reading of varied matter, a large part of which deals with Spanish-American countries. Texts (subject to modification): Seymour and Carnahan, *Alternate Spanish Review Grammar;* Castillo and Sparkman, *Volando por Sudamérica;* Crow, *Cuentos Hispánicos;* Quintero, *Doña Clarines.*

L91, L92. Elementary Italian. Pronunciation, elementary grammar, easy reading matter, practice in conversational phrases useful for travel. Texts (subject to modification): Russo, *Elementary Italian Grammar;* Russo, *Nel Paese del Sole;* Capocelli, *L'Italia nel Passato e nel Presente;* Wilkins and Altrocchi, *Italian Short Stories.*

For description of the following see Division of General Studies.

G581, G582. Elementary Russian.

MATHEMATICS

Subjects M1 to M99

M1. Entrance Algebra.

M3. Entrance Solid Geometry.

M4. Entrance Trigonometry.

M11. Calculus. Fundamental ideas of calculus. Differentiation and graphical representation of algebraic, trigonometric, logarithmic and exponential functions. Integration of simple algebraic and transcendental functions. Maxima and minima applications to problems in geometry and mechanics, such as determination of velocity, acceleration, area, volume and pressure. Discussion of the analytic geometry of the straight line, and the conic sections.

M112. Mathematics (College Transfer). For college transfer students who have taken calculus prior to their transfer but whose preparation is not sufficient to cover first year requirements.

M12. Calculus. Parametric representation of curves, polar coördinates. Methods of integration including approximate integration. Further applications of derivatives and integrals, including arc length, curvature, surface area, center of gravity and moment of inertia. Average values. Elementary vector analysis in the plane, vector velocity and acceleration.

M21. Calculus. Partial differentiation. Infinite series. Complex numbers. Surfaces and vectors in three-dimensional space. Dot and cross products of vectors and their applications. Multiple integration and geometrical and physical applications.

M212. Mathematics (College Transfer). For college transfer students who have taken calculus prior to their transfer but whose preparation is not sufficient to cover second year requirements.

M22. Differential Equations. Treatment of ordinary differential equations including principal types of first and second order equations, simultaneous equations, and linear equations with constant coefficients. Illustrated by numerous applications to geometry, chemistry, physics and mechanics. Phillips, *Differential Equations, Third Edition.*

M31. Differential Equations. Complex numbers, Fourier series, partial differentiation, systems of ordinary differential equations and some simple partial differential equations with applications to the long line and heat flow. Laplace Transforms. Franklin, *Differential Equations for Electrical Engineers.*

M32. Elementary Statistics. General survey of practical application of statistical methods to scientific and engineering problems, covering frequency distributions, moments, precision of measurements, correlation, tests of significance, analysis of variability and experimental design.

M331. Mathematical Theory of Statistics (B). Mathematical methods of statistics and their application to scientific and engineering data, including systems of frequency curves and moments, theory of large and small sampling simple partial and multiple correlations, contingency, statistical estimation, and analysis of variance.

M332. Mathematical Theory of Statistics (B). Statistical principles applied to design and analysis of complex experiments. Discussion of mathematical theory underlying modern experimental arrangements. Practical problems involving Latin squares and their variations, factorial design, split plot experiments, confounding and partial confounding, etc.

M341, M342. Modern Statistical Theory (B). Topics varying from year to year. Discussion of papers taken from recent journals. Solution of scientific and industrial statistical problems.

M351, M352. Advanced Calculus for Engineers (A) Vector calculus with applications to geometry, kinematics, mechanics and hydromechanics. Partial differentiation. Fourier series and complex variables with applications to differential equations. Lagrange's equations for dynamical systems and applications to vibrations, stability, and theory of structures. Franklin, *Methods of Advanced Calculus;* Karman and Biot, *Mathematical Methods in Engineering.*

M36, M37. Advanced Calculus (A). Complex variable, power series, partial differentiation, implicit functions, Gamma and Beta functions, line, surface and space integrals, vectors, ordinary differential equations, Bessel functions, partial differential equations, calculus of variations, elliptic integrals.

M381, M382. Theory of Functions (A). General subject in analysis somewhat more advanced than M36, M37. Series, infinite products, the Riemann integral, functions of a complex variable, contour integration, asymptotic expansions, Fourier series, differential equations, integral equations, and various transcendental functions of importance in the applications of mathematics. Logical derivation of the processes of analysis connected with these topics. Whittaker and Watson, *Modern Analysis.*

M441. Projective Geometry (B). Homogeneous coördinates. Point, line, and plane coördinates. Ranges and pencils. Principle of duality. Curves and surfaces of second order and of second class. Linear transformations. Projective measurement. Non-Euclidean geometry. Pentaspherical and Plücker coördinates. F. S. Woods, *Higher Geometry.*

M442. Elementary Differential Geometry (B). 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. W. C. Graustein, *Differential Geometry;* L. P. Eisenhart, *Differential Geometry.*

Mathematics Continued

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 Applied Mathematics (A). Mathematical discussion of linear and non-linear problems arising in the field of mechanics of a continuum.

M54. Mathematical Laboratory (B). 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.*

M551, M552. Functions of a Real Variable (A). Theory of Lebesgue's integral with applications to important topics of the theory of functions of a real variable, such as trigonometric series, Fourier integrals, almost periodic functions, etc. 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.

M561, M562. Functions of a Complex Variable (A). Complex integration, Cauchy's theorem, zeros, Jensen's theorem, Carleman's theorem, analytic continuation, maximum-modulus theorem, conformal mapping, power-series, entire functions. Content based upon the first eight chapters of Titchmarch, *Theory of Functions.*

M571, M572. Differential Equations (A). Constant reference to the physical problems which have given rise to the field of differential equations. Various aspects of the linear differential equation including boundary value problems and representation of an arbitrary function by Sturm Liouville functions, solution of certain of the more common equations by series and integrals, and classification of equations by singular points. Relationship between integral and differential equations. Non-linear differential equations, particularly as related to physical problems, studied by topological and analytic methods. Detailed treatment of the linear partial differential equation of the second order and study of problems from potential theory, vibrations, heat flow, and other fields by methods including the integral equation and Fourier transform. Ince, *Ordinary Differential Equations;* and a text on partial differential equations.

M581, M582. Continuous Groups (A). Basic concepts of group-theory, such as group, sub-group, invariant sub-group, finite and infinitesimal transformations; one-parameter groups and their applications to differential equations and geometry; r-parameter groups, structure constants, the fundamental theorems of Lie; invariant theories associated with continuous groups; differential invariants and applications to systems of partial differential equations.

M62. Modern Algebra (B). Polynomials, determinants, linear equations, linear transformation, matrices, linear independence, introduction to groups.

M641, M642. Tensor Calculus (A). Elements of tensor algebra, followed by analysis of tensor fields, especially of those in which a metric is defined with the aid of a quadratic differential form. Applications to differential geometry, mechanics and physics.

M651, M652. Analytical Mechanics (A). Treatment of analytical dynamics of particles and rigid bodies, mainly by Lagrange's equations in generalized coördinates and Hamilton's canonical equations. Contact Transformation, Hamilton-Jacobi theory, theory of vibrations, and non-holonomic systems.

M671, M672. Partial Differential and Integral Equations (A). Designed to show how various types of physical problems lead to partial differential equations and to integral equations; and existing technique for solving such equations. Partial differential equations, Fourier technique, various types of harmonics and special orthogonal functions, and the Fourier integral. Treatment of equations which arise in potential theory, heat flow, wave propagation, etc. Integral equations showing how such equations arise in different types of physical problems. Available methods for solving such equations, together with the various series, solutions, characteristic functions, etc. The Laplace transformation. Integral equation methods contrasted with differential equation methods.

M681. Calculus of Variations (A). Extension of theory of maxima and minima as begun in calculus. Determination of functions, curves or surfaces with given maximum or minimum properties. Applications to geometry and physics; geodesics, minimal surfaces, isoperimetric properties of circle and sphere, Fermat's principle of least time (optics), Hamilton's principle, catenary, brachistochrone. Bolza, *Lectures on the Calculus of Variations;* Bliss, *Calculus of Variations;* Goursat, *Cours d'Analyse, vol. 2, chapter XXIII.*

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.*

M71, M72. Mathematics. Graphical and mechanical computation, review of algebra, trigonometry, analytic geometry, calculus. Differential equations, advanced calculus, elements of vector analysis. (Restricted to selected officers of the U. S. Navy and Coast Guard only.)

M73. Review of Mathematics. Review of college algebra, trigonometry, elementary calculus, differential equations. (Restricted to selected officers of the U. S. Navy and Coast Guard only.)

M731, M732. Mechanics (B). Statics; point kinematics with applications to linkwork and mechanism; polar diagrams of velocity and acceleration; kinematics and dynamics of rigid bodies in three dimensions; dynamics of mechanisms; impact, theory of the gyroscope, with applications; Lagrange's equations; Hamilton's principle; theory of vibrations, with applications to engineering problems.

M76. Theory of Probability (A). Permutations and combinations. Elementary principles of theory of probabilities. Bernoulli's Theorem. Bayes' Theorem. Distributive functions and continuous variables. Averages. Curve fitting. H. Levy and L. Roth, *Elements of Probability;* T. C. Fry, *Probability and Its Engineering Uses.*

M77. Vector Analysis (B). Treatment of vector functions and operations required in theoretical work on electricity. Phillips, *Vector Analysis.*

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 bending and torsion of bars. Theory of plane stress and strain, Airy's stress function, use of elements of complex variable theory. Bending of flat plates. Bending and stretching of thin shells. Elastic stability theory. Elements of the finite deformation theory of elasticity.

M831, M832. Analysis (B). Advanced calculus for those already familiar with elementary technique and desiring some knowledge of the logical development of calculus as a mathematical science. Real and complex number system, limits, continuity, convergence, series, integration, theory of functions of real and complex variables. Franklin, *A Treatise on Advanced Calculus.*

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.

For description of the following see Division of General Studies.

G8. History of Philosophy.

MILITARY SCIENCE AND TACTICS

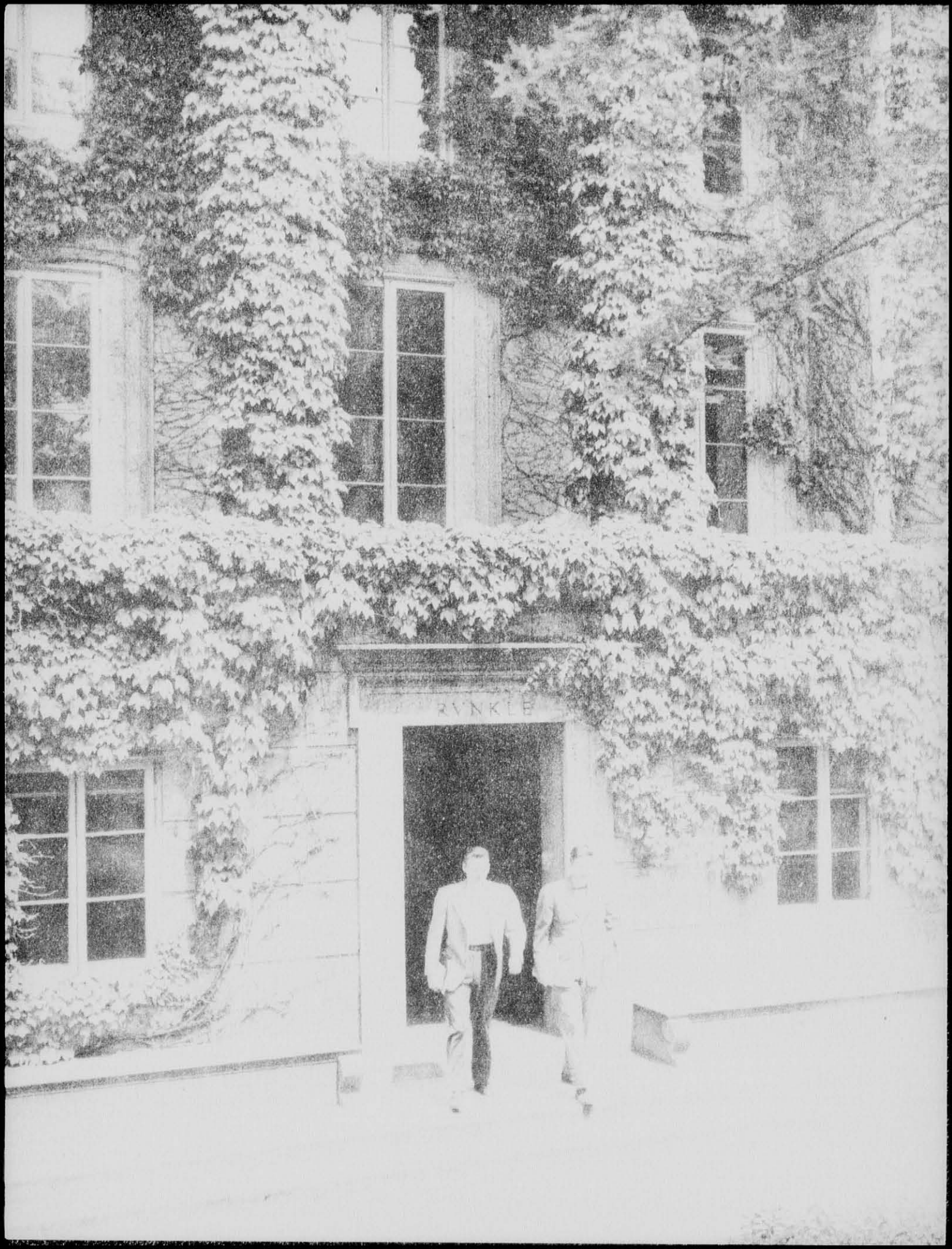
SUBJECTS MS1 TO MS99

MS11. MILITARY SCIENCE. (Required in all Courses.) Consists of eight weeks of infantry drill, ceremonies and physical drill and seven weeks of lectures on basic military training subjects.

MS12. MILITARY SCIENCE. (Required in all Courses.) Consists of nine weeks of dimounted drill, extended order drill, formations, ceremonies, and physical drill and six weeks of marksmanship and map reading.

MS21. MILITARY SCIENCE. (Required in all Courses.) Consists of eight weeks of infantry drill, formations, ceremonies and physical drill and seven weeks of lectures on interior guard duty, mechanical training with rifle, map and photograph reading.

MS22. MILITARY SCIENCE. (Required in all Courses.) Consists of six weeks of formations, ceremonies and physical drill and nine weeks of classroom instruction covering combat branches of the army, tactical training and administrative procedures.


RVNKLE


DARWIN

SUBJECTS OF INSTRUCTION TABULATED

The information below is necessarily 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 required.

(A) following the year indicates that the subject is primarily for Graduate students. (B) indicates subjects for Graduate as well as Undergraduate students. (R) means that the subject is restricted to the special groups indicated at the end of the description of the subject.

Some "B" subjects will not be credited toward a graduate degree in Courses in which they are required subjects of the undergraduate schedule.

Then follows the time distribution of the subject in units (a unit representing fifteen hours work). The total credit for a subject is the sum of 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	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
1·00	Surveying	D12	–	–	–	2	0	2	Shea
1·00T	Surveying Fieldwork	D12	2	S	I	0	13	0	Shea
			3	S	XVII				
1·01	Topographical Drawing	D12	–	–	–	0	4	0	Shea
1·01T	Survey. Fieldwork, Adv.	1·00T	2	S	I	0	4	0	Shea
1·03	Surveying, Adv.	1·01T	2	I	I	3	3	6	Shea
1·04	Const. Survey. Fldwk.	1·00T	3	S	XVII	0	10	0	Shea
1·05	Surveying	D12	2	1	IV-B	1	2	1	Shea
1·054	Surveying Fieldwork	1·00	–	–	–	0	8	0	Shea
1·06	Photogrammetry	1·03 or 1·05	4(B)	2	(Elective)	2	—	4	Shea
1·07	Geodetic Surveying	1·03	4(B)	S	(Elective)	0	23	0	Shea
1·08	Navigation	M11	3	2	(Elective)	2	—	4	Shea
1·122	Engineering Astronomy	*1·00*	–	–	–	1	—	2	Shea
1·13	Geodesy	1·122	–	–	–	2	—	3	Shea
1·141	Geodesy, Adv.	1·03	G(A)	1	(Elective)	2	—	4	Shea
1·142	Geodesy. Adv.	1·141	G(A)	2	(Elective)	3	—	6	Shea
1·15	Vibration Theory, Int.	M22	G(A)	1	(Elective)	3	—	6	Ruge
1·16	Vibration Problems	1·15	G(A)	2	(Elective)	3	—	6	Ruge
1·20	Route Survey. Fldwk.	1·00T	2	S	I	0	6	0	Babcock
1·21	Route & Const. Survey.	1·20	2	2	I	2	—	4	Babcock
1·24	Municipal Eng.	——	3	1	IV-B	3	—	3	Bone
1·26	Railway Signaling	——	4(B)	1	(Elective)	2	—	4	Babcock
1·271	Transportation Eng.	1·21	4(B)	1	I(b)	3	3	6	Babcock, Bone
1·272	Transportation Eng.	1·271	4(B)	2	I(b)	3	3	3	Babcock, Bone
1·28	Highways & Airports	1·21	4(B)	1	I(d)	3	—	3	Bone
1·29	Transportation	—	4(B)	1 or 2	(Elective)	2	—	4	Babcock, Bone
1·301	Railway Transport., Adv.	1·272	G(A)	1	(Elective)	2	—	4	Babcock
1·302	Railway Transport., Adv.	1·301	G(A)	2	(Elective)	2	—	4	Babcock
1·311	High. Transport., Adv.	1·272 or 1·28	G(A)	1	(Elective)	2	—	4	Breed, Bone
1·312	High. Transport., Adv.	1·311	G(A)	2	(Elective)	2	—	4	Breed, Bone
1·32	Airport Design	1·271 or 1·28	G(A)	2	(Elective)	0	6	0	Bone
1·35T	Soil Mech. & Found. Eng.	2·04	4(B)	1	I	3	3	6	D. W. Taylor
1·351	Soil Mech. & Found. Eng.	2·04	4(B)	1	$XVII_1$	2	2	4	D. W. Taylor
1·361	Soil Mechanics	2·04	G(A)	1	(Elective)	3	—	6	D. W. Taylor
1·362	Soil Mechanics	1·361	G(A)	2	(Elective)	3	—	6	D. W. Taylor
1·37	Soil Mech. Lab.	*1·35T, 1·351* or *1·361*	G(A)	1	(Elective)	0	3	3	D. W. Taylor
1·38	Soil Eng. Spec. Studies	*1·361*	G(A)	1 or 2	(Elective)		★		D. W. Taylor
1·40	Structures	2·04	–	–	–	3	2	4	Fife
1·40T	Structures	2·04	3	2	I	3	3	6	Fife
1·401	Structures	2·04	3	2	XVII	3	—	6	Fife
1·41	Structures	1·40T or 1·401	4(B)	1	$I, XVII_1$	3	—	6	Mirabelli
1·42	Structures	1·41	4(B)	2	$I, XVII_1$	3	—	6	Mitsch
1·43	Reinforced Concrete Design	*1·40T*	3	2	I	0	6	0	Mitsch
1·441	Bridge Design	*1·41*	4(B)	1	I	0	6	0	Mirabelli

★ Time specially arranged.

Civil and Sanitary Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
1·442	Structural Design	1·441	4(B)	2	I	0	6	0	Mirabelli
1·45	Engineering Materials	—	3	1	I	3	—	6	Norris
1·461	Structures	2·04	G(B)	1	XIII-B	3	—	6	Fife
1·462	Structures	1·461	G(B)	2	XIII-B	3	3	6	Fife
1·521	Structural Lab.	1·42	G(A)	1	(Elective)		★		Norris
1·522	Structural Lab.	*1·42*	G(A)	2	(Elective)		★		Norris
1·541	Reinf. Conc. Des., Adv.	1·42	G(A)	1	(Elective)	0	6	0	Mitsch
1·542	Reinf. Conc. Des., Adv.	1·43 or 1·541	G(A)	2	(Elective)	0	6	0	Peabody
1·551	Structural Design, Adv.	1·41	G(A)	1	(Elective)	0	6	0	Wilbur
1·552	Structural Design, Adv.	1·41	G(A)	2	(Elective)	0	6	0	Wilbur
1·561	Structural Theory, Adv.	1·41	G(A)	1	(Elective)	4	—	8	Fife
1·562	Structural Theory, Adv.	1·561	G(A)	2	(Elective)	2	—	4	Fife
1·571	Stat. Indet. Structures	1·42 or *1·561*	G(A)	1	(Elective)	3	—	6	Wilbur
1·572	Stat. Indet. Structures	1·42 or 1·561	G(A)	2	(Elective)	3	—	6	Wilbur
1·61	Fluid Mechanics	*2·01*	2	2	I	2	—	4	Russell
1·62	Fluid Mechanics	1·61	3	1	I	3	—	6	Russell
1·63	Hydraulics	2·01	4	1	XV-A	2	—	4	Russell
1·64	Hydraulics	2·01	4	1	VI$_1$	3	—	6	Russell
1·66	Hydraulics, Adv.	1·62	G(A)	1 or 2	(Elective)	2	—	4	Russell
1·67	Des. of Harbor Works	1·35T or 1·351	G(A)	1	(Elective)	0	6	0	—
1·681	Theory of Models	1·62	G(A)	1	(Elective)	2	—	4	—
1·682	River Hydraulic Lab.	1·62, 1·681	G(A)	2	(Elective)	0	9	0	—
1·69	River Engineering	1·62	G(A)	2	(Elective)	2	—	4	—
1·70	Hydrology & Flood Cont.	1·62	4(B)	1	I(c)	3	3	6	Gifford
1·701	Hydrology & Flood Cont.	—	4(B)	1	(Elective)	3	—	6	Gifford
1·71	Water Power Eng.	1·40, 1·43, 1·70	4(B)	2	I(c)	3	3	3	Gifford
1·711	Water Power Eng.	1·62 or 1·64; 1·70 or 1·701	4(B)	2	(Elective)	3	—	3	Gifford
1·72	Hydrology & Water Power Eng.	1·62 or 1·64; 2·04	4(B)	1	I(d)	3	—	3	Gifford
1·731	Water Power Eng., Adv.	1·42, 1·71, *1·741*	G(A)	1	(Elective)	3	—	6	Gifford
1·732	Water Power Eng., Adv.	1·731, *1·742*	G(A)	2	(Elective)	3	—	6	Gifford
1·741	Water Power Des., Adv.	*1·731*	G(A)	1	(Elective)	0	8	0	Gifford
1·742	Water Power Des., Adv.	*1·732*, 1·741	G(A)	2	(Elective)	0	8	0	Gifford
1·75	Water Supply & Purif.	1·62	4(B)	1	I(a)	3	3	6	Stanley
1·76	Sewer. & Sew. Treatment	1·62	4(B)	2	I(a)	3	3	3	Stanley
1·77T	Water Sup. & Sewerage	1·62	4(B)	2	I(d)	3	3	3	Stanley
1·771	Sanitation	—	3	1	IV	2	—	4	Stanley, Horwood
1·78	Sanitary Analysis	5·02	3	1	(Elective)	0	6	2	—
1·79	Sanitary Eng. Design	1·75 or *1·76*	4(B)	2	(Elective)	0	6	0	Stanley
1·811	Sanitary Eng., Adv.	*1·75*	G(A)	1	(Elective)	3	—	6	Stanley
1·812	Sanitary Eng., Adv.	*1·76*	G(A)	2	(Elective)	3	—	6	Stanley
1·821	Sanitary Eng. Lab.	*1·75*	G(A)	1	(Elective)		★		—
1·822	Sanitary Eng. Lab.	*1·76*	G(A)	2	(Elective)		★		—
1·831	Sanitary Chemistry	1·78	4(B)	1	(Elective)	2	—	4	—
1·832	Water & Sewage Analysis	1·831	4(B)	2	(Elective)	0	6	2	—
1·84	Bact. Ex. of Wat. & Sew.	1·78	4(B)	1	(Elective)	0	6	2	Horwood
1·85	San. Bacteriology, Adv.	1·84	G(A)	2	(Elective)	2	4	4	Horwood
1·86	Sanitary Science, Prin.	1·84	G(A)	1	(Elective)	3	—	6	Horwood
1·871	Pub. Health Admin. Prac.	1·84	G(A)	1	(Elective)	3	—	6	Horwood
1·872	Pub. Health Eng. Fldwk.	1·871	G(A)	2	(Elective)	2	3	4	Horwood
1·881	Sanitary Design, Adv.	*1·811*	G(A)	1	(Elective)	0	6	0	Stanley
1·882	Sanitary Design, Adv.	*1·812*	G(A)	2	(Elective)	0	6	0	Stanley
1·91	Professional Prob.	—	4(B)	1	I	2	—	4	Wilbur
1·92	Eng. Construction	—	4(B)	2	I	3	—	3	Breed

MECHANICAL ENGINEERING — 2·00–2·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2·00	Statics	8·02, M12	2	1	I, II, VI, XIII, XIII-C, XIV, XV-A, XVI, XVII	3	—	5	L. S. Smith
2·01	Dynamics	2·00	2	2	I, II, VI, XIII, XIII-C, XIV, XV-A, XVI, XVII	3	—	5	L. S. Smith

★ Time specially arranged.

Mechanical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2·011	Statics & Dynamics	8·02, M12	2	1	III, IV	3	—	5	L. S. Smith
			2	2	X				
2·013	Basic Mechanics	—	3	1	—	6	2	10	—
2·04	Strength of Materials	2·01, 2·011	2	2	III, IV	3	—	6	MacGregor
			3	1	I, II, VI(1, 3, 4), IX-B, X, XIII, XIII-C, XV-A, XVI, XVII				
			4	1	XIII-B				
2·044	Strength of Materials	—	3	2	—	3	2	8	—
2·046	Strength of Mat. & Dynamics	2·01	4	1	XIII-A	3	—	6	Adkins
2·06	Dynamics	2·04	3	2	II	3	—	6	Adkins
2·062	Strength of Mat. & Dynamics	2·04	3	2	XIII	3	—	6	Adkins
			4	2	XIII-B				
2·07	Dynamics	2·04	3	2	VI (1, 4)	3	—	6	Hrones
2·081	Strength of Materials	2·04	4(B)	1	II	3	—	6	Soderberg
			G	1	XIII-A, XIII-B				
2·082	Dynamics	2·081	4(B)	2	$II_{2,3}$	3	—	6	Soderberg
2·10	Ordnance Engineering	2·04	4(B)	1 or 2	(Elective)	3	—	6	Holmes
2·11	Industrial Plant Eng.	2·06	4(B)	2	(Elective)	4	—	5	Holmes
2·121	Photoelasticity	2·04	4(B)	1 or 2	(Elective)	2	3	4	Murray
2·125	Photoelasticity Res.	2·121	G(A)	1 or 2	(Elective)		★		Murray
2·126	Exp. Stress Analysis	2·081	4(B)	2	(Elective)	2	3	4	Murray
2·128	Exp. Stress Analysis	2·081	4(B)	2	(Elective)	2	6	4	Murray
2·141	Dynamics	2·082	G(A)	1	(Elective)	3	—	9	Den Hartog
2·142	Dynamics	2·141	G(A)	2	(Elective)	3	—	9	Den Hartog
2·211	Mech. Eng. Prob., Adv.	2·082	G(A)	1	(Elective)	3	—	9	Soderberg
			G	1	XIII-A				
2·212	Mech. Eng. Prob., Adv.	2·211	G(A)	2	(Elective)	3	—	9	Soderberg
2·213	Gas Turbine Prob., Adv.	2·211, 2·43	G(A)	1 or 2	(Elective)	3	—	9	Soderberg
			G	2	XIII-A				
2·214	Gas Turbine Prob., Adv.	2·213	G(A)	1 or 2	(Elective)	3	—	9	Soderberg
2·221	Plasticity	2·082	G(A)	1	(Elective)	3	—	9	MacGregor
2·222	Plasticity Prob., Adv.	2·221	G(A)	2	(Elective)	3	—	9	MacGregor
2·223	Plasticity Research	2·221	G(A)	1 or 2	(Elective)		★		MacGregor
2·231	Elasticity, Theory	2·082	G(A)	1	(Elective)	3	—	9	Adkins
2·232	Elasticity, Theory	2·231	G(A)	2	(Elective)	3	—	9	Adkins
2·251	Fluid Mechanics	2·01, M22	3	1	II, XIII, XIV	3	—	6	Rightmire
			4	1	VI_4, XIII-B				
2·252	Fluid Mechanics	2·251	3	2	II	3	—	6	Rightmire
2·253	Fluid Mechanics	—	3	1	—	2	1	4	Rightmire
2·254	Fluid Mechanics	—	3	2	—	2	1	4	Rightmire
2·256	Fluid Mechanics	2·046, 2·402	4(B)	1 or 2	(Elective)	3	—	6	Rightmire
			4	2	XIII-A				
2·258	Hyd. Trans. & Control	2·07, M22	G	1	—	2	—	4	Rightmire
2·271	Hydromechanics	2·252	G(A)	1	(Elective)	3	—	9	Rightmire
2·30T	Engineering Materials	—	2	1	XIII, XVI	4	1	4	F. R. Evans
			2	2	II				
			3	2	XV-A				
2·301	Engineering Materials	—	3	1	—	3	—	3	Kyle
2·31T	Engineering Metals	2·30T	4(B)	1	II	2	2	4	Kyle
2·32T	Engineering Metals	2·31T	4(B)	2	(Elective)	3	—	6	Kyle
2·322	Engineering Metals	2·31T	4(B)	2	(Elective)	3	3	6	Kyle
2·33	Metal Processing	3·32	4(B)	1	III_1	2	2	4	Bartholomew
2·34	Mech. Prop. of Metals	2·31T, 2·37	4(B)	2	(Elective)	3	—	6	Lessells
2·35	Fatigue of Metals	2·34	G(A)	1	(Elective)	3	—	6	Lessells
2·37	Test. Materials Lab.	2·04, 2·30T	3	2	II	2	2	4	Cowdrey
2·371	Test. Materials Lab.	*2·04*	3	1	XVI	0	2	2	Cowdrey
			4	1	III_1, X, XIII				
			4	2	XIII-B				
2·373	Test. Materials Lab.	2·04	3	2	I	0	5	2	Cowdrey
			4	2	IV, XVII				
2·40	Heat Engineering	8·02, M21	3	1	II, VI(1), IX-B, XIII, XIII-C, XIV, XVI	4	—	5	Svenson
			4	1	XIII-B				
2·402	Heat Engineering	—	4	1	XIII-A	4	2	7	Keenan
2·403	Thermodynamics	—	4	1	—	4	2	6	—
2·404	Thermodynamics & Engines	—	4	2	—	5	2	8	—

★ Time specially arranged.

Mechanical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2·41	Heat Engineering	8·02, M21	3	1	I, XV-B, XVII	4	—	5	Taft
			3	2	XV-A				
2·42	Heat Engineering	2·40	3	2	II, VI(1), IX-B, XIII, XIII-C, XVI	3	—	6	Svenson
2·422	Heat Engineering	2·402	4	2	XIII-A	2	—	4	Keenan
2·43	Heat Engineering	2·252, 2·40	4(B)	1	II	3	—	6	Keenan
2·44	Heat Engineering	2·43	4(B)	2	II_3	3	—	6	Shapiro
2·45	Eng. Thermodyn., Adv.	2·43, M36	G(A)	2	(Elective)	3	—	9	Keenan
2·47	Steam Turbine Eng.	2·42	4(B)	2	(Elective)	3	—	6	Keenan
2·48	Gas Turbine Eng.	2·43	4(B)	2	(Elective)	3	—	6	Keenan
2·482	Gas Turbine Eng.	2·43	4(B)	2	(Elective)	3	3	6	Keenan
2·50	Heat Measurements	8·04	3	2	III(1)	1	2	1	Wilkes
2·501	Heat Measurements	8·04	3	1	(Elective)	0	2	1	Wilkes
2·53	Heat Measurements	2·50 or 2·501	4(B)	1 or 2	(Elective)		★		Wilkes
2·551	Power Plant Eng.	2·42	4(B)	2	—	3	—	5	Holt
2·56	Mech. Eng. Practice	2·43	4(B)	2	II_1	3	—	6	Holt
2·562	Mech. Eng. Practice	2·43	4(B)	2	(Elective)	3	3	6	Holt
2·57	Power Plants, Adv.	2·56	G(A)	1 or 2	(Elective)	3	—	9	Holt
2·59	Torpedoes	—	G(RA)	2	—	3	—	5	Keenan
2·601	Food Engineering	8·04	4	1	VII-B, VII-C	2	2	2	Jones
2·602	Food Engineering	2·601	4	2	VII-B, VII-C	2	2	2	Jones
2·621T	Refrigeration	2·43	4(B)	2	(Elective)	3	—	6	Svenson
2·622T	Refrigeration, App.	2·42	4(B)	2	(Elective)	3	—	6	Jones
2·66	Air Conditioning	2·40 or 2·41	4(B)	1	(Elective)	3	—	6	Holt
2·661	Heating & Ventilation	—	3	1	IV	2	—	4	Holt
2·662	Heating & Ventilation	2·661	3	2	IV	2	—	4	Holt
2·671	Air Conditioning, Adv.	2·66	G(A)	1	(Elective)	3	—	9	Holt
2·672	Heat. & Vent. Design	2·671	G(A)	2	(Elective)	2	3	4	Holt
2·681	Engineering Lab.	2·40 or 2·41 or 10·29	4	1	II, VI_1, X	0	3	3	Eames
2·682	Engineering Lab.	2·681	4(B)	2	II_1	0	3	3	Eames
2·683T	Engineering Lab.	2·40	3	2	XIII-C	0	4	4	Eames
			4	1	XIII				
2·684	Engineering Lab.	2·40	4	1	—	0	2	2	Eames
2·687	Hydraulic Lab.	1·62	3	2	I	0	2	2	Eames
2·701	Machine Drawing	D12	2	1	II	0	6	0	Sloane
			2	2	XVI				
2·72	Machine Design	—	G	1	XIII-A	3	—	6	Townsend
2·730	Machine Design	2·01, D12	3	1	II, XVI	1	3	2	Sloane
2·731	Machine Design	2·04, 2·30T, *2·730*	3	2	II	2	2	2	Townsend
2·732	Machine Design	2·731	4(B)	2	(Elective)	2	3	4	Swett
2·733	Machine Design	—	4	1	—	2	3	1	—
2·751	Machine Design	2·732	G(RA)	1	—	2	4	4	Swett
2·752	Machine Design	2·751	G(RA)	2	—	2	4	4	Swett
2·78	Hydraulic Machinery, Des.	2·251	4(B)	2	(Elective)	2	3	4	Hrones
2·782	Mech. Systems, Des.	2·731, 6·19	4(B)	2	(Elective)	3	3	6	Hrones
2·79T	Int. Comb. Eng., Elem.	2·04; 2·41 or 2·42 or 10·29	4(B)	1	(Elective)	3	—	6	Rogowski
2·791	Internal Combustion Eng.	2·06, 2·42	4(B)	1	II_3	3	—	6	Rogowski
2·792	Internal Combustion Eng.	2·791	4(B)	2	II_3	3	—	6	Rogowski
2·793	Dynamics of Engines	—	3	2	—	2	—	2	E. S. Taylor
2·794	Int. Comb. Eng. Lab.	2·791	4(B)	2	II_3	0	4	2	Ku
2·7941	Int. Comb. Eng. Lab.	2·791	4(B)	1	—	0	2	1	Ku
2·7942	Int. Comb. Eng. Lab.	2·7941	4(B)	2	—	0	2	1	Ku
2·796	Int. Comb. Eng. Des.	2·791	4(B)	2	(Elective)	3	—	6	C. F. Taylor
2·797	Int. Comb. Eng. Des.	2·792, 2·796	G(A)	1	(Elective)	3	3	6	C. F. Taylor
2·798	Int. Comb. Eng. Des.	2·797	G(A)	2	(Elective)	3	3	6	C. F. Taylor
2·799	Automotive Dynamics	2·082, 2·792	G(A)	1 or 2	(Elective)	3	—	9	E. S. Taylor
2·801	Int. Comb. Eng. Prob., Adv.	2·792	G(A)	1	(Elective)	3	—	9	E. S. Taylor
2·802	Int. Comb. Eng. Prob., Adv.	2·801	G(A)	2	(Elective)	3	—	9	E. S. Taylor
2·805	Diesel Engines	2·046, 2·42	4(B)	2	(Elective)	3	—	6	C. F. Taylor
			G	2	XIII-A				
2·851	Machine Tool Lab.	—	2	1	II, VI, XIII, XIV, XV-A	0	4	0	English
			2	2	XVI				
			3	S	III				
			3	1	XIII-C				
			4	1	XIII-A				
			G	S	XIII-B				

★ Time specially arranged.

Mechanical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2·852	Machine Tool Practice	2·851	2 4 G	2 2 S	II, XIII XIII-A XIII-B	0	4	0	English
2·871	Manufacturing Eng.	2·731	4(B)	2	(Elective)	3	—	6	Buckingham
2·872	Prep. for Manufacturing	2·731, 2·852	4(B)	1 or 2	(Elective)	3	—	6	Buckingham
2·88	Metrology & Dimens. Stand.	2·082	G(A)	1	(Elective)	3	—	6	Buckingham
2·901	Fabric Struct., Prin.	8·02	4	1	(Elective)	3	—	6	Schwarz
2·902	Fabric Struct., Prin.	2·901	4(B)	2	(Elective)	3	—	6	Schwarz
2·903	Textile Manufact., Elem.	8·02	4	1	(Elective)	3	—	6	Fox
2·904	Textile Manufact., Prin.	2·903	4(B)	2	(Elective)	3	—	6	Fox
2·905	Textile Tech. Anal.	8·04	G(A)	1	(Elective)	3	—	6	Schwarz
2·906	Textile Tech. Anal.	2·905	G(A)	2	(Elective)	3	—	6	Schwarz
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 Testing Lab.	2·905	G(A)	1	(Elective)	0	6	2	Fox
2·912	Textile Research Lab.	2·906	G(A)	2	(Elective)	0	6	2	Schwarz
2·913	Textile Tech. Seminar	2·905, 2·907	G(A)	1	(Elective)	2	—	2	Schwarz
2·914	Textile Tech. Seminar	2·906, 2·908	G(A)	2	(Elective)	2	—	2	Schwarz
2·991	Mechanical Eng. Seminar	——	G(A)	1	(Elective)	2	—	2	Soderberg
2·992	Mechanical Eng. Seminar	——	G(A)	2	(Elective)	2	—	2	Soderberg

METALLURGY — 3·00–3·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
3·01	Non-Ferrous Met. I	5·02	3	2	III	4	—	4	Hayward
3·02	Non-Ferrous Met. II	3·01	4	1	(Elective)	2	—	4	Hayward
3·03	Non-Ferrous Met. III	3·02	4(B)	2	(Elective)		★		Hayward
3·04	Metallurgical Lab.	——	3	2	III	0	4	0	Hayward
3·041	Electric Furnaces	5·02, 8·04	4(B)	1	(Elective)	0	3	2	Hayward
3·05	General Metallurgy	*3·02*, 3·12	4(B)	1	(Elective)	2	2	4	Hayward
3·06	Non-Ferrous Met., Adv.	3·05	G(A)	1	(Elective)	2	—	6	Hayward
3·07	Metal. Com. Metals	5·02	4	2	(Elective)	2	—	4	Hayward
3·08	General Metallurgy, Adv.	3·05	G(A)	2	(Elective)	2	—	6	Hayward
3·09T	Metal. Calculations	*3·01*, 3·12	3	2	III(1)	2	—	4	Bever
3·10	Metal. Plant Visits	——	3	—	(Elective)	0	3	1	Floe
3·11	Metal. Calc., Adv.	3·09T	G(A)	2	(Elective)	2	—	6	Hayward
3·12	Met.: Iron & Steel	5·02	3	1	III	2	—	4	Waterhouse
3·16	Met.: Iron & Steel, Adv.	3·12	G(A)	2	(Elective)		★		Waterhouse
3·20	Metal. Thermodynamics	5·62	4(B)	1	III	4	—	4	Chipman
3·21	Steelmaking, Prin.	3·20	4(B)	2	(Elective)	2	—	4	Chipman
3·30	Metallography	8·04	3	2	XV-A	2	2	2	Floe
3·31	Physical Metallurgy I	5·12, 8·04	3	1	III	2	3	4	Cohen
3·32	Physical Metallurgy II	3·31	3	2	III(1)	2	3	4	Floe
3·33	Industrial Phys. Met.	3·30 or 3·32	4(B)	1	III_1	0	3	2	Homerberg
3·34	Physical Metal., Adv.	3·33, 3·50	G(A)	1	(Elective)	2	—	4	Cohen
3·35	Physical Metal., Adv.	3·33, 3·50	G(A)	2	(Elective)	2	—	4	Cohen
3·38	Physical Metal., Adv.	——	G	1	——	2	2	4	R. S. Williams
3·39	Physical Metal., Adv.	3·38	G	2	——	1	3	2	Homerberg
3·391	Properties of Metals	——	4 G	1 1	XIII-A XIII-B	2	1	3	R. S. Williams
3·392	Properties of Metals	3·391	4 G	2 2	XIII-A XIII-B	2	1	3	Homerberg
3·394	Metallurgy	——	3	2	——	3	2	3	——
3·395	Metallurgy	3·394	4	1	——	3	2	3	——
3·40	Cor. & Heat Res. Alloys	3·30 or 3·32	4(B)	1	(Elective)	2	—	4	Wulff
3·41	Industrial Non-Fer. Alloys	3·30 or 3·31	3	2	III(1)	2	—	2	R. S. Williams
3·42	Powder Metallurgy	3·30 or 3·32	4(B)	2	(Elective)	2	—	4	Wulff
3·422	Powder Metal. Lab.	3·30 or 3·32	4(B)	2	(Elective)	0	4	2	Wulff
3·50	X-ray Metallography	3·30 or 3·31; M22	4(B)	1	(Elective)	2	2	4	J. T. Norton
3·51	Physics of Metals	3·50	4(B)	2	(Elective)	2	—	4	J. T. Norton
3·52	Physics of Metals, Adv.	3·50, 3·51	G(A)	1 or 2	(Elective)		★		J. T. Norton
3·60	Ferromagnetism	3·51	G(A)	1	(Elective)	2	—	4	Bitter

★ Time specially arranged.

Metallurgy Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
3·61	Atomic Arrangements in Alloys	3·51	G(A)	2	(Elective)	2	—	4	Bitter
3·62	Sp. Prob. in Metallurgy	——	G(A)	1	(Elective)		★		R. S. Williams
3·63	Sp. Prob. in Metallurgy	——	G(A)	2	(Elective)		★		R. S. Williams
3·65	Theory of the Solid State	8·04, M22	4(B)	2	(Elective)	3	—	6	Bitter
3·70	Ceramics	5·02, 8·04	4(B)	1	(Elective)	2	3	4	F. H. Norton
3·71	Optical Ceramics	8·04	4(B)	1	(Elective)	0	6	2	F. H. Norton
3·73	Ceramic Process, Fund.	2·50, 3·70, 5·61	G(A)	1	(Elective)	3	4	4	F. H. Norton
3·74	Phys. Prop. Cer. Prod.	3·73	G(A)	2	(Elective)	2	3	4	F. H. Norton
3·75	Spec. Prob. Ceramics	3·70, 3·71	G(A)	1	(Elective)		★		F. H. Norton
3·76	Spec. Prob. Ceramics	3·70, 3·71	G(A)	2	(Elective)		★		F. H. Norton
3·81	Mineral Dressing I	8·04, *12·011T*	3	1	III	3	3	4	Gaudin
3·82	Mineral Dressing II	3·81	3	2	III(2)	2	—	4	Schuhmann
3·83T	Mineral Dressing III	3·81	4(B)	1	III_2	2	—	4	Schuhmann
3·84T	Mineral Dressing IV	3·81	4(B)	2	III_2	2	—	4	Schuhmann
3·86T	Quantitative Mineragraphy	3·81	3	2	III(2)	1	6	2	Schuhmann
3·87T	Ore Testing	3·81	4(B)	1	III_2	0	10	0	Gaudin, Schuhmann
3·88T	Mineral Dressing Prac.	3·81	4(B)	2	III_2	2	—	4	Locke
3·89	Mineral Dressing Design	3·88T	G(A)	1 or 2	(Elective)		★		Locke
3·90	Mineral Dressing, Adv.	3·82; 3·83T or 3·84T	G(A)	1 or 2	(Elective)	2	—	4	Gaudin
3·901	Mineral Dressing Lab., Adv.	3·86T or 3·87T	G(A)	1 or 2	(Elective)		★		Gaudin
3·902	Mineral Dressing Lab., Adv.	3·901	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
4·031	Freehand Drawing	——	3	1	IV	0	4	0	Selmer-Larsen
4·032	Freehand Drawing	4·031	3	2	IV	0	4	0	Selmer-Larsen
4·041	Freehand and Color	4·032	4	1	(Elective)	0	4	0	Selmer-Larsen
4·042	Freehand and Color	4·032	4	2	IV	0	6	0	Selmer-Larsen
4·051T	Freehand and Color	4·042	5(B)	1	IV	0	6	0	Selmer-Larsen
4·052T	Freehand and Color	4·051T	5(B)	2	IV	0	6	0	Selmer-Larsen
4·053	Freehand Drawing	4·052	G(A)	1	(Elective)	0	6	0	Selmer-Larsen
4·054	Freehand Drawing	4·053	G(A)	2	(Elective)	0	6	0	Selmer-Larsen
4·07	Shop	——	2	2	IV	0	4	0	Selmer-Larsen
4·10	Arch. Illumination	——	4	2	(Elective)	0	9	0	Anderson
4·41	Fine Arts	——	4	1	(Elective)	3	—	5	H. L. Seaver
4·451	Hist. of Architecture	E22	5	1	IV	3	—	6	E. T. Putnam
4·452	Hist. of Architecture	4·451	5	2	IV	3	—	6	E. T. Putnam
4·461	Europ. Civilization & Art	*4·451*	5(B)	1	(Elective)	3	—	6	Seaver
4·462	Europ. Civilization & Art	4·461	5(B)	2	(Elective)	3	—	6	Seaver
4·50	Office Practice	——	4	S	(Elective)		40 h.p.w.		F. J. Adams
4·52	Office Practice	4·50	G(A)	1	(Elective)	0	30	0	F. J. Adams
4·541	Housing Seminar	4·683 or 4·751	G(A)	1	(Elective)	2	—	4	Burchard
4·542	Housing Seminar	4·541	G(A)	2	(Elective)	2	—	4	Burchard
4·59	Govt. & Public Admin.	——	3	1	IV-B	2	—	4	Shurtleff
4·60	Plan. Legis. & Admin.	4·59	4(B)	2	IV-B	2	—	4	Shurtleff
4·62	Site Plan. & Const.	4·681	3	2	IV-B	0	9	3	Bender
4·621	Site Plan. & Const.	4·741	5(B)	1	IV	0	9	3	Bender
4·641	City Planning, Principles	——	2	2	IV-B	2	—	4	Shurtleff
			4	2	IV				
4·651	City Plan., Th. & Prac.	4·641	3	1	IV-B	2	—	4	F. J. Adams
4·652	City Plan., Th. & Prac.	4·651	3	2	IV-B	2	—	4	F. J. Adams
4·661	City Planning Research	4·683	G(A)	1	(Elective)	2	—	4	F. J. Adams
4·662	City Planning Research	4·661	G(A)	2	(Elective)	2	—	4	F. J. Adams
4·672	City Planning Design	——	2	2	IV-B	0	10	5	Bender
4·681	City & Regional Planning	4·672	3	1	IV-B	0	12	6	Adams, Greeley
4·682	City & Regional Planning	4·681	3	2	IV-B	0	9	3	Adams, Greeley
4·683	City & Regional Planning	4·682	4(B)	1	IV-B	0	9	3	Adams, Greeley
4·691	City & Reg. Plan., Adv.	4·683	G(A)	1	(Elective)	0	30	0	F. J. Adams
4·692	City & Reg. Plan., Adv.	4·691	G(A)	2	(Elective)	0	30	0	F. J. Adams
4·721	Architectural Design	——	2	1	IV	0	9	3	Anderson, Bridge
4·722	Architectural Design	4·721	2	2	IV	0	9	3	Anderson, Bridge
4·731	Architectural Design	4·722	3	1	IV	0	12	6	Anderson, Bridge

★ Time specially arranged.

Architecture and Planning Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
4·732	Architectural Design	4·731	3	2	IV	0	12	6	Anderson, Bridge
4·741	Architectural Design	4·732, 4·811, 4·812	4	1	IV	0	12	6	Anderson
4·742	Architectural Design	4·741	4	2	IV	0	12	6	Anderson
4·751T	Architectural Design	4·742	5(B)	1	IV	0	9	3	Anderson
4·761	Architectural Design	4·751	G(A)	1	(Elective)	0	36	0	Anderson
4·762	Architectural Design	4·761	G(A)	2	(Elective)	0	30	0	Anderson
4·78	Planning Principles	—	2	2	XVII	0	4	0	Anderson
4·811	Structural Analysis	2·04, 4·722	3	1	IV	2	6	0	Gelotte
4·812	Structural Analysis	4·731, 4·811	3	2	IV	2	6	0	Gelotte
4·98	Thesis Research	—	G(A)	1, 2	(Elective)	0	6	0	Anderson, Adams

CHEMISTRY — 5·00–5·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
5·00	Chemistry, Entrance	—	–	–		3	3	6	Young
5·01	Chemistry, General	—	1	1	All courses	4	3	4	Wareham
5·02	Chemistry, General	5·01	1	2	All courses	4	3	4	Wareham
5·03	Chemistry	—	3	1	—	3	2	5	Davis
5·061	Inorganic Chem., Adv.	5·13	4(B)	1	V	2	—	4	Schumb
5·062	Inorganic Chem., Adv.	5·061	4(B)	2	V	2	—	4	Schumb
5·071	Sp. Topics Inorg. Chem.	5·062	G(A)	1	(Elective)	2	—	4	Schumb
5·072	Sp. Topics Inorg. Chem.	5·071	G(A)	2	(Elective)	2	—	4	Schumb
5·08	Inorganic Lab., Adv.	5·062	G(A)	1 or 2	(Elective)	0	6	0	Young
5·10	Qualitative Analysis	5·02	2	S	V	3	12	3	Simpson
			2	1	(Elective)				
5·11	Qualitative Analysis	5·02	2	1	III, VII, VII-B, VIII, X, XII, XV-B, XVIII	3	4	3	Marvin
5·12	Quantitative Analysis	5·10 or 5·11	2	1	V	3	4	3	Marvin
			2	2	III, VII, VII-B, X, XII, XV-B				
5·13	Quantitative Analysis	5·12	2	1	(Elective)	3	4	3	Marvin
			2	2	V				
5·141	Anal. Chemistry	5·12, 8·04	3	1	V, VII-B	0	4	2	Gibb
			3	2	(Elective)				
5·35	Applied Chemistry	5·02	3, 4	1, 2	(Elective)	2	—	4	Marvin
5·41	Organic Chemistry I	5·12, 8·04	3	S	VII, VII-B	4	—	4	Gibb
			3	1	V, IX-A, X, XV-B				
			4	1	III_2				
5·414	Organic Preparations	5·12, *5·41*	3	1	V	0	9	0	Fletcher
5·416	Organic Preparations	5·12, *5·41*	3	1	X	0	6	0	Ashdown
5·417	Quant. Org. Anal.	5·41	3	2	V	0	4	0	Fletcher
5·42	Organic Chemistry II	5·41	3	2	V, IX-A, X	4	—	4	Gibb
5·424	Org. Compounds, Ident.	5·414	3	2	V	0	9	0	Fletcher
5·426	Org. Compounds, Ident.	5·416	3	2	X	0	6	0	Ashdown
5·428	Organic Chemistry Lab.	*5·41*	3	S	VII, VII-B	0	10	0	Ashdown
5·43	Organc Chemistry III	5·42	4(B)	1	V	2	—	4	Huntress
5·44	Organiic Chemistry IV	5·43	4(B)	2	V	2	—	4	Huntress
5·51	Functional Groups in Organic Chemistry	5·44	G(A)	1	(Elective)	3	—	6	Huntress
5·52	Reactivity, Mech. & Struct.	5·51	G(A)	2	(Elective)	3	—	6	Morton
5·55	Org. Compounds, Ident.	5·44	G(A)	1	(Elective)	2	8	0	Huntress
5·561	Chem. of Heterocyc. Comp.	5·44	G(A)	1	(Elective)	2	—	4	Morton
5·562	Carbohydrates	5·44	G(A)	2	(Elective)	2	—	4	Scattergood
5·565	Terpenes	5·44	G(A)	1	(Elective)	2	—	4	Ashdown
5·566	Amino Acids & Proteins	5·44	G(A)	2	(Elective)	2	—	4	Ashdown
5·568	Natural Products	5·44	G(A)	2	(Elective)	2	—	4	Milas
5·581	Organic Lab., Adv.	5·44	G(A)	1	(Elective)	1	5	0	Morton
5·582	Organic Lab., Adv.	5·581	G(A)	2	(Elective)	0	6	0	Morton
5·591	Recent Adv. in Org. Chem.	5·44	G(A)	1	(Elective)	1	—	2	Huntress
5·592	Recent Adv. in Org. Chem.	5·44	G(A)	2	(Elective)	1	—	2	Huntress
5·61	Physical Chem. I	5·12, 8·03, M21	3	1	III, V, VII, VII-B, X, XII, XV-B	4	—	4	Millard
5.611	Physical Chem. Lab. I	*5·61*	3	1	V, VII, VII-B	0	4	0	Dietrichson
5·612	Physical Chem. Lab. I	*5·61*	3	1	X	0	2	0	Dietrichson

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
5·62	Physical Chem. II	5·61	3	2	III, V, VII, VII-B, X, XII, XV-B	4	—	4	Millard
5·621	Physical Chem. Lab. II	5·611, *5·62*	3	2	V, VII, VII-B	0	4	0	Dietrichson
5·622	Physical Chem. Lab. II	5·612, *5·62*	3	2	X	0	2	0	Dietrichson
5·63	Thermodynamics, Int.	5·62	4(B)	1	V	2	—	4	Stephenson
5·64	Rad. Chemistry, Int.	5·62	4(B)	2	V	2	—	4	L. Harris
5·65	Kinetics of Chem. Reactions	5·62	4(B)	1	V	2	—	4	Amdur
5·66	Surface & Colloid Chem.	5·63	4(B)	2	V	2	—	4	Stockmayer
5·71T	Physico-Chem. Exp. Tech.	*5·63*	G(A)	1	(Elective)	0	4	2	Beattie
5·72T	Radiation Chem.	5·63	G(A)	2	(Elective)	2	—	4	L. Harris
5·73	Radiation Chem., Adv.	5·64	G(A)	1	(Elective)	2	—	4	L. Harris
5·74	Statistical Mechanics	5·73	G(A)	2	(Elective)	2	—	4	Stockmayer
5·75	Chem. Thermodynamics	5·63	G(A)	1	(Elective)	3	—	6	Beattie
5·76	Chem. Thermodynamics	5·75	G(A)	2	(Elective)	3	—	6	Scatchard
5·77	Kinetic Theory	*5·63*	G(A)	1	(Elective)	2	—	4	Amdur
5·79	Physical Chem. of High Polymers	5·42, 5·63	G(A)	1	(Elective)	2	—	4	Stockmayer
5·90	Spec. Prob. in Chem.	—	G(A)	1, 2	(Elective)		★		Huntress
5·911	Journal Meeting in Inorganic Chem.	5·062	G(A)	1	(Elective)	1	—	2	Schumb
5·912	Journal Meeting in Inorganic Chem.	5·911	G(A)	2	(Elective)	1	—	2	Schumb
5·913	Journal Meeting in Organic Chem.	5·44	G(A)	1	(Elective)	1	—	2	Morton
5·914	Journal Meeting in Organic Chem.	5·913	G(A)	2	(Elective)	1	—	2	Morton
5·931	Physical Chem. Seminar	*5·63*	G(A)	1	(Elective)	1	—	2	Scatchard
5·932	Physical Chem. Seminar	5·931	G(A)	2	(Elective)	1	—	2	Scatchard
5·941	Research Conf. in Inorganic Chem.	5·062	G(A)	1	(Elective)	1	—	2	Schumb
5·942	Research Conf. in Inorganic Chem.	5·941	G(A)	2	(Elective)	1	—	2	Schumb
5·943	Research Conf. in Organic Chem.	5·44	G(A)	1	(Elective)	1	—	2	Morton
5·944	Research Conf. in Organic Chem.	5·943	G(A)	2	(Elective)	1	—	2	Morton
	Research	—	G(A)	1, 2	(Elective)		★		Huntress
	Inorganic Chemistry								Schumb
	Organic Chemistry								Morton
	Physical Chemistry								Scatchard

ELECTRICAL ENGINEERING — 6·00–6·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6·00T	Elec. Eng., Prin.	8·03, *M22*	2	2	VI, VIII	4	—	8	Frazier
6·01T	Elec. Eng., Prin.	6·00	3	1	VI	3	—	6	Kingsley
6·02T	Elec. Eng., Prin.	6·00	3	2	VI	3	—	6	Gray
6·03T	Elec. Eng., Prin.	6·01T	4(B)	1	VI	3	—	6	Lyon
6·04	Elec. Eng., Prin.	6·03T	4(B)	2	VI_1	3	—	6	Dwight
6·05	Elec. Eng., Prin.	M12	2	1	VI	2	1	5	Frazier, Gray
6·11	Elec. Eng., Prin.	6·00	3	1	VIII	4	—	8	Gray, Kingsley
6·16	Electricity	8·03	4	1	IV	3	—	6	Dawes
6·17	Illumination	8·03	4	2	IV	2	—	4	Moon
6·18	Elec. Eng., Fund.	8·04	3	1	II, XV-A	3	1	6	Fitzgerald
			3	2	I, XV-B				
			4	1	III_1, X, XIII, XVI				
			5	1	XIII-C				
6·181	Electrical Eng.	—	4	1	—	3	2	6	Fitzgerald
6·19	Elec. Eng., Fund.	6·18 or 6·40	3	2	XV-A	3	1	6	Fitzgerald
			4	1	II_2				
			4	2	III_1				
6·191	Electrical Eng.	—	4	2	—	3	2	6	Fitzgerald
6·20	Electronic Cont. & Meas.	6·02T	4(B)	1	VI_4	3	—	6	Gray
6·211	App. Elec. to Industry	6·02T	4(B)	1	(Elective)	3	—	6	Dawes
6·212	App. Elec. to Industry	6·03T	4(B)	2	(Elective)	3	—	6	Dawes

★ Time specially arranged.

Electrical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6·221	Elec. Power Generation	2·42	4(B)	1	(Elective)	3	—	6	Mulligan
6·222	Elec. Power Generation	6·03T	4(B)	2	(Elective)	3	—	6	Mulligan
6·23	Electrical Implementation	6·02T	4(B)	2	VI_4	3	—	6	Frazier
6·251	Elec. Mach. Design	*6·03T*	4(B)	1	(Elective)	3	—	6	Dwight
6·252	Elec. Mach. Design	6·03T	4(B)	2	(Elective)	3	—	6	Dwight
6·26	Electric Insulation	8·04	4(B)	1	(Elective)	3	—	6	von Hippel
6·27	Illum. Eng., Prin	8·04	3	2	VI(2)	3	—	6	Moon
6·271	Illum. Eng., Prin.	6·27	4(B)	1	VI_2	3	—	6	Moon
6·272	Illum. Eng., Prin.	6·271	4(B)	2	VI_2	3	—	6	Moon
6·281	Wire Com., Prin.	6·02T	4(B)	1	(Elective)	3	—	6	C. E. Tucker
6·293	Radar, Prin. & App.	——	G(R)	—	——	3	3	6	Radford
6·294	Radar, Prin. & App.	——	G(RB)	2	——	3	4	6	Radford
6·295	Radar, Prin. & App.	6·294	G(RB)	1	——	3	4	6	Radford
6·30	Elec. Com., Prin.	6·01T	3	2	VI(3)	3	—	6	Guillemin
6.311	Elec. Com., Prin.	6·02T	4(B)	1	VI_3	3	—	6	Radford
6·312	Elec. Com., Prin.	6·311	4(B)	2	(Elective)	3	—	6	Arguimbau
6·321	Elec. Com., Prin.	6·30	4(B)	1	VI_3	3	—	6	Guillemin
6·322	Elec. Com, Prin.	6·321	4(B)	2	(Elective)	3	—	6	Guillemin
6·331	Elec. Com. Lab.	6·02T, *6·311*	4(B)	1	VI_3	0	3	3	Radford
6·332	Elec. Com. Lab.	6·331	4(B)	2	VI_3	0	4	5	Radford
6·34	Elec. Com. Lab.	——	4(B)	1 or 2	(Elective)		★		Radford
6·40	Elec. Eng., Elem.	8·04	3	1	XVII	4	—	6	Hudson
			3	2	IX-B				
6·43	Electrical Eng.	——	G	1	XIII-A, XIII-B	3	—	6	Kingsley
6·44	Electrical Eng.	6·43	G	2	XIII-A, XIII-B	3	1	6	Kingsley
6·45	Electrical Eng.	6·44	G(RB)	1	XIII-A	3	1	6	Kingsley
6·46	Electrical Eng.	6·45	G(RB)	2	XIII-A	3	1	6	Fitzgerald
6·48	Elec. Equip. Bldgs.	8·04	4	2	(Elective)	2	—	4	Hudson
6·501	Elec. Eng. Seminar	6·04 or 6·32	G(A)	1	(Elective)	2	—	10	Gardner
6·502	Elec. Eng. Seminar	6·501	G(A)	2	(Elective)	2	—	2	Gardner
6·511	Elec. Power Circuits	6·04	G(A)	1	(Elective)	3	—	6	Wildes
6·512	Elec. Power Circuits	6·04	G(A)	2	(Elective)	3	—	6	Wildes
6·515	Power Systems Lab.	6·511, 6·516, 6·651 or 6·652	G(A)	1 or 2	(Elective)		★		Fitzgerald
6·516	Power System Analysis	6·04	G(A)	2	(Elective)	3	2	6	Fitzgerald
6·521	A-c. Machinery, Adv.	6·03, M31	G(A)	1	(Elective)	3	—	6	Lyon
6·522	A-c. Machinery, Adv.	6·04, M31	G(A)	2	(Elective)	3	—	6	Lyon
6·531	Power System Economics	6·04, Ec12	G(A)	1	(Elective)	3	—	6	Balsbaugh
6·532	Power System Economics	6·04, Ec12	G(A)	2	(Elective)	3	—	6	Balsbaugh
6·541	Electric Power Gen.	6·03T, Ec12	G(A)	1	(Elective)	3	—	6	Mulligan
6·542	Electric Power Gen.	6·03T, Ec12	G(A)	2	(Elective)	3	—	6	Mulligan
6·551	Railroad Elec. Trac.	6·03T, Ec12	G(A)	1	(Elective)	3	—	6	Balsbaugh
6·552	Railroad Elec. Trac.	6·551	G(A)	2	(Elective)	3	—	6	Balsbaugh
6·561	Network Theory, Adv.	6·322	G(A)	1	(Elective)	3	—	6	Guillemin
6·562	Network Theory, Adv.	6·561	G(A)	2	(Elective)	3	—	6	Guillemin
6·571	Illum. Eng., Prin.	6·272	G(A)	1	(Elective)	3	—	6	Moon
6·572	Illum. Eng., Prin.	6·571	G(A)	2	(Elective)	3	—	6	Moon
6·58	Trans. in Linear Systems	6·04 or 6·321; M31	G(A)	1 or 2	(Elective)	3	—	7	M. F. Gardner
6·585	Int. Equa. in Elec. Eng., App.	6·03T, M22	G(A)	1	(Elective)	3	—	6	Moon
6·586	Eng. App. of Field Theory	M22	G(A)	2	(Elective)	3	—	6	Moon
6·59	Communications Lab.	6·332	G(A)	1 or 2	(Elective)		★		Radford
6·60	Math. Anal. by Mech. Meth.	M22	G(A)	1	(Elective)	2	—	4	S. H. Caldwell
6·601	Sp. App. of Mechanized Math.	*6·60*	G(RA)	1	——	0	2	2	S. H. Caldwell
6·605	Servomechanisms	6·04, M22	G(A)	1	(Elective)	3	—	6	G. S. Brown
6·606	Servomechanisms	6·605	G(A)	2	(Elective)	3	3	6	G. S. Brown
6·607	Servomechanisms Lab.	6·605	G(A)	2	(Elective)	0	12	0	G. S. Brown
6·61	Gen. & Util. of Super Voltages	6·04	G(A)	2	(Elective)	3	—	6	Trump
6·62	Elec. Com., Prin.	6·322	G(A)	2	(Elective)	2	2	6	Bowles
6·621	Radio Lines, Ant. & Prop.	6·322	G(A)	1	(Elective)	3	—	6	Guillemin
6·622	Radio Lines, Ant. & Prop.	6·621	G(A)	2	(Elective)	3	—	6	Guillemin
6·627	Patents & Rel. to Sci. & Eng.	——	G(A)	1	(Elective)	2	—	4	Bowles
6·628	Patent Background of Elec. Com. in U. S.	6·627	G(A)	2	(Elective)	2	—	4	Bowles
6·631	Engineering Electronics	6·03T	G(A)	1	(Elective)	3	—	6	Gray
6·632	Engineering Electronics	6·631	G(A)	2	(Elective)	2	2	6	Gray

Electrical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6·64	App. of Atomic Phys. in Elec. Eng.	6·26	G(A)	2	(Elective)	3	—	6	von Hippel
6·651	Elec. Power Distribution	6·04	G(A)	1	(Elective)	3	—	6	Balsbaugh
6·652	Elec. Power Distribution	6·04	G(A)	2	(Elective)	3	—	6	Balsbaugh
6·661	Elec. Mach. Dev., Prin.	6·03T	G(A)	1	(Elective)	3	1	6	Dwight
6·662	Elec. Mach. Dev., Prin.	6·03T	G(A)	2	(Elective)	3	1	6	Dwight
6·663	Aircraft Elec. Syst. & Mach.	6·03T	G(RA)	1	——	3	1	6	Fitzgerald, Kingsley
6·664	Aircraft Elec. Syst. & Mach.	6·663	G(RA)	2	——	3	1	6	Fitzgerald, Kingsley
6·671	Vibrations	M31; or 2·082 and M22	G(A)	1	(Elective)	3	1	6	Woodruff
6·672	Vibrations	6·671	G(A)	2	(Elective)	3	1	6	Woodruff
6·68	Sp. Prob. in Elec. Eng.	——	G(A)	1 or 2	(Elective)		★		Hazen, Gardner
6·681	Spec. Prob. in Fire Control	6·605, 6·606	G(RA)	1	——	0	8	0	Hazen
6·69	Sound in Elec. Com.	6·04 or 6·332; 8·05; M31	G(A)	2	(Elective)	2	2	6	Fay
6·73	Elec. Meas. Lab., Adv.	6·02T, 6·76	G(A)	1 or 2	(Elective)		★		Gray
6·74	Elec. Eng. Lab., Adv.	6·04, 6·79T	G(A)	1 or 2	(Elective)		★		C. E. Tucker
6·75	Elec. Eng. Lab.	*6·01T*	3	1	VI	1	3	5	Gray
6·76	Elec. Eng. Lab.	*6·02T*, 6·75	3	2	VI	1	2	3	Gray
6·77	Elec. Eng. Lab.	6·01T	3	2	VI(1, 3, 4)	2	2	4	C. E. Tucker
6·78	Elec. Eng. Lab.	*6.03T*, 6·77	4	1	VI_1	1	3	4	C. E. Tucker
6·781	Elec. Eng. Lab.	6·03T, 6·77	4	2	$VI_{3,4}$	1	2	3	C. E. Tucker
6·79T	Elec. Eng. Lab.	*6·04*, 6·78	4	2	VI_1	1	2	3	C. E. Tucker
6·80	Elec. Eng. Lab.	6·00 or 6·40	4(B)	1 or 2	(Elective)		★		Tucker, Gray
6·81	Elec. Eng. Lab.	6·40	4	2	(Elective)	1	1	2	Gray
6·82	Elec. Eng. Lab.	*6·11*	3	1	VIII	0	2	3	C. E. Tucker
6·83	Electronic Eng. Lab.	6·76	4	1	VI_4	1	2	3	Gray
6·84	Elec. Implement Lab.	6·76	4	2	VI_4	1	3	5	Gray, Frazier
6·85	Elec. Eng. Lab.	6·18 or 6·40	4	2	X	0	2	3	C. E. Tucker
6·89	Elec. Eng. Lab.	6·40	3 or 4	1 or 2	(Elective)	0	2	2	C. E. Tucker
6·901 — 6·904	General Electric Industrial Prac.	——	—	—	VI-A	40 h.p.w.			Timbie
6·911 — 6·914	Boston Edison Pub. Util. Prac.	——	—	—	VI-A	40 h.p.w.			Timbie
6·941 — 6·944	Bell System Com. Prac.	——	—	—	VI-A	40 h.p.w.			Timbie
6·951 — 6·954	General Radio Ind. Prac.	——	—	—	VI-A	40 h.p.w.			Timbie
6·961 — 6·964	Philco Corp. Ind. Prac.	——	—	—	VI-A	40 h.p.w.			Timbie

BIOLOGY
FOOD TECHNOLOGY } — 7·00–7·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
7·01	General Biology I	——	2	1	VII, VII-B	3	3	4	Schmitt
7·02	General Biology II	7·01	2	2	VII, VII-B	3	3	4	Schmitt
7·03	Genetics	7·02	4(B)	2	VII, VII-A	2	—	4	Blake
7·11	Embryology	7·02	3	2	VII	2	6	4	Waugh
7·12	General Cytology	7·19, *7·20*	G(A)	2	(Elective)	2	4	2	Waugh
7·14	Comparative Anatomy	7·02	3	1	VII	2	6	4	Blake
7·19	General Physiology I	5·62, 7·80	4(B)	1	VII, VII-A	2	—	4	Bear
7·20	General Physiology II	7·19	4(B)	2	VII, VII-A	2	—	4	Schmitt
7·211	Gen. Physiol. Lab. I	*7·19*	4(B)	1	VII, VII-A	0	4	0	Bear, Waugh
7·212	Gen. Physiol. Lab. II	7·211	4(B)	2	VII, VII-A	0	4	0	Sizer
7·22	Chemistry of Nutrition	5·41, 7·80	4(B)	2	VII-B, VII-C	2	—	2	R. S. Harris
7·222	Chem. of Nutrition Lab.	5·41, 7·80	4(B)	2	VII-C	1	4	0	R. S. Harris
7·23	Applied Nutrition	7·22	G(A)	2	(Elective)	2	2	4	R. S. Harris
7·24	Nutrition, Adv.	7·22	G(A)	2	(Elective)	2	4	2	R. S. Harris
7·301	Bacteriology	7·02	3	1	VII-B	2	4	2	——
7·31	Biol. of Bacteria	7·02, 7·80	4	1	VII-A	3	4	4	Jennison
7·321	Bacteriology, Adv.	7·31, 7·80	G(A)	1	(Elective)	2	—	4	Jennison
7·322	Bacteriology, Adv.	7·321	G(A)	2	(Elective)	2	4	2	Jennison
7·361	Industrial Microbiol.	7·301	3	2	VII-B	2	4	4	Sluder
7·371	Ind. Microbiol., Adv.	7·361	G(A)	1	(Elective)	2	4	4	Proctor, Dunn

★ Time specially arranged.

Biology and Food Technology Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
7·372	Ind. Microbiol., Adv.	7·371	G(A)	2	(Elective)	2	4	4	Proctor, Dunn
7·39	Bacteriology of Foods	7·361, 7·80	G(A)	2	(Elective)	2	4	2	Proctor
7·42	Chemistry of Food	5·12	3	2	(Elective)	2	4	2	R. S. Harris
7·701	Tech. & Chem. Food Supplies	5·41, *7·301*	3	1	VII-B	2	4	2	Proctor
7·702	Tech. & Chem. Food Supplies	*7·361*	3	2	VII-B	2	4	4	Proctor
7·711	Tech. Food Products	7·702	4(B)	1	VII-B, VII-C	2	4	4	Proctor
7·712	Tech. Food Products	7·711	4(B)	2	VII-B, VII-C	2	4	4	Proctor
7·721	Food Technology, Adv.	7·712	G(A)	1	VII-C	2	6	4	Proctor
7·722	Food Technology, Adv.	7·721	G(A)	2	VII-C	2	4	4	Proctor
7·791	Food Technology Sem.	7·712	G(A)	1	VII-C	2	—	2	Proctor
7·792	Food Technology Sem.	7·791	G(A)	2	VII-C	2	—	2	Proctor
7·80	Biochemistry	5·41	4(B)	1	VII-B, VII-C	2	6	4	Gould
			3	1	VII				
7·81	Enzymology	*7·19*	G(A)	1	VII-C	2	4	4	Sizer
7·82	Biochemistry, Adv.	*7·20*, 7·80	G(A)	2	(Elective)	2	4	4	Gould
7·831	Biochem. of Microörganisms	5·428, 7·31	G(A)	1	(Elective)	0	6	0	Gould
7·832	Biochem. of Microörganisms	7·831	G(A)	2	(Elective)	0	6	0	Gould
7·85	Biophysics I	*7·19*, 8·04	G(A)	1	VII-A	2	—	2	Bear
7·86	Biophysics II	7·85	G(A)	2	VII-A	2	—	2	Bear
7·87	Spectr. of Biol. Materials	*7·19*	G(A)	1	(Elective)	2	—	2	Loofbourow
7·871	Spectr. of Biol. Mater. Lab.	*7·87*	G(A)	1	(Elective)	0	4	0	Loofbourow
7·881	Biophysics Lab. I	*7·19*	G(A)	1	VII-A	0	4	0	Bear
7·882	Biophysics Lab. II	7·881	G(A)	2	VII-A	0	4	0	Bear
7·91	Instrument. in Biol. I	*7·19*	G(A)	1	VII-A	2	4	4	Lion
7·92	Instrument. in Biol. II	7·91	G(A)	2	VII-A	2	4	4	Lion
7·93	Selected Topics in Biology	*7·19*	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

PHYSICS — 8·00–8·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
8·00	Physics, Entrance	——	—	S	——	2	—	5	——
8·01	Physics (Mechanics)	——	1	1	All courses	4	2	5	Sears
8·012	Physics (College Transfer)	M11	1	1	——	5	—	6	
8·02	Physics (Mech. and Heat)	8·01	1	2	All courses	4	2	5	Sears
8·03	Physics (Electricity)	8·01, M12	2	1	All courses	4	1	5	Sears
8·034	Physics (College Transfer)	M11	2	2	——	5	—	6	
8·04	Physics (Elec., Optics & Modern Physics)	8·03	2	2	All courses except IV and IV-B	4	1	5	Sears
8·05	Vibration and Sound	8·04, M22	4(B)	1	VI_3	3	—	6	Feshbach
8·051	Sp. Problems in Acoustics	8·05	G(A)	1 or 2	(Elective)		★		P. M. Morse
8·052	Experimental Acoustics	8·05	4(B)	1	(Elective)	0	3	4	Feshbach
8·053	Architectural Acoustics	8·02	4	1	IV	3	2	3	Feshbach
8·061	Intermediate Physics (Thermodynamics & Kinetic Theory)	8·04	3	1	VI(2,3,4), VIII, IX-A	3	—	6	Sears
8·062	Intermediate Physics (Electronics)	8·04	3	2	VI(2,3,4), VIII, IX-A	3	—	6	Sears
8·09	Physical Measurements	8·04	3	1	VIII	0	3	2	Stockbarger
			4	1	VII-A				
8·11	Experimental Physics	8·202, 8·312	4(B)	1	VIII	2	6	4	Mueller
8·15	Photography	8·04	3	2	(Elective)	2	—	1	Hardy
8·152	Photography, Adv.	8·15 or 8·161	—	2	(Elective)	0	3	2	Hardy
8·161	Optics	8·04	3	1	VI(2), VIII	3	—	6	Hardy
8·162	Optical Measurements	*8·161*	3	1	VIII	0	3	2	Hardy
8·164	Optics	8·04	G(RB)	2	——	3	—	6	Hardy
8·173	Color Measurements	8·04	4(B)	2	(Elective)	0	3	2	Hardy
8·183	Sp. Problems in Optics	8·161	G(A)	1 or 2	(Elective)		★		Hardy
8·202	Electronics Lab.	8·061	3	2	VIII	0	3	2	Nottingham
8·21	Electronic Phen.	8·061, 8·062, *8·212*	G(A)	2	(Elective)	2	—	4	Nottingham
8·212	Experimental Electronics	8·061, *8·21*	G(A)	2	(Elective)	1	3	3	Nottingham
8·215	Sp. Prob. in Electronics	8·061	G(A)	1 or 2	(Elective)		★		Nottingham
8·26	Molecular Structure	8·462	G(A)	1	(Elective)	3	—	6	Mueller
8·27	X-rays & Crys. Phys.	8·04, M22	4(B)	1	(Elective)	3	1	5	Warren

★ Time specially arranged.

Physics Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
8·28	X-ray Diffraction	8·27	G(A)	2	(Elective)	3	—	6	Warren
8·29	Quantum Th. of the Solid State	8·463	G(A)	2	(Elective)	3	—	6	Tisza
8·30	Sp. Prob. in Crys. Phys.	8·27	G(A)	2	(Elective)		★		Warren
8·311	Atomic Structure	8·04	3	2	VIII	3	—	6	Mueller
			4	2	VII-A				
8·312	Atomic Struct. Lab.	8·09, *8·311*	3	2	VIII	0	3	2	Stockbarger
			4	2	VII-A				
8·32	Line Spectra	8·311	G(A)	2	(Elective)	3	—	6	McNally
8·343	Sp. Prob. in Spectros.	8·32	G(A)	1 or 2	(Elective)		★		Harrison
8·411	Nuclear Physics	8·311	4(B)	1	(Elective)	2	3	4	R. D. Evans
8·412	Nuclear Physics	8·411	4(B)	2	(Elective)	2	3	4	R. D. Evans
8·43	Th. of Nuclear Struct.	8·411, 8·521	G(A)	2	(Elective)	2	—	6	Feshbach
8·44	Applied Radiochemistry	5·12, 8·411, 8·412	G(A)	2	(Elective)	2	3	3	Irvine
8·441	Sp. Prob. in Nuclear Phys.	8·311, 8·411	G(A)	1	(Elective)		★		R. D. Evans
8·442	Sp. Prob. in Nuclear Phys.	8·412, 8·441	G(A)	2	(Elective)		★		R. D. Evans
8·461	Int. to Th. Physics I (Mechanics)	8·04, M22	4(B)	1	VI_2, VIII	4	—	8	Slater
8·462	Int. to Th. Physics II (Electromagnetic Theory)	M77	4(B)	2	VI_2, VIII	4	—	8	Slater
8·463	Int. to Th. Physics III	8·311, 8·461	G(A)	1	(Elective)	3	—	9	Tisza
8·491	Meth. of Theoret. Phys.	8·462	G(A)	1	(Elective)	3	—	9	Feshbach
8·512	Statistical Mechanics	8·461	G(A)	2	(Elective)	3	—	9	Tisza
8·521	Quantum Mechanics	8·463	G(A)	2	(Elective)	3	—	9	Feshbach
8·56	Electromag. Wave Theory	8·462	G(A)	2	(Elective)	3	—	9	Slater
8·60	Sp. Prob. Theoret. Phys.	——	G(A)	1 or 2	(Elective)		★		Slater

CHEMICAL ENGINEERING — 10·00–10·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
10·17	Industrial Chemistry	5·41, 5·61	3	2	X, XV-B	3	—	4	Meissner
10·18	Industrial Chemistry	5·62, 10·17	4	1	X, XV-B	3	—	6	Meissner
10·21T	Industrial Chemistry	10·18	4(B)	2	X	3	—	6	W. K. Lewis
10·25	Industrial Chemistry	5·42, 5·62	G(A)	1	(Elective)	5	—	7	W. K. Lewis
10·26	Industrial Chem. Lab.	*10·18*	4(B)	—	——	2	3	1	W. K. Lewis
10·26T	Industrial Chem. Lab.	10·17	4(B)	S	X	0	20	0	W. K. Lewis
10·27	Industrial Chem. Lab.	10·18	G(A)	1	(Elective)	2	6	0	W. K. Lewis
10·28	Chemical Eng.	*5·61*	3	1	X	4	—	6	Stokes
			4	1	VII-B, VII-C				
10·29	Chemical Eng.	10·28	3(B)	2	X	4	—	6	Stokes
			4	2	VII-B, VII-C				
10·30	Eng. Equipment	10·32	4	2	(Elective)	0	6	0	
10·31	Chemical Eng.	10·17, 10·29; or 2·41, 10·17; or *3·20*	4(B)	1	III_2, X, XV-B	4	—	6	McAdams
10·311	Heat Transfer	——	G(RB)	1	XIII-A	3	—	3	McAdams
10·32	Chemical Eng.	10·31	4(B)	2	III_2, X, XV-B	4	—	6	McAdams
10·33	Anal. Treat. of Chem. Eng. Processes	5·62, M22	G(A)	1	(Elective)	3	—	6	Sherwood
10·38	Explosives Plant Eng.	5·412	G(R)	1	——	5	—	3	——
10·39	Int. Ballistics, Th.	10·38	G(R)	2	——	4	—	6	——
10·40	Chem. Eng. Thermodyn.	5·62, 10·29	G(A)	1	(Elective)	4	—	8	Meissner
10·41	Distillation	10·32	G(A)	2	(Elective)	3	—	6	G. C. Williams
10·45	Distil. & Absorption	10·32	G(A)	1	(Elective)	4	—	8	G. C. Williams
10·46	Absorption & Extraction	10·32	G(A)	2	(Elective)	3	—	6	Sherwood
10·50	Heat Transmission	10·31	G(A)	2	(Elective)	2	—	4	McAdams
10·52	Chemical Eng. II	10·32	G(A)	1	(Elective)	4	—	5	McAdams
10·53	Chem. Eng. Design	10·81, 10·82, 10·83	G(A)	1	(Elective)	0	12	0	
10·54	Econ. Balance in Chem. Ind.	10·32	G(A)	1	(Elective)	4	—	8	G. C. Williams
10·55	Economic Balance	10·32	G(A)	2	(Elective)	3	—	6	Sherwood
10·62	App. Chem. Thermodyn.	5·62, 10·29	G(A)	2	(Elective)	3	—	6	Meissner
10·63	Industrial Chemistry II	10·661 or 10·663	G(A)	2	(Elective)	3	—	6	W. K. Lewis
10·65	Catal. & High Pres. Proc.	5·62, 10·29	G(A)	2	(Elective)	3	—	6	Meissner
10·661	Colloid Chem., Int.	5·42, 5·62	G(A)	1	(Elective)	2	—	4	Hauser
10·662	Colloid Chemistry	10·661	G(A)	2	(Elective)	2	—	4	Hauser

★ Time specially arranged.

Chemical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
10·663	Applied Colloid Chem., Int.	5.42, 5·62	G(A)	2	(Elective)	2	—	4	Hauser
10·673	Colloid Chem. Lab.	10·63 or 10·661	G(A)	1, 2	(Elective)	0	3	3	Hauser
10·674	Colloid Chem. Lab.	10·763	G(A)	1, 2	(Elective)	0	3	3	Hauser
10·68	Corrosion	5·62	G(A)	1	(Elective)	2	—	4	W. K. Lewis
10·69	Plastics and Other High Polymeric Substances	——	G(A)	1	(Elective)	2	—	4	Hauser
10·70	Combustion, Prin.	——	G(A)	1	(Elective)	4	—	8	Hottel
10·71	Fuel Engineering	10·70	G(A)	2	(Elective)	3	—	6	Hottel
10·74	Furnace Design	10·31	G(A)	1 or 2	(Elective)	3	—	6	Hottel
10·76	Sem. Rad. Heat Trans.	10·31	G(A)	2	(Elective)	2	—	4	Hottel
10·79	Automotive Fuels	5·42; 5·62; 2·42 or 10·29	G(A)	1	(Elective)	2	—	4	Hottel
10·81	Sch. Chem. Eng. Practice (Bangor Station)	10·32	G(A)	—	(Elective)	0	12	0	——
10·82	Sch. Chem. Eng. Practice (Parlin Station)	10·32	G(A)	—	(Elective)	0	12	0	——
10·83	Sch. Chem. Eng. Practice (Buffalo Station)	10·32	G(A)	—	(Elective)	0	12	0	——
10·84	Sch. Chem. Eng. Practice (Bangor Station)	10·32	4	—	(Elective)	0	12	0	——
10·85	Sch. Chem. Eng. Practice (Parlin Station)	10·32	4	—	(Elective)	0	12	0	——
10·86	Sch. Chem. Eng. Practice (Buffalo Station)	10·32	4	—	(Elective)	0	12	0	——
10·90	Exp. Research Problem	——	G(A)	1, 2	(Elective)		★		Stokes
10·911	Research Conf.	5·42, 5·62	G(A)	1	(Elective)	1	—	2	McAdams
10·912	Research Conf.	10·911	G(A)	2	(Elective)	1	—	2	McAdams
10·991	Seminar Chem. Eng.	10·32	G(A)	1	(Elective)	2	—	4	G. C. Williams
10·992	Seminar Chem. Eng.	10·32	G(A)	2	(Elective)	2	—	4	G. C. Williams

GEOLOGY — 12·00–12·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
12·011T	Mineralogy	5·02, *12·20*	3	1	III, XII	0	3	1	Buerger
12·012	Mineralogy	12·011T	3	2	XII	0	4	2	Buerger
12·05	Mineral. Seminar	12·012, 12·24	G(A)	1	(Elective)	2	—	4	Buerger
12·06	Mineral. Research	——	G(A)	2	(Elective)		★		Buerger
12·15	Petrography	12·23	3	2	XII	0	6	2	Fairbairn
12·161	Petrology Seminar	12·15	G(A)	1	(Elective)	2	—	4	Fairbairn
12·162	Petrology Seminar	12·15	G(A)	2	(Elective)	2	—	4	Fairbairn
12·17	Petrography, Adv.	12·15	G(A)	1	(Elective)	0	4	0	Fairbairn
12·20	Elem. Crystallog.	M12	3	1	III, XII	2	—	2	Buerger
12·23	Optical Crystallog.	*12·20*	3	1	XII	2	3	4	Buerger
12·24	Theoretical Crystallog.	12·20	4(B)	2	III_2	2	—	4	Buerger
12·26	X-ray Crystallog.	12·24	G(A)	2	(Elective)	2	—	4	Buerger
12·27	Crystallog. Research	——	G(A)	1 or 2	(Elective)		★		Buerger
12·301	General Geology	——	2	1	XII	3	4	3	Shrock
12·302	General Geology	12·301	2	2	XII	3	4	3	Shrock
12·321	Engineering Geology	——	2	1	IV-B	2	2	4	Whitehead
			3	1	I				
12·322	Engineering Geology	12·321	G(B)	2	(Elective)	2	—	4	Whitehead
12·36	Econ. Geog. of World	——	2	2	XIII-C	2	—	4	Morris
12·37	Geomorphology	12·301	4(B)	2	XII	3	—	6	Morris
12·38	Geomorphology, Adv.	12·37	G(A)	2	(Elective)	3	—	6	Morris
12·39	Reg. Geomorph. of Earth	12·37	4	1 or 2	(Elective)	2	—	4	Morris
12·40	Economic Geology	12·011T, 12·302	4(B)	1	XII	3	—	6	Newhouse
12·41	Econ. Geology Lab.	*12·40*	4(B)	1	XII	0	6	0	Newhouse
12·42	App. Econ. Geology	12·40	4(B)	2	(Elective)	3	—	6	Newhouse
12·431	Econ. Geol. Lab., Adv.	12·41	G(A)	1	(Elective)	0	4	1	Newhouse
12·432	Econ. Geol. Lab., Adv.	12·41	G(A)	2	(Elective)	0	4	1	Newhouse
12·433	Econ. Geol. Sem., Adv.	12·40	G(A)	1	(Elective)	2	—	4	Newhouse
12·434	Econ. Geol. Sem., Adv.	12·40	G(A)	2	(Elective)	2	—	4	Newhouse
12·44	Econ. Geol. of Fuels	G9	4(B)	2	(Elective)	3	—	6	Whitehead
12·511	Paleontology	12·301 or G9	4	1	(Elective)	0	4	4	Shrock
12·512	Paleontology	12·511	4	2	(Elective)	0	4	4	Shrock

★ Time specially arranged.

Geology Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
12·52	Paleontology, Adv.	12·512	G(A)	1 or 2	(Elective)	1	3	2	Shrock
12·53	Index Fossils	12·511	G(A)	2	(Elective)	1	4	2	Shrock
12·54	Micropaleontology	12·512	G(A)	1	(Elective)	1	3	2	Shrock
12·55	Org. Evolution, Adv.	G10	G(A)	1 or 2	(Elective)	2	1	4	Shrock
12·581	Sedimentation	12·301	4(B)	2	XII	2	3	4	Shrock
12·582	Sedimentation	12·581	G(A)	2	(Elective)	2	3	4	Shrock
12·60	Glacial Geology	12·302	4(B)	2	(Elective)	2	—	4	Morris
12·63	Physical Geol. Sem.	12·702	G(A)	1	(Elective)	2	—	4	Staff
12·64	Geology of N. America	12·302	G(A)	1	(Elective)	2	—	4	Whitehead
12·66	Research	——	4(B)	1 or 2	(Elective)		★		Staff
12·671	Prob. in Geol. Seminar	12·15	G(A)	1	(Elective)	1	—	2	Staff
12·672	Prob. in Geol. Seminar	12·15	G(A)	2	(Elective)	1	—	2	Staff
12·701	Structural Geology	12·301 or 12·321	3(B)	1	XII	3	—	6	Whitehead
12·702	Structural Geology	12·701	3(B)	2	XII	3	—	6	Whitehead
12·71	Structural Geology, Adv.	12·702	G(A)	2	(Elective)	3	—	6	Whitehead
12·80	Geology Coal & Petrol.	12·302 or G9	4(B)	2	(Elective)	3	—	6	Whitehead
12·81	Geology Petrol., Adv.	12·80	G(A)	2	(Elective)	3	—	6	Whitehead
12·851	Th. Geophysics, Adv.	8·461	G(A)	1	(Elective)	3	—	6	Slichter
12·852	Th. Geophysics, Adv.	8·461	G(A)	2	(Elective)	3	—	6	Slichter
12·86	Seismology, Elem.	M22	4(B)	2	(Elective)	2	—	4	Slichter
12·87	Geophys. Prospecting, Int.	12·302	4(B)	1	(Elective)	2	—	4	Slichter
12·91	Mining, Elements	12·40	4(B)	2	(Elective)	3	—	5	Parks
			3	2	III(2)				
12·92	Mining Meth. & Practice	12·91	4(B)	2	(Elective)	3	—	6	Parks
12·94	Mineral Economics	12·40	4(B)	1	(Elective)	2	—	4	Parks
12·95	Mine Valuation	12·92	G(A)	2	(Elective)	3	—	6	Parks
12·96	Mineral Econ. Sem.	12·94	G(A)	2	(Elective)		★		Parks

NAVAL ARCHITECTURE AND MARINE ENGINEERING — 13·00–13·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
13·01	Naval Architecture	8·01, M21	3(B)	1	XIII, XIII-C	3	—	6	Manning
			4	1	XIII-A, XIII-B				
13·02	Naval Architecture	13·01	3(B)	2	XIII	3	—	6	Chapman
			4	2	XIII-A, XIII-B				
13.021	Naval Architecture	13·01	3	2	XIII-C	2	—	4	Chapman
13·03	Naval Arch. and Ship Design	13·02, *13.45*	G(A)	1	(Elective)		★		——
13·04	Naval Arch. and Ship Design	13·03	G(A)	2	(Elective)		★		——
13·10	Hist. of Warship Design	13·01	4(B)	2	XIII-B	2	—	4	Manning
13·11	Struct. Des. of Warships	2·062, 13·02	G(A)	1	XIII-B	4	—	8	Turner
13·12	Th. of Warship Design	13·01	4(RB)	2	XIII-A	2	—	4	Manning
13·13	Th. of Warship Design	2·046	G(RA)	1	XIII-A	4	—	8	Turner
13·14	Protection & Armament	13·11, 13·27	G(A)	2	XIII-B	3	—	6	Manning
13·15	Th. of Warship Design	13·13	G(RA)	1	XIII-A	3	—	6	Manning
13·16	Th. of Warship Design	13·15	G(RA)	2	XIII-A	3	—	6	Manning
13·17	Basic Des. of Naval Vessels	13·02, 13·11	G(A)	1	XIII-B	3	—	6	Manning
13·21	Warship Design	——	4(RB)	1	XIII-A	0	5	0	Robertson
13·22	Warship Design	13·01	4(RB)	2	XIII-A	0	5	0	Lovelace
13·23	Warship Design	13·01, 13·421	4(B)	2	XIII-B	0	6	0	Robertson
13·24	Warship Design	13·13	G(RA)	2	XIII-A	0	5	0	Lovelace
13·25	Warship Design	13·24	G(RA)	1	XIII-A	0	5	0	Manning
13·26	Warship Design	13·15	G(RA)	2	XIII-A	0	8	0	Manning
13·27	Warship Design	13·02	G(A)	1	XIII-B	0	6	0	Manning
13.28	Warship Design	13·11, 13·27	G(A)	2	XIII-B	0	9	0	Manning
13·29	Warship Design	13·17	G(A)	2	XIII-B	0	8	0	Manning
13·34	Ship Construction	——	3	1	XIII, XIII-C	3	—	3	Burtner
13·341	Hull Engineering	13·01, 13·421	4	2	XIII-B	2	—	4	Burtner
13·40	Ship Construction, Elem.	——	2	2	XIII	2	3	2	Turner
13·42	Ship Drawing	13·01, 13·34	3	2	XIII	0	6	0	Turner
13·421	Naval Arch. Drawing	——	4	1	XIII-B	0	6	0	Robertson
13·45T	Ship Design	13·02, 13·42	4(B)	1	XIII	3	4	3	Turner
13·46T	Ship Design	13·45T	4	2	XIII	1	6	0	Manning
13·47	Ship Design	13·021, 13·34	5	2	XIII-C	1	6	1	Turner
13·52	Marine Engineering	2·40	3	2	XIII, XIII-C	3	—	6	Burtner

★ Time specially arranged.

Naval Architecture and Marine Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
13.54	Marine Engineering	2·062, 13·52	4(B)	1	XIII	2	—	4	F. M. Lewis
			G	2	XIII-B				
13·55	Marine Engineering	2·42, 13·52	4	2	XIII	2	—	4	Burtner
†13·56	Marine Engineering	13·52	5	1	XIII-C	3	—	6	Chapman
13·57	Marine Engineering	2·40, 13·02	G	1	XIII-B	3	—	6	——
13·58	Diesel Engineering	13·57	G(B)	2	XIII-B	2	—	4	F. M. Lewis
13·61	Marine Eng. Design	2·04, 2·40, 13·52	4(B)	1	XIII	0	6	0	Burtner
13·62	Marine Eng. Design	13·61	4(B)	2	XIII	1	6	1	Burtner
13·64	Marine Eng. Design	13·57	G	2	XIII-B	0	3	0	Burtner
13·71	Naval Engineering	13·57, 13·58, 13·64	G(A)	1	(Elective)	2	3	4	——
13·72	Naval Engineering	13·71	G(A)	2	(Elective)	3	3	6	——
13·73	Mechanical Vibration	2·046 or 2·06 or 2·062	G(A)	2	XIII-A	3	—	6	F. M. Lewis
			G	2	(Elective)				
13·74	Mechanical Vibration	13·73	G(A)	1	XIII-A	3	—	6	F. M. Lewis
			G	1	(Elective)				
13·75	Naval Engineering	2·422	G(RA)	1	XIII-A	3	2	8	——
13·76	Naval Engineering	13·75	G(RA)	2	XIII-A	2	4	4	——
13·78	Propeller Th. & Exp. Res.	13·02	G(A)	2	(Elective)	2	—	4	F. M .Lewis
13·79	Propeller Design	13·02	G(RA)	1	XIII-A	1	1	2	F. M. Lewis
13·791	Propeller Design	2·251, 13.02	G(A)	1	XIII-B	1	1	2	F. M. Lewis
†13·81	Ship Operation	13·021, 13·52, 13·84	5(B)	1	XIII-C	3	—	6	Chapman
†13·82	Ship Operation	13·81	5(B)	2	XIII-C	3	—	6	Chapman
13·83	Ports and Port Facilities	12·36	3	1	XIII-C	3	—	4	Chapman
13·84	Cargo Handling and Stowage	13·83	3	2	XIII-C	3	2	3	Chapman

METEOROLOGY — 14·00–14·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
14·01	Descriptive Meteorol. I	8·02, M12	3	1	XIV	3	—	6	Willett
14·02	Descriptive Meteorol. II	14·01	3	2	XIV	3	—	6	Willett
14·14	Long Range Weather Fore.	14·02, 14·45, 14·53, 14·61	G(A)	2	(Elective)	3	8	6	Willett
14·30	General Climatology	14·01	3	2	XIV	2	—	4	Malone
14·31	Regional Climatology	14·02, 14·30, *14·51*	4(B)	1	(Elective)	2	—	4	Malone
14·43	Synoptic Meteorol. I	14·01	4(B)	1	XIV	3	—	6	Willett
14·44	Synoptic Meteorol. II	14·43, 14·51, 14·61	4(B)	2	XIV	3	—	6	Austin
14·45	Synoptic Meteorol. III	14·44	G(A)	1	(Elective)	3	—	6	Austin
14·50	Meteorol. Lab., Int.	*14·01*	3	2	XIV	0	9	3	Malone
14·51	Synoptic Lab. I	14·50	4(B)	1	XIV	0	15	0	Austin
14·52T	Synoptic Lab. II	14·51	4(B)	2	XIV	0	15	0	Austin
14·53	Synoptic Lab. III	14·43, 14·52T	G(A)	1	(Elective)	0	15	0	Malone
14·60	Thermodyn. of Atmos.	8·02, M22	3	2	XIV	3	—	6	Houghton
14·61	Dynamic Meteorol. I	14·60	4(B)	1	XIV	2	—	4	Haurwitz
14·62T	Dynamic Meteorol. II	14·61	4(B)	2	XIV	3	—	6	Haurwitz
14·64	Dynamic Meteorol. III	14·62T	G(A)	1	(Elective)	3	—	9	Haurwitz
14·65	Dynamic Meteorol. IV	14·64	G(A)	2	(Elective)	3	—	6	Haurwitz
14·67	Graphical Analysis	*14·62T*	4(B)	2	(Elective)	0	3	0	Haurwitz
14·70	Phys. of Atmos., Elem.	14·01	3	2	XIV	2	—	4	Houghton
14·72	Physical Meteorology	8·04, 14·61	G(A)	1	(Elective)	3	—	6	Houghton
14·83	Oceanography	*14·43, 14·61*	4(B)	1	XIV	2	—	4	Houghton
14·91	Meteorol. Seminar I	14·44, 14·62T	G(A)	1	(Elective)	2	—	2	Houghton
14·911	Meteorol. Seminar I	14·44, 14·62T	G(A)	1	(Elective)	1	—	2	Houghton
14·912	Meteorol. Seminar II	14·911	G(A)	2	(Elective)	1	—	2	Houghton
14·92	Meteorol. Seminar II	14·91	G(A)	2	(Elective)	2	—	2	Houghton
14·95	Sp. Prob. in Meteorol.	14·44, 14·62T	G(A)	1 or 2	(Elective)		★		Staff

BUSINESS AND ENGINEERING ADMINISTRATION — 15·00–15·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
15·11	Bus. Manage., Int.	Ec11	4(B)	2	XIII	3	—	6	Cunningham
			3	2	VII-B				
15·20	Ocean Ship. Admin.	——	5	2	XIII-C	2	—	4	Fernstrom
15·25	Indust. Traffic Manage.	15·92	G(A)	1	(Elective)	3	—	6	Fernstrom

★ Time specially arranged.

† Open only to students in Course XIII-C who have had one year's practical work with a Steamship Company with nine months spent at sea.

Business and Engineering Administration Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
15·30	Personnel Management	15·70	2	2	XV-A, XV-B	3	—	5	Pigors
15·41	Finance	15·50, Ec11	4(B)	1	XV-A, XV-B, XVII$_2$	3	—	6	R. E. Freeman
15·42	Financial Problems	15·41	4(B)	2	(Elective)	3	—	6	D. S. Tucker
15·46	Fin. Adm. of Industry	15·41 or Ec47	G(A)	2	(Elective)	3	—	6	R. E. Freeman, D. S. Tucker
15·50	Accounting	*Ec11*	3	1	XV-B	3	2	4	Porter, Robnett
			3	2	XV-A, XVII				
15·51	Indust. Accounting	15·50	4(B)	2	(Elective)	3	2	4	Robnett
15·52	Accounting	*Ec11*	4	2	(Elective)	2	2	2	Porter, Robnett
			5	1	XIII-C				
15·55	Prob. in Account. Policy	15·41	G(A)	1	(Elective)	3	—	6	Robnett
15·58	Prob. in Account. Control	15·51	G(A)	2	(Elective)	3	—	6	Robnett
15·61	Law of Contracts	*Ec11*	3(B)	1	XV-A, XV-B	3	—	6	Schaefer
			4	1	IV-B, XVII$_2$				
			5	1	XIII-C				
15·62	Law of the Market	15·61	4(B)	2	(Elective)	3	—	6	Schaefer
15·63	Industrial Law	15·61	4(B)	1	(Elective)	3	—	6	Schaefer
15·64	Patent Law	15·61	4(B)	1	(Elective)	3	—	6	Schaefer
15·65	Labor Law	15·61	4(B)	2	(Elective)	3	—	6	Schaefer
15·70	Production	—	2	1	XV-A, XV-B	3	—	6	Schell
			4	2	(Elective)				
15·71	Production	15·70	4(B)	1	(Elective)	3	—	6	Schell
15·72	Tech. of Exec. Control	15·70	4(B)	2	(Elective)	3	—	6	Schell
15·73	Management Lab.	2·731 or 15·11 or 15·70	4(B)	1, 2	(Elective)	3	3	3	Goodwin
15·74	Management Lab., Adv.	15·73	4(B)	2	(Elective)	3	3	3	Goodwin
15·75	Manufact. Analysis	15·71	G(A)	1	(Elective)	3	—	6	Schell
15·76	Mass Production Methods	2·851, 15·70	4(B)	1 or 2	(Elective)	3	—	6	—
15·81T	Marketing and Reports	*Ec11*	3	1	XV-A	4	—	8	Bartlett,
			3	2	XV-B				Tallman
			4	1	XVII$_2$				
15·82	Sales Promotion: Strategy & Methods	15·81T	4(B)	2	XVII$_2$	3	—	6	Cunningham, Tallman
15·83	Marketing Research: Field Surveys	15·81T	4(B)	2	(Elective)	3	—	6	—
15·84	Marketing Research: Sales Anal. & Poten.	15·81T	4(B)	2	(Elective)	3	—	6	—
15·86	New Prod. Appraisal & Development	15·82 or 15·83 or 15·84	G(A)	1	(Elective)	3	—	6	—
15·88	Marketing Seminar	15·82 or 15·83 or 15·84	G(A)	2	(Elective)	3	—	6	—
15·92	Industrial Problems	15·30, 15·41, 15·61, 15·70, 15·81T	4(B)	2	XV-A, XV-B	3	—	6	Schell
15·94	Contemp. Prob. Seminar	15·92	G(A)	2	(Elective)	3	—	6	Schell
15·95	Sp. Prob. in Management	—	G(A)	1, 2	(Elective)		★		Schell
15·96	Adm. Th. & Practice	15·92	G(A)	2	(Elective)	3	—	6	Schell
15·97	Seminar in Bus. Adm.	—	G(A)	2	(Elective)	3	—	6	Schell
	Graduate Thesis	—	G(A)	—	XV		★		Cunningham

AERONAUTICAL ENGINEERING — 16·00–16·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
16·01	Aero. Mech., Int.	M22	3(B)	1	XVI	4	2	6	Rauscher
16·02	Aero. Mech., Int.	16·01	3(B)	2	XVI	4	2	6	Rauscher
16·03	Aerodyn. Non-Viscous Fluids	16·02	G(A)	1	(Elective)	3	—	6	R. H. Smith
16·032	Aero. Mechanics	16·621, M72	4	2	—	2	—	4	R. H. Smith
16·033	Aero. Mechanics	16·032	4	S	—	2	—	4	R. H. Smith
16·04	Aerodyn. Viscous Fluids	16·03	G(A)	2	(Elective)	3	—	6	R. H. Smith
16·06	Wing Flutter, Int.	16·02	4(B)	2	(Elective)	2	—	4	Rauscher
16·061	Flutter Mechanics	16·02	G(A)	1	(Elective)	3	—	6	Rauscher
16·07	Aerodynamics — Compressible Fluids	16·02	G(A)	1	(Elective)	3	—	6	R. H. Smith
16·08	Adv. Topics in Aeromechanics	16·02	G(A)	2	(Elective)	3	—	6	R. H. Smith
16·10	Applied Aerodynamics	2·04, 8·04, 16·01	3(B)	2	—	3	—	3	Ober

★ Time specially arranged.

Aeronautical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
16·10T	Applied Aerodynamics	16·01, 16·82	3(B)	2	XVI	4	—	8	Ober
16·102	Aerodynamics	—	3	2	—	4	—	4	Ober
16·11	Airplane Performance	16·02, 16·10	4(B)	1	—	3	—	3	Ober
16·13	Airpl. Stab. & Control	16·10T	4(B)	1	XVI	3	—	6	Koppen
16·132	Aerodynamics	—	4	2	—	4	—	6	Koppen
16·14	Airpl. Design Prob.	16·13, 16·17	4(B)	2	(Elective)	2	6	4	Koppen
16·16	Power Plant Perform. & Install.	2·42, 2·06 or 16·02	4(B)	2	XVI	3	—	6	E. S. Taylor
16·161	Engine Installation	—	4	S	—	2	—	4	E. S. Taylor
16·17	Airpl. Des. Practice	16·10T, *16.13*	4(B)	1	XVI	0	6	0	Koppen
16·172	Airplane Design	—	4	2	—	0	2	0	Koppen
16·173	Airplane Design	—	4	S	—	0	6	0	Newell
16·18	Airpl. Des. Practice	—	G(RA)	2	—	0	8	0	Newell
16·20	Structures	2·04	3	2	XVI	3	—	6	Newell
16·201	Structures	—	4	1	—	4	—	6	Newell
16·21	Structures	16·20	4(B)	1	XVI	3	—	6	Newell
16·212	Structures	—	4	2	—	4	—	6	Newell
16·22	Aircraft Structures	16·21	4(B)	2	—	3	—	6	Newell
16·22T	Aircraft Structures	16·21	4(B)	2	(Elective)	3	2	6	Newell
16·25	Aircraft Struct., Adv.	16·21	G(A)	1	(Elective)	3	—	6	Newell
16·33	Meteorological Observations	8·02, M12	3	1	XIV	1	3	2	Keily
16·34	Aircraft Instruments	8·04, M22	4(B)	2	(Elective)	3	2	6	McKay
16·37	Instrumentation	2·081	G(RA)	1 or 2	—	3	—	6	Draper
16·38	Instruments	16·37	G(RA)	1 or 2	—	4	—	8	Draper
16·39	Instruments Laboratory	16·37	G(RA)	1 or 2	—	0	8	0	Draper
16·40	Instruments Laboratory	16·38	G(RA)	1 or 2	—	0	8	0	Draper
16·41	Instrumentation	2·082 or 16·02	G(A)	1	(Elective)	3	—	9	Draper
16·42	Aircraft Instruments	16·41	G(A)	2	(Elective)	3	—	9	McKay
16·43	Instruments Lab.	*16·41*	G(A)	1	(Elective)	0	3	6	McKay
16·44	Meteorological Inst.	8·02, 14·11, M21	4(B)	2	(Elective)	2	2	6	Keily
16·45	Sp. Prob. in Aero. & Met. Inst.	16·42 or 16·44	G(A)	1	(Elective)		★		Draper
16·46	Vibration Measurements	6·671 or 8·05 or 13·73; 16·41	G(A)	2	(Elective)	2	3	6	McKay
16·47	Instrument Des. Practice	16·41	G(A)	1	(Elective)	2	6	2	McKay
16·48	Instrument Des. Practice	16·47	G(A)	2	(Elective)	2	6	2	McKay
16·50	Rotat. Wing Aircraft	16·10T	4(B)	2	(Elective)	3	—	6	Miller
16·501	Rotating Wing Aircraft	16·10T	G(A)	2	(Elective)	3	—	6	Miller
16·52	Aircraft Propeller Des.	16·10T, 16·20	G(A)	2	(Elective)	2	2	4	Ober
16·53	Airplane Eng. Des., Adv.	2·792	G(A)	1	(Elective)	1	4	3	E. S. Taylor
16·60	Aero. Prob., Adv.	16·13 or 16·25 or 16·63	G(A)	1 or 2	(Elective)		★		Staff
16·62	Aerodynamic Lab.	16·01, 16·10T	4(B)	1	XVI	2	2	4	Ober
16·621	Aerodynamics	—	4	1	—	2	2	4	Ober
16·63	Aerodynamic Lab.	16·62	4(B)	2	(Elective)	2	2	4	Ober
16·75	Constr. Details of Aircraft	16·17	4(B)	2	XVI	2	3	4	Koppen
16·81	Aeronautics, General	1·40 or 2·06; 2·252; M21	4(B) G	1 or 2 1	(Elective) XIII-B	3	—	6	Markham
16·82	Aeronautical Eng., Int.	M21	2	2	XVI	3	—	1	Markham
16·83	Aeronautical Engineering	—	3	1	—	2	—	0	Markham
16·84	Aero. & Prod. Eng.	—	4	S	—	2	—	0	—

BUILDING ENGINEERING AND CONSTRUCTION — 17·00–17·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
17·22	Building Construction	D12	2	1	XVII	2	3	4	Dietz
17·31	Building Construction	17·22	3	1	XVII(1)	2	3	4	Staley
17·32	Building Construction	17·31	3	2	XVII(1)	2	3	4	Staley
17·33	Building Construction	17·22	3	1	XVII(2)	2	3	4	Dietz
17·34	Building Construction	17·33	3	2	XVII(2)	2	3	4	Voss
17·40	Estimating & Job Manage.	17·32 or 17·34	4(B)	2	XVII	2	3	4	Voss
17·401	Job Management, Adv.	17·40	G(A)	1	(Elective)	3	—	6	Voss
17·45	Construction Problems	17·32 or 17·34	4(B)	1 or 2	(Elective)		★		Voss
17·52	Structural Problems	2·04	3	2	XVII	3	4	5	Peabody

★ Time specially arranged.

Building Engineering and Construction Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
17·53	Structural Design	17·52	4(B)	1	$XVII_1$	4	4	6	Peabody
17·531	Reinf. Concrete Des., Adv.	1·42 or 17·53	G(A)	1	(Elective)	3	—	6	Peabody
17·532	Reinf. Concrete Des., Adv.	17·531	G(A)	2	(Elective)	3	—	6	Peabody
17·54	Structural Design	17·53	4(B)	2	$XVII_1$	3	4	5	Peabody
17·542	Structural Steel Des., Adv.	1·42 or 17·54	G(A)	2	(Elective)	3	—	6	Peabody
17·56	Structural Design	17·52	4	2	$XVII_2$	3	4	5	Peabody
17·71	Materials	5·02, 8·02	2	2	IV, XVII	2	—	4	Dietz
17·72	Materials	17·71	3	2	IV, XVII	2	—	4	Staley
17·73	Materials	17·72	4	1	IV, XVII	2	—	4	Dietz
17·77	Sp. Prob. in Build. Mat.	——	G(A)	1 or 2	(Elective)		★		Staley

GRAPHICS — D1–D99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
D11	Engineering Drawing	——	1	1	All courses	0	6	0	Rule
D12	Descriptive Geometry	D11	1	2	All courses	0	6	0	Rule
D31	Nomography	D12, M12	2, 3	1, 2	(Elective)	2	—	4	D. P. Adams

ECONOMICS AND SOCIAL SCIENCE — EC1–EC99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
Ec11	Economic Principles	E12	3	1	All courses	3	—	5	D. S. Tucker
			G	1	XIII-B				
Ec12	Industrial Economics	Ec11	3	2	(Elective)	3	—	5	Myers
Ec15	Economic Principles	E12	G	2	XIII-A	3	—	5	R. E. Freeman
			G	2	(Elective)				
Ec17	Economic Analysis	Ec50	G(A)	1	(Elective)	3	—	6	Samuelson
Ec18	Economic Analysis	Ec17	G(A)	2	(Elective)	3	—	6	Samuelson
Ec19	Math. Approach to Economics	Ec18	G(A)	1	(Elective)	3	—	6	Samuelson, H. A. Freeman
Ec23	Postwar Problems	Ec12	4(B)	1	(Elective)	3	—	6	Bissell
Ec24	Schools of Econ. Thought	Ec50	G(A)	2	(Elective)	3	—	6	D. V. Brown, Bissell
Ec26	Business Cycles	Ec50	G(A)	2	(Elective)	3	—	6	Samuelson
Ec28	Econ. of Technol. Change	Ec12	4(B)	1	(Elective)	3	—	6	Maclaurin
Ec29	Econ. of Technol. Change	Ec28	4(B)	2	(Elective)	3	—	6	Maclaurin
Ec32	Economic Statistics	M12	2	2	IV-B	3	—	6	H. A. Freeman
Ec33	Statistics, Adv.	M12	4(B)	1	(Elective)	3	—	6	Festinger
Ec37	Econ. Statistics, Adv.	Ec32	G(A)	1	(Elective)	3	—	6	H. A. Freeman, Samuelson
Ec38	Industrial Statistics	M21	4(B)	1	XV-A	3	—	6	H. A. Freeman
Ec39	Statistical Inference	M21	4(B)	1	(Elective)	3	—	6	H. A. Freeman
Ec40	Money & Banking	Ec11	3	2	IV-B	2	—	4	R. E. Freeman
Ec47	Investment Finance	Ec50	G(A)	1	(Elective)	3	—	6	D. S. Tucker
Ec48	Investment Analysis	15·42 or Ec47	G(A)	2	(Elective)	3	—	6	D. S. Tucker
Ec49	Public Finance	Ec11	4(B)	1	IV-B	2	—	4	Samuelson
Ec50	Banking & Finance	Ec11	4(B)	2	(Elective)	2	—	4	R. E. Freeman
Ec54	Corporations	Ec11	5(B)	2	XIII-C	2	—	4	D. S. Tucker
Ec56	Industrial Econ., Prob.	Ec12	4(B)	2	(Elective)	3	—	6	D. V. Brown
Ec57	International Relations	Ec11	4	1	(Elective)	3	—	5	Padelford
Ec58	International Relations	Ec57	4	2	(Elective)	3	—	5	Padelford
Ec59	International Economics	Ec58	G(A)	1	(Elective)	3	—	6	R. E. Freeman
Ec60	Labor Relations	Ec11	3	2	(Elective)	3	—	5	Pigors
Ec65	Industrial Relations	15·30 or Ec60	4(B)	1	(Elective)	3	—	6	Pigors
Ec66	Seminar in Indust. Rel.	Ec65	G(A)	2	(Elective)	3	—	6	Pigors
Ec67	Seminar in Labor Probs.	Ec65	G(A)	1	(Elective)	3	—	6	D. V. Brown
Ec68	Seminar in Labor Probs.	Ec67	G(A)	2	(Elective)	3	—	6	D. V. Brown
Ec70	Introductory Psychology	——	3	2	(Elective)	3	—	5	McGregor, Knickerbocker
Ec71	Motivation & Pers. Dev.	1 yr. Psych.	4(B)	1	(Elective)	3	—	6	McGregor
Ec72	Motivation & Pers. Dev.	Ec71	4(B)	2	(Elective)	3	—	6	Knickerbocker
Ec721	Psych. Perception & Action	Ec72	G(A)	1	(Elective)	3	—	6	Cartwright
Ec731	Group Psych., Int.	1 yr. Psych.	4(B)	1	(Elective)	3	—	6	Lippitt
Ec732	Group Psych., Int.	Ec731	4(B)	2	(Elective)	3	—	6	Lippitt

★ Time specially arranged.

Economics and Social Science Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
Ec735	Group Psychology, Adv.	Ec77	G(A)	1	(Elective)	3	—	6	Bavelas
Ec75	Lab. in Research Methods	1 yr. Psych.	G(A)	1	(Elective)	3	9	0	Lippitt
Ec76	Lab. in Research Methods	Ec75	G(A)	2	(Elective)	3	9	0	Lippitt
Ec77	Seminar in Topol. Psych.	1 yr. Psych.	G(A)	1	(Elective)	3	—	6	Lewin
Ec781	Social Psych. of Change	Ec77	G(A)	1	(Elective)	3	—	6	Radke
Ec782	Social Psych. of Change	Ec781	G(A)	2	(Elective)	3	—	6	Radke
Ec791	Psychological Seminar, Adv.	Ec77	G(A)	1	(Elective)	2	—	4	Lewin, Radke
Ec792	Psychological Seminar, Adv.	Ec791	G(A)	2	(Elective)	2	—	4	Lewin
Ec793	Psychological Seminar, Adv.	Ec792	G(A)	1	(Elective)	2	—	4	Lewin
Ec794	Psychological Seminar, Adv.	Ec793	G(A)	2	(Elective)	2	—	4	Lewin
Ec80	American Government	Ec11	3	2	(Elective)	3	—	6	Schaefer
Ec82	Govt. Control of Industry	Ec50	G(A)	2	(Elective)	3	—	6	Thresher
Ec83	Urban Sociology	—	2	2	IV, IV-B	2	—	4	Pigors
Ec85	Land Economics	4·651, Ec11	4(B)	1	IV-B	2	—	4	F. J. Adams
			5	1	IV				
Ec86	Land Economics	Ec85	4(B)	2	IV-B	3	—	6	F. J. Adams
Ec88	Building Economics	Ec11	5	2	IV	2	—	4	D. S. Tucker
Ec91	Economics Seminar	Ec17	G(A)	1	(Elective)	3	—	6	R. E. Freeman
Ec92	Economics Seminar	Ec91	G(A)	2	(Elective)	3	—	6	R. E. Freeman
Ec93	Ind. Econ. Seminar	Ec56	G(A)	1	(Elective)	3	—	6	D. V. Brown
Ec94	Ind. Econ. Seminar	Ec93	G(A)	2	(Elective)	3	—	6	D. V. Brown
Ec95	Social Science Seminar	Ec50	G(A)	1	(Elective)	3	—	6	McGregor
Ec96	Social Science Seminar	Ec95	G(A)	2	(Elective)	3	—	6	Knickerbocker

ENGLISH AND HISTORY — E1–E99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
E1	English, Entrance	—	—	S	—	2	—	5	—
E11	English Composition	—	1	1	All courses	3	—	5	Bryant
E12	English Composition	E11	1	2	All courses	3	—	5	Bryant
E21	U. S. in World History	—	2	1	All courses	3	—	5	Rae
E22	U. S. in World History	—	2	2	All courses	3	—	5	Rae
E25	English Composition	—	3, 4	1 or 2	(Elective)		★		Urbach
E33	Report Writing	E22	4	1	(Elective)	2	—	4	Bartlett
E35	Reports	E22	2	1	IV-B	2	—	4	Chalmers
			3	2	(Elective)				
E41	History of Thought	E22	4	1	(Elective)	3	—	5	de Santillana
E42	History of Thought	E22	4	2	(Elective)	3	—	5	de Santillana
E43	Western World Literature	E22	4	1	(Elective)	3	—	5	Greene
E44	Western World Literature	E22	4	2	(Elective)	3	—	5	Greene
E46	Music, Int.	—	4	2	(Elective)	3	—	5	D. M. Fuller
E51	Seminar Ec. and Ind. Hist.	Ec50	G(A)	1	(Elective)	3	—	6	Bartlett
E52	Seminar Ec. and Ind. Hist.	Ec51	G(A)	2	(Elective)	3	—	6	Bartlett

GENERAL STUDIES — G1–G99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
G1	History of Science	—	—	1	—	2	—	4	de Santillana
G2	History of Science	—	—	2	—	2	—	4	de Santillana
G7	Prob. of Modern Philos.	—	—	1	—	2	—	2	de Santillana
G8	History of Philosophy	—	—	2	—	2	—	2	Wiener
G9	Geology	—	—	1	—	2	—	4	Morris
G12	Seminar in Biography	—	4	2	—	3	—	3	Bartlett
G28	Economic Geography	—	2	2	—	2	—	4	Morris
G29T	Topog. in the World War	—	—	1	—	2	—	2	Morris
G38	Public Speaking	—	4	2	IV-B	3	—	3	Copithorne
G39	Reading Seminar	—	—	1 or 2	—	2	—	4	Chalmers
G581	Russian, Elementary	—	—	1	—	3	—	5	Znamensky
G582	Russian, Elementary	G581	—	2	—	3	—	5	Znamensky
G67	Debating, Prin.	—	—	1	—	2	—	2	Leggett
G68	Debating, Prin.	—	—	2	—	2	—	2	Leggett
G75	Human Relations	—	—	1	—	3	—	3	Magoun
G76	Human Relations	—	—	2	—	3	—	3	Magoun
G79T	Comp. Political Inst.	—	—	1	—	2	—	4	Schaefer

★ Time specially arranged.

MODERN LANGUAGES — L1–L99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
L11	German, Elem.	—	—	1, 2	(Elective)	3	—	5	Currier
			2	1	XIV				
L12	German, Elem.	L11	—	1, 2	(Elective)	3	—	5	Currier
			2	2	XIV				
L21	German, Int.	L12, or Elem. Entrance German	—	1, 2	(Elective)	3	—	5	Kurrelmeyer
L22	German, Int.	L21	—	1, 2	(Elective)	3	—	5	Kurrelmeyer
L31	German, Int.	L12, or Elem. Entrance German	3	1	(Elective)	2	—	3	Kurrelmeyer
L41	German, Adv.	L22 or Int. Entrance German	2 or 3	1	(Elective)	3	—	5	Currier
L51	French, Elem.	—	—	1, 2	(Elective)	3	—	5	Langley
L52	French, Elem.	L51	—	1, 2	(Elective)	3	—	5	Langley
L61	French, Int.	L52 or Elem. Entrance French	—	1, 2	(Elective)	3	—	5	Koch
L62	French, Int.	L61	—	2	(Elective)	3	—	5	Koch
L81	Spanish, Elem.	—	—	1	(Elective)	3	—	5	Koch
L82	Spanish, Elem.	L81	—	2	(Elective)	3	—	5	Koch
L83	Spanish, Int.	L82	—	1	(Elective)	3	—	5	Koch
L84	Spanish, Int.	L83	—	2	(Elective)	3	—	5	Koch
L91	Italian, Elem.	—	—	1	(Elective)	3	—	5	—
L92	Italian, Elem.	L91	—	2	(Elective)	3	—	5	—

MATHEMATICS — M1–M99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
M1	Algebra, Entrance	—	—	S	—	2	—	5	—
M3	Solid Geom., Entrance	—	—	S	—	2	—	5	—
M4	Trigonometry, Entrance	—	—	S	—	2	—	5	—
M11	Calculus	Entrance Algebra, Solid Geometry, Trigonometry	1	1	All courses	3	—	6	Douglass
M112	Mathematics (College Transfer)	—	1	1	—	3	—	6	Douglass
M12	Calculus	M11	1	2	All courses	3	—	6	Douglass
M21	Calculus	M12	2	1	All courses	3	—	6	Zeldin
M212	Mathematics (College Transfer)	—	2	1	—	3	—	6	Douglass
M22	Diff. Equations	*M21*	2	2	(All courses except IV & IV-B)	3	—	6	Zeldin
M31	Diff. Equations	M22	3	1	VI	2	—	4	Franklin
M32	Statistics, Elementary	M21	2	2	XVIII	3	—	6	Wadsworth
M331	Math. Th. of Statistics	M22	3(B)	1	XIV, XVIII(2)	3	—	6	Wadsworth
M332	Math. Th. of Statistics	M331	3(B)	2	XVIII(2)	3	—	6	Wadsworth
M341	Modern Statistical Th.	M332	4(B)	1	$XVIII_2$	3	—	6	Wadsworth
M342	Modern Statistical Th.	M341	4(B)	2	$XVIII_2$	3	—	6	Wadsworth
M351	Adv. Calculus for Engineers	M22	G(A)	1	(Elective)	3	—	6	Franklin
M352	Adv. Calculus for Engineers	M351	G(A)	2	(Elective)	3	—	6	Franklin
M36	Advanced Calculus	M22	G(A)	1	(Elective)	3	—	6	Douglass
			3	1	IX-A				
			4	1	XIII-A, XIII-B				
M37	Advanced Calculus	M36	G(A)	2	(Elective)	3	—	6	Douglass
			3	2	IX-A				
			4	2	XIII-A, XIII-B				
M381	Theory of Functions	M22	G(A)	1	(Elective)	3	—	9	Cameron
M382	Theory of Functions	M381	G(A)	2	(Elective)	3	—	9	Cameron
M441	Projective Geometry	M22	3(B)	1	(Elective)	3	—	6	Struik
M442	Diff. Geometry, Elem.	M22	4(B)	2	$XVIII_1$	3	—	6	Struik
M451	Fourier Series & Integrals	M22	G(A)	1	(Elective)	3	—	9	Wiener
M452	Fourier Series & Integrals	M451	G(A)	2	(Elective)	3	—	9	Wiener
M461	Seminar in App. Math.	M22	G(A)	1	(Elective)	3	—	9	Reissner
M54	Mathematical Lab.	M22	3(B)	2	(Elective)	3	—	6	Douglass
M551	Funct. of Real Variable	M22	G(A)	1	(Elective)	3	—	9	Salem
M552	Funct. of Real Variable	M551	G(A)	2	(Elective)	3	—	9	Salem

Mathematics Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
M561	Functions of a Complex Variable	M22	G(A)	1	(Elective)	3	—	9	Levinson
M562	Functions of a Complex Variable	M561	G(A)	2	(Elective)	3	—	9	Levinson
M571	Diff. Equations	M22	G(A)	1	(Elective)	3	—	9	Levinson
			4	1	$XVIII_1$				
M572	Diff. Equations	M571	G(A)	2	(Elective)	3	—	9	Levinson
			4	2	$XVIII_1$				
M581	Continuous Groups	M22	G(A)	1	(Elective)	3	—	9	Zeldin
M582	Continuous Groups	M581	G(A)	2	(Elective)	3	—	9	Zeldin
M62	Modern Algebra	M22	3(B)	2	XVIII(1)	3	—	6	Hitchcock
M641	Tensor Calculus	M22	G(A)	1	(Elective)	3	—	9	Struik
M642	Tensor Calculus	M641	G(A)	2	(Elective)	3	—	9	Struik
M651	Analytical Mechanics	M22	G(A)	1	(Elective)	3	—	9	Crout
M652	Analytical Mechanics	M651	G(A)	2	(Elective)	3	—	9	Crout
M671	Partial Differential & Integral Equations	M22	G(A)	1	(Elective)	3	—	9	Crout
M672	Partial Differential & Integral Equations	M671	G(A)	2	(Elective)	3	—	9	Crout
M681	Calculus of Variations	M22	G(A)	2	(Elective)	3	—	9	Cameron
			4	1	$XVIII_1$				
M691	Charact. Value Prob.	M22	G(A)	1	(Elective)	3	—	9	Franklin
M692	Charact. Value Prob.	M691	G(A)	2	(Elective)	3	—	9	Franklin
M71	Mathematics	—	3	1	—	5	2	8	Thomas
M72	Mathematics	—	3	2	—	5	2	8	Thomas
M73	Review of Mathematics	—	4	—	XIII-A	20	—	0	Douglass
M731	Mechanics	M22	3(B)	1	XVIII (1)	3	—	6	Crout
M732	Mechanics	M731	3(B)	2	XVIII (1)	3	—	6	Crout
M76	Th. of Probability	M21	G(A)	2	(Elective)	3	—	9	Struik
M77	Vector Analysis	*M22*	3(B)	1	XVIII (1)	3	—	6	Phillips
			3	2	VI (2), VIII				
M791	Th. & App. Elasticity	M22	G(A)	1	(Elective)	3	—	9	Reissner
M792	Th. & App. Elasticity	M791	G(A)	2	(Elective)	3	—	9	Reissner
M831	Analysis	M22	3(B)	1	XVIII	3	—	6	Franklin
M832	Analysis	M831	3(B)	2	XVIII	3	—	6	Franklin
M90	Math. Reading	—	G(A)	1 or 2	(Elective)		★		Phillips

MILITARY SCIENCE — MS1–MS99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
MS11	Military Science	—	1	1	All courses	0	3	0	Cuddire
MS12	Military Science	—	1	2	All courses	0	3	0	Cuddire
MS21	Military Science	—	2	1	All courses	3	—	0	Cuddire
MS22	Military Science	—	2	2	All courses	3	—	0	Cuddire

APPENDIX A

STUDENT AID AND PRIZES

RESOURCES for financial aid to students include: the Technology Loan Fund, available for undergraduate and graduate students; Freshman Competitive and other scholarships open to students entering from secondary schools; undergraduate scholarship aid to upper classmen; fellowships and graduate scholarships, Teaching Fellowships, and full- and part-time Assistantships to aid students pursuing work leading to the Master's or Doctor's degree; and prizes.

The extent of these resources is indicated by the facts that, since its establishment in 1930, over 2,500 men have borrowed more than $1,880,000 from the Technology Loan Fund; and approximately $90,000 and $102,000 are annually available for undergraduate and graduate scholarship aid, respectively.

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 $1,800 during his undergraduate period, or $2,400 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 two per cent 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.

FRESHMAN SCHOLARSHIPS

These are confined to students who make application to the Office of the Dean of Students before April 1 in advance of matriculation as of July or September, 1946.

Approximately 200 Freshman Competitive awards covering part tuition for the first year are made annually to students entering from secondary schools. Selection is based, to a large degree, upon the candidate's entrance record, College Boards, Regents, and preparatory or high school records; in other words, upon the evidence that he has the academic aptitude and training to enable him to pursue Institute studies with profit to himself and, in due time, to graduate creditably. However, and this is *considered of utmost importance*, the candidate is expected to give evidence through recommendations from former teachers, prominent citizens of his local community, and Institute graduates that he possesses excellent qualities of character and personal bearing, as well as willingness and ability to coöperate with the demands of an engineering, scientific, or architectural curriculum.

Except where distance from Cambridge precludes, a personal interview between an officer of the Institute and the applicant is required and, to facilitate these arrangements, early application is desired. Interviews with some nearby representative of the Institute will be arranged for candidates who live at a distance from Cambridge.

Besides the Freshman Competitive awards, other freshman scholarships are open to qualified applicants under terms set forth below. Most of these grants depend in part upon a candidate having some special qualification in addition to presenting evidence that he has high scholastic ability, i.e., that he be from a particular locality, a graduate of a particular school, etc. The figures in parentheses are the dates of establishment.

ALUMNI REGIONAL (1926). As a means of coöperating 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 of full tuition 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., 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, Marine Corps and Coast Guard Officers, who are admitted as undergraduate students to the Institute, will pay half the regular tuition upon the recommendation of the Faculty Committee on Undergraduate Scholarships, 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 Office of the Dean of Students and should be accompanied by documentary evidence that the applicant's father is a commissioned officer in the regular Army, Navy, Marine Corps or Coast Guard. It is the policy of the Committee not to recommend a man for one of these awards unless he has satisfied with high standing all entrance requirements of the Institute. Holders of these scholarships, if recommended by the Committee, may continue at the half-tuition rate during their second and succeeding undergraduate years.

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 Office of the Dean of Students.

CAMBRIDGE (1916). A limited number of scholarships is 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 satis-

factory scholastic record and continues to furnish evidence of need. Original application for a Cambridge Scholarship should be made through the Headmaster, or Principal, of the applicant's school, and such application must be filed with the Headmaster, or Principal. Awards will be by competition, based upon special examinations given by the Institute, with the stipulation that no successful candidate will be entitled to benefit from an award unless he or she satisfies prior to admission, all entrance requirements of the Institute.

CLASS OF '96 FUND (1923). Received from the Class of 1896 to found a scholarship to be awarded subject to the approval of the Secretaries of the Class. Preference in making awards will be given to descendants of members of the Class of 1896, including freshmen, and grants from this fund are to be considered as loans to be repaid by the recipients when and if able.

CLASS OF '09 FUND (1937). Established as the "Class of 1909 Scholarship Fund," the net income to "be used to assist such deserving students as may be selected from time to time . . . , preference being given to direct descendants of members of the Class of 1909."

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."

EAST BRIDGEWATER (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 School of East Bridgewater, Massachusetts, recommended by the Principal, to whom application must be made.

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 at the Office of the Dean of Students. Selection will be based on qualifying examinations given by the Institute, and with the stipulation that no individual will be eligible to receive an award until he has fulfilled all entrance requirements of the Institute.

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, which are suspended for the duration of the war, may be obtained from the Office of the Dean of Students.

LLORA CULVER KRUEGER FUND (1936). Established from the residuary estate of the late Emma Robinson Culver "for needy and worthy Massachusetts Institute of Technology students who come from Schenectady or its immediate vicinity, preferably those recommended by the local Regional Scholarship Committee."

GEORGE H. MAY (1914). Gift of $5000 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.

VERMONT (1924). Gift of $25,000 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."

UNDERGRADUATE SCHOLARSHIP AID FOR UPPER CLASSMEN

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 Faculty Committee on Undergraduate Scholarships 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 Room 3-108.

The scholarships or funds described are arranged in the alphabetical order of their names, the figures in parentheses being the dates of establishment:

ELISHA ATKINS (1894). Founded by Mrs. Mary E. Atkins of Boston with a gift of $5,000.

THOMAS WENDALL BAILEY (1914). Bequest of Thomas Wendall 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."

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."

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."

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."

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."

CLASS OF '96 FUND (1923). Received from the Class of 1896 to found a scholarship to be awarded subject to the approval of the Secretaries of the Class. Preference in making awards will be given to descendants of members of the Class of 1896, including freshmen, and grants from this fund are to be considered as loans to be repaid by the recipients when and if able.

CLASS OF '09 FUND (1937). Established as the "Class of 1909 Scholarship Fund," the net income to "be used to assist such deserving students as may be selected from time to time . . . , preference being given to direct descendants of members of the Class of 1909."

CLASS OF 1917 SCHOLARSHIP FUND (1942). Established on the twenty-fifth anniversary of the Class, the "income and principal . . . to be used to assist such deserving students as may be selected from time to time, preference being given to direct descendants of members of the Class of 1917. Beneficiaries are expected to issue notes agreeing to repay the face value, without interest, of amounts received."

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.

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 an annual stipend of $800 per year for each of the four undergraduate years, is annually offered to an entering freshman. Application should be made to the Office of the Dean of Students.

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."

CONSOLIDATED VULTEE AIRCRAFT CORPORATION SCHOLARSHIPS (1944). Two scholarships carrying stipends of full tuition for the senior year, established by this Corporation and "open to highly recommended engineering students in Civil Engineering, Electrical Engineering, Mechanical Engineering, or Aeronautical Engineering, and pursuing courses related to aeronautical engineering, who will have completed their junior year."

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."

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."

ISAAC W. DANFORTH (1903). Bequest of $5,000 from James H. Danforth for scholarship purposes as a memorial to his brother, Isaac Warren Danforth.

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."

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."

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 . . ."

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.

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 $5,000 from Barnett D. Gordon of the Class of 1916, "the income as scholarships for deserving students at M. I. T."

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."

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.

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."

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."

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."

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."

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 Dean of Students.

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."

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."

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. . . ."

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.

JOHN FELT OSGOOD (1909). Bequest of $5,000 from Eliza B. Osgood "to establish and maintain a scholarship in Electricity in memory of my husband, John Felt Osgood."

GEORGE L. PARMELEE (1921). Bequest from George L. Parmalee 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."

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."

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."

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.

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. . . ."

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."

WILLIAM BARTON ROGERS (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.

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 by the Scholarship Committee 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.

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.

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.

ANNA SPOONER FUND (1939). Bequest of approximately $7,500 "the income therefrom . . . to be used . . . in assisting meritorious students."

STEVENSON TAYLOR (1928). Established by the American Bureau of Shipping in memory of Stevenson Taylor, its late President. Tenable for two years; carries an annual stipend of $500; awarded in alternate years to a deserving third year student (who must be an American citizen) in the Course in Marine Transportation of the Department of Naval Archi-

tecture and Marine Engineering. Applications should be made directly to the Head of the Department of Naval Architecture and Marine Engineering.

TECHNOLOGY 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 Dean of Students, and restricted "to boys who reside in the area of the club membership."

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. Applications should be made directly to the Head of the Department of Geology.

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 $25,000 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."

HERMAN E. WEIHMILLER FUND (1942). Gift of H. E. Weihmiller of the Class of 1925 in memory of his late father "for aiding students or prospective students of M. I. T., who are deserving of financial aid in furtherance of, or as assistance towards an aeronautical career at M. I. T. . . . without restriction as to sex, creed, color or nationality."

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." Since the donor was an architect, this scholarship, in accordance with the wish of the Executor of the donor's estate, is given, if possible, to a Jewish student in the Department of Architecture.

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 J. 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."

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."

GRADUATE FELLOWSHIPS AND SCHOLARSHIPS

GRADUATE scholarships are awarded only to students pursuing programs leading to higher degrees. Applications from new students must be accompanied by an application for admission to the Graduate School, indicating the Department in which the student desires to major. Except for Institute students, an official transcript of the applicant's college record and at least three letters addressed to the Dean by persons personally acquainted with his academic work are required. Both applications must be made on forms which may be obtained from the Secretary of the Committee on the Graduate School.

Awards to students who have not been in residence at least one term will usually be limited to the amount of full tuition. Fellowships carrying stipends in excess of tuition are, in general, awarded only to students who have demonstrated their ability to carry on graduate study and research in residence.

In the award of graduate scholarships the Committee on the Graduate School considers primarily the ability of the applicant to pursue advanced study and research. Grants are not made unreservedly and their continuance from term to term is dependent on the recipient maintaining a satisfactory standard of scholarship. The recipient of a scholarship grant is expected to complete the period of study for which the grant is made. In case he discontinues his work before the end of such period, he will be expected to refund the amount received from the grant, unless released therefrom for satisfactory reasons by the Committee on the Graduate School.

Correspondence concerning scholarship aid may be addressed to the Dean of the Graduate School or to the Chairman of the appropriate Departmental Committee on Graduate Students.

ASSISTANTSHIPS AND TEACHING FELLOWSHIPS

Assistantships and Teaching Fellowships are staff appointments made upon recommendations of heads of departments to whom applications shall be addressed, at the same time that application for admission to the Graduate School and Application for Scholarship Aid are filed with the Secretary of the Committee on the Graduate School.

A "full time" assistant, if also a graduate student, may register for approximately 17 units per term of work toward an advanced degree; a "half time" assistant or teaching fellow for approximately 25 units per term.

Graduate students on the staff may also apply for financial assistance to the Technology Loan Fund.

FELLOWSHIPS

ALLIED CHEMICAL AND DYE COMPANY FELLOWSHIPS. Two fellowships open to graduate students, one in Chemical Engineering, one in Physical Chemistry or Physics Each stipend, $750 per academic year.

AUSTIN RESEARCH FELLOWSHIP. Open to a graduate student in any department. Stipend, $1,000 per academic year.

WILLIAM SUMNER BOLLES FELLOWSHIP. Open to a graduate student in any department for study in residence or abroad. The stipend may be divided in any year to provide one or more scholarships. Stipend, $900 per academic year.

BRUCE'S JUICES, INC. FELLOWSHIP IN FOOD TECHNOLOGY. Open to a veteran of the present war who is enrolled as a graduate student for the doctorate in Food Technology. Stipend, not to exceed $2,000 per calendar year.

COMPANIA ARGENTINA DE ELECTRICIDAD FELLOWSHIPS. Open to three graduate electrical engineers of Argentina.

CONSOLIDATED VULTEE AIRCRAFT CORPORATION FELLOWSHIPS. Three fellowships open to highly recommended graduates of engineering, metallurgy, chemistry, physics or mathematics, enrolled for graduate study and research in the field of Aeronautical Engineering. Stipends are $750, plus tuition per academic year.

DUPERIAL FELLOWSHIP. Open to a graduate of a college or university of Argentina.

DU PONT FELLOWSHIPS. Stipends $1,000 each, plus tuition per calendar year. One in Chemical Engineering, one in Chemistry, and one in Physics.

RICHARD C. DU PONT MEMORIAL FELLOWSHIP. For a graduate student in the field of Meteorology. Stipend not to exceed $1,200 per academic year.

HARRY WENTWORTH GARDNER FELLOWSHIP. Open to a graduate student in the School of Architecture for advanced study in residence or elsewhere. Not available in 1945–46.

GOODYEAR TIRE & RUBBER COMPANY FELLOWSHIP IN AERONAUTICAL ENGINEERING. Open to a graduate student in Aeronautical Engineering. Stipend $900 plus tuition per academic year.

LEVER BROTHERS FELLOWSHIP IN NUTRITIONAL BIOCHEMISTRY. Stipend not to exceed $1,500 per calendar year.

ARTHUR D. LITTLE FELLOWSHIP. Open to a student enrolled for a doctorate in Chemistry. Stipend, $1,000 per academic year.

ARTHUR D. LITTLE FELLOWSHIP. Open to a student enrolled for a doctorate in Chemical Engineering. Stipend, $1,000 per academic year.

McINTOSH APPLE FUND FELLOWSHIP IN FOOD TECHNOLOBY. Open to a graduate student whose research will be devoted to the properties and uses of McIntosh apples. Stipend, not to exceed $2,000 per calendar year.

MOORE FELLOWSHIP. Open to a graduate of this Institute for study in residence or elsewhere in Chemistry, preference being given to the field of Organic Chemistry. Stipend, $1,100.

NATIONAL RESEARCH CORPORATION FELLOWSHIP. Open to an American graduate student undertaking research in the field of high vacuum. Research shall in general relate to a study or development of new processes performed under free air or gas pressures in the range of 10^{-7}–1 mm. Hg. in the fields of Chemistry, Physics, Metallurgy, Chemical or Mechanical Engineering. Stipend, not exceeding $1,000 per term.

PAINT AND VARNISH PRODUCTION CLUB RESEARCH FELLOWSHIP. For research on the technology of paint and varnish. Stipend, $750 per academic year.

ELLEN H. RICHARDS MEMORIAL FELLOWSHIP. Open to a graduate student, preferably a woman, in the department of chemistry for advanced research in sanitary or allied branches of chemistry. Stipend, $800.

SPERRY GYROSCOPE COMPANY FELLOWSHIP. Open to a graduate student whose major study is related to aeronautical instrumentation or air transportation. Stipend, $1,000 per academic year.

STANDARD OIL COMPANY OF CALIFORNIA FELLOWSHIP. Awarded to an employee of the donor company on leave of absence who is able to qualify for admittance into the Graduate School, whose demonstrated technical ability and other qualifications are such that it is judged that he will benefit by graduate study. Stipend, $1,500.

TEXTILE SCHOOL GRADUATE FELLOWSHIPS. Open to American born graduates of the Lowell Textile School for mechanical engineering or chemical work in textile research. Stipend, $750 per academic year.

S. K. WELLMAN FELLOWSHIP IN POWDER METALLURGY. Open to a graduate student in the Department of Metallurgy. Stipend not to exceed $1,200 plus tuition per calendar year.

GRADUATE SCHOLARSHIPS

AUSTIN FUND. Open to graduate students in all departments, as tuition scholarships not to exceed $600. Available July 1, 1945 through June 30, 1946, $13,500.

CAUCA UNIVERSITY SCHOLARSHIP. Open to an advanced student from Cauca University, Colombia.

F. W. CHANDLER TRAVELING SCHOLARSHIP IN CITY PLANNING. Open to a regular or special student in City Planning who has passed at least two years in the course, of which one must have been either a senior or graduate year, for study and travel in any country. Available, $350.

COLLAMORE SCHOLARSHIP. Open to women graduate students in all departments. May be subdivided. Available, $450.

CHARLES H. DALTON SCHOLARSHIP. Open to an American male graduate of this Institute for advanced chemical study and research — especially if applicable to textile industries. Available, $250.

FRANCES AND WILLIAM EMERSON FUND. Open to graduate students in the School of Architecture, tuition scholarships not to exceed $600 each, upon recommendation of the Dean of Architecture.

WILFRED LEWIS SCHOLARSHIP IN MECHANICAL ENGINEERING. Open to a graduate student in the Department of Mechanical Engineering. Not available in 1945–46.

NATIONAL SCHOOL OF ENGINEERS SCHOLARSHIP. Open to a graduate of the National School of Engineers, Lima, Peru.

HENRY BROMFIELD ROGERS SCHOLARSHIPS. Open to women graduate students in all departments. Tuition scholarships not to exceed $600 each. Available, $800.

HENRY SALTONSTALL SCHOLARSHIP. Open to a graduate student in any department. For exceptional merit, may be increased to not over $750. Stipend, $350.

JAMES SAVAGE SCHOLARSHIP. Open to a graduate student in any department. For exceptional merit, may be increased to not over $750. Stipend, $450.

STAFF GRADUATE SCHOLARSHIPS. Open to graduate students holding staff appointments in all departments. Tuition scholarships.

SUSAN H. SWETT SCHOLARSHIP. Open to a graduate student in any department. Stipend, $350.

FRANK HALL THORP SCHOLARSHIP. Open to a graduate student in industrial chemistry, approved by the department of Chemical Engineering. For exceptional merit, may be increased to not over $750. Stipend, $350.

LOUIS FRANCISCO VERGES SCHOLARSHIP. Open to a graduate student conducting research in the sugar industry. For exceptional merit may be increased to not over $750. Stipend, $350.

WHITNEY FUND. Open to graduate students in all departments, as tuition scholarships not to exceed $300 per term. Available, July 1, 1945 through June 30, 1946, $17,000.

THE TECHNOLOGY LOAN FUND

Graduate students on scholarship or without scholarship aid may apply for financial assistance not to exceed $600 per academic year to the Technology Loan Fund. For further information regarding this Fund address the Chairman of the Technology Loan Fund Board, 3–108, Massachusetts Institute of Technology.

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 first- and second-year men on the basis of essays written on topics announced by the Department of English and History.

CABOT MEDALS (1901). Gift of Samuel Cabot of the Class of 1870, awarded to five members of each first-year class who have shown the greatest physical improvement during the year.

JAMES MEANS MEMORIAL (1925). A medal and monetary prize of $100 offered annually for the best thesis on an aeronautical subject. Joint thesis may be entered and, if successful, duplicate medals will be awarded and the prize divided. Open only to candidates for the Bachelor's degree. (Not offered during the war.)

WILLIAM BARTON ROGERS AWARDS (1937). Monetary prizes to members of the Senior Class who, in the opinion of the Faculty Committee on Undergraduate Scholarships, have demonstrated "outstanding qualities, weight to be given to non-academic or extra-curricular as well as academic accomplishment, and consideration of financial need to be disregarded."

STRATTON (1930). Established by the late President Samuel W. Stratton. Prizes of $50, $30, and $20 awarded for the best presentation of scientific papers by undergraduates, the final competition being held at a public meeting.

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 School 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 (1914). 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. Three prizes of $5 each awarded to students in the third-year class in Architecture for sketch problems.

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 and one prize of $10 awarded in either Course IV-B or IV-C.

FREEHAND DRAWING (1920). Prizes of a book to each of the students whose work is judged to be the best in composition and in life class drawing.

LIBRARY (1931). Awarded to the second-year student receiving the highest award on a designated project.

ROTCH (1895). Gift of Arthur Rotch. Two prizes of $200 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.

SCHOOL OF ARCHITECTURE MEDALS (1922). A bronze medal of the School awarded at the end of the academic year to the winner of each prize, and also to students in the fifth and graduate years with the highest number of "medal" values.

STUDENT MEDAL OF THE AMERICAN INSTITUTE OF ARCHITECTS (1914). Awarded on the recommendation of the School to the member of the fifth-year class whose record for the Course is the best.

SUMMER SKETCHING (1921). For the best set of outdoor summer sketches in pencil or pen and ink or measured drawings, and for the best set of outdoor summer sketches in water colors or wash; prizes of a book to each.

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). In memory of the founder of the School, prizes totalling $50 for week-end conjunctive problems with Harvard and the Boston Architectural Club.

H. LANGFORD WARREN (1923). In memory of Professor Warren, prizes totalling $50 for week-end conjunctive problems with Harvard and the Boston Architectural Club.

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 $50 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.

APPENDIX B

DIRECTORY OF HONORARY SECRETARIES

THE Honorary Secretaries listed below are alumni "Ambassadors of Technology" in communities throughout the United States and in selected foreign centers. Prospective applicants for admission to the First-Year Class, living more than 100 miles from Cambridge, are referred to the nearest Honorary Secretary for a conference as a part of the required entrance procedure.

The Honorary Secretary is not expected to be a source of detailed information on entrance requirements, credits and the like, nor does he make, on behalf of the Institute, commitments regarding admission or the award of scholarships. All such matters should be taken up directly with the proper officers of the Institute. The function of the Honorary Secretary is to advise the student regarding his educational program and objectives, and to assist the Admissions Office in the selection of the limited number of applicants accepted each year in the entering class.

Students wishing to enter with advanced standing, or as members of the graduate school, are likewise encouraged to confer with the nearest Honorary Secretary, but are not required to do so.

ALABAMA:
Birmingham. Douglas F. Elliott, '24, Alabama Power Co., 600 N. 18th St.

ARIZONA:
Phoenix. Charles F. Willis, '06, *The Mining Journal,* 520 Title and Trust Bldg.

CALIFORNIA:
Los Angeles. Kenneth C. Kingsley, '23, Norris Stamping and Mfg. Co., 5215 S. Boyle Ave.
Charles H. Toll, Jr., '23, U. S. Steel Products Co., 5100 Santa Fe Ave.
San Francisco. Richard L. Cheney, '27, Food Container Co., 405 Montgomery St.

COLORADO:
Denver. Alfred E. Perlman, '23, Chief Engineer, Denver & Rio Grande Western R. R., Rio Grande Bldg., 1531 Stout St.

CONNECTICUT:
Bridgeport. Edward L. Wemple, '34, 939 Barnum Ave.
Hartford. James A. Burbank, '16, The Travelers Insurance Co., 700 Main St.
Thomas D. Green, '26, 38 Montclair Dr., W. Hartford.
New Haven. Albert S. Redway, '23, The Geometric Tool Co., Blake and Valley Sts.
Waterbury. Harold G. Manning, '12, The Post College Bldg., 24 Central Ave.

DELAWARE:
Wilmington. Willis F. Harrington, '05, E. I. du Pont de Nemours & Co., du Pont Bldg.

DISTRICT OF COLUMBIA:
Washington.
J. Y. Houghton, '26, Department of Justice.
William K. MacMahon, '22, Rosslyn Gas Co., 3240 Wilson Blvd., Arlington, Va.
Edward D. Merrill, '09, Capital Transit Co., 36th and M Sts., N.W.
George D. Mock, '28, Washington Gas Light Co., 1100 29th St., N.W.
Robert K. Thulman, '22, Federal Housing Administration, 1001 Vermont Ave., N.W.

FLORIDA:
Jacksonville. George W. Simons, Jr., '15, Hildebrandt Bldg.
Miami. B. Howard Brown, '30, 70 S. W. 27th Rd.
Tampa. Franklin O. Adams, '07, 305 Morgan St.

GEORGIA:
Atlanta. William E. Huger, '22, Courts & Co., 11 Marietta St., N.W.

ILLINOIS:
Chicago. L. H. G. Bouscaren, '04, Stone & Webster, 33 S. Clark St.
Edmund G. Farrand, '21, United Conveyor Corp., 1200 Old Colony Bldg.
Lonsdale Green, '87, 5639 Kenwood Ave.
J. Sherry O'Brien, '17, Harvey Metal Corp., 74th St. and Ashland Ave.
Ralph Sargent, '18, Sargent & Lundy, 140 S. Dearborn St.
Dixon. William C. Steinwedell, '25, Green River Ordnance Plant, Stewart-Warner Corp.
Rockford. Arthur B. Brand, '26, Cummings, Brand & McPherson Advertising, 716 Gas-Electric Bldg.

INDIANA:
Fort Wayne. Frederick P. Feustel, '33, City Light and Water Utilities, 308 E. Berry St.
Indianapolis. Howard S. Morse, '03, Indianapolis Water Co., 113 Monument Circle.

IOWA:
Des Moines. Harold C. Neumann, '17, Arthur H. Neumann & Bros., Inc., Hubbell Bldg.
Dubuque. Richard V. McKay, '06, Key City Gas Co., 669 Main St.

KENTUCKY:
Louisville. Frank D. Rash, '01, 55 Hill Rd., "Castlewood."

LOUISIANA:
New Orleans. Theo. O. Hotard, '12, Orleans Parish School Board, 703 Carondelet St.

MAINE:
Augusta. Willard B. Purinton, '22, Purinton Brothers Co., 333 Water St.
Bangor. Carl E. Danforth, '05, 164 Leighton St.
Portland. Stanley W. Hyde, '17, Prin., N. Yarmouth Academy, Yarmouth.

MARYLAND:
Baltimore. George W. Spaulding, '21, 1605 Lexington Bldg.

MICHIGAN:
Detroit. Charles T. Ellis, '17, 1377 Harvard Rd., Grosse Pointe Park.
Allyne C. Litchfield, '17, U. S. Rubber Products, Inc., 6600 E. Jefferson Ave.

MINNESOTA:
Duluth. William C. Lounsbury, '03, Minnesota Power and Light Co.
Minneapolis. Willis R. Salisbury, '12, Salisbury & Satterlee Co.
St. Paul. Winter Dean, '21, Nicols, Dean & Gregg.

MISSOURI:
Kansas City. James C. Irwin, Jr., '18, U. S. Cold Storage Corp., 500 E. Third St.
St. Louis. Delos G. Haynes, '09, 818 Olive St.
Philip E. Morrill, '14, Bemis Bro. Bag Co., 408 Pine St.

MONTANA:
Butte. William A. Kemper, '04, 118 W. Broadway.
Great Falls. Earl S. Bardwell, '06, 18 Smelter Hill.

NEBRASKA:
Omaha. Louis A. Metz, '23, Ceco Steel Products Corp., 1141 N. 11th St.

NEW HAMPSHIRE:
Concord. Leigh Spaulding Hall, '14, Hall Brothers Co., 31 S. Main St.

NEW JERSEY:

Atlantic City. Harold I. Eaton, '09, Eastern Engineering Co., 4 N. North Carolina Ave.
Bloomfield. Carole A. Clarke, '21, 215 Linden Ave., Glen Ridge.
Camden. Robert E. Worden, '36, Campbell Soup Co., Second and Market Sts.
Dover. Howard B. Allen, '18, New Jersey Power and Light Co., 9 W. Blackwell St.
East Orange. Harold McCready, '09, 130 S. Munn Ave.
Elizabeth. Donald D. Way, '19, 226 Wychwood Rd., Westfield.
Glen Ridge. Stewart C. Coey, '06, 39 Wildwood Ter.
Hackensack. Harold H. Brackett, '12, 515 Summit Ave., Oradell.
Irvington. William J. Grady, '22, 26 N. Crescent, Maplewood.
Jersey City. Edwin S. Lockwood, '21, Public Service Electric and Gas Co., 325 Palisade Ave.
Kearny. Dr. Robert V. Townend, '14, 101 Seeley Ave., Arlington.
Manasquan. Munroe C. Hawes, '21, 111 Union Ave.
Maplewood. Gordon G. Holbrook, '10, 9 Beach St.
Millburn. A. Raymond Brooks, '17, Wayside, Brantwood, Short Hills.
Montclair. Livingston P. Ferris, '11, 11 Bellevue Ave., Upper Montclair.
Morristown. Everett W. Vilett, '22, 91 Whitney Rd., Short Hills.
Newark. Henry C. Colson, Jr., '09, Carnrick Co., 20 Mt. Pleasant Ave.
Orange. Frank Maguire, '17, 201 Vose Ave., S. Orange.
Passaic. Frank L. P .dley, '20, Forstmann Woolen Co.
Paterson. Edmund J. Thimme, '23, Valley View Ter., Packanack Lake.
Plainfield. Geoffrey M. Rollason, '13, Aluminum Co. of America, Garwood.
Ridgewood. Herman A. Affel, '14, 827 Morningside Rd.
Rutherford. Newton S. Foster, '28, 15 E. Pierrepont Ave.
South Orange. Alfred I. Phillips, Jr., '10, 211 Lenox Ave.
Summit. Winfield I. McNeill, '17, 14 Hillcrest Ave.
Trenton. Thomas H. Gill, '22, 9 Stuart Ave., Hillwood Lakes.
Westfield. Lyman L. Tremaine, '23, 422 Baker Ave.

NEW YORK:

Albany. Burt R. Rickards, '99, State Department of Health.
Binghamton. Irving K. Peck, '21, Binghamton Gas Works, 267 Court St.
Buffalo. Whitworth Ferguson, '22, Ferguson Electric Construction Co., 204 Oak St.
Marvine Gorham, '93, 420 Jackson Bldg.
Hudson. Robert A. Schmucker, '15, 545 Union St.
Newburgh. Thomas C. Desmond, '09, 94 Broadway.
New York City. William J. Barrett, '16, Metropolitan Life Insurance Co.
C. George Dandrow, '22, Johns-Manville Co., 22 E. 40th St.
Laurence B. Davis, '22, Socony-Vacuum Oil Co., Inc., 26 Broadway.
Charles P. Fiske, '14, General Motors Acceptance Corp., 1775 Broadway.
Saxton W. Fletcher, '18, J. O. Ross Eng. Corp., 350 Madison Ave.
Alfred T. Glassett, '20, W. J. Barney Corp., 101 Park Ave.
Laurence C. Hart, '13, Johns-Manville Co., 22 E. 40th St.
Irving D. Jakobson, '21, Jakobson Shipyard, Inc., West End Ave., Oyster Bay, L. I.
William T. Kniesner, '16, Room 2800, Commerce Bldg., 155 E. 44th St.
Charles C. Ladd, '30, Blair, Curtis & Hayward, 60 E. 42d St.
William H. Latham, '26, Director of Maintenance and Operation, Arsenal Bldg., 5th Ave. and 64th St.
Duncan R. Linsley, '22, First Boston Corp., 100 Broadway.
James A. Lyles, '27, Vice-President, First Boston Corp., 100 Broadway.
William H. Mueser, '22, Moran, Proctor, Freeman, and Mueser, 420 Lexington Ave.
John J. Murphy, '23, Linde Air Products Co., 30 E. 42d St.
Kenneth Reid, '18, Editor, *Pencil Points*, 330 W. 42d St.
Raymond C. Rundlett, '22, Curtis Publishing Co., 60 E. 42d St.
Robert P. Shaw, '23, N. Y. Museum of Science and Industry, R. C. A. Bldg., 30 Rockefeller Plaza.
Poughkeepsie. George T. Welch, '21, Comptroller, Vassar College.
Rochester. John F. Ancona, '03, 311 Hiram Sibley Bldg., 316 Alexander St.
Rome. Richard A. Wilkins, '18, Revere Copper and Brass, Inc.
Schenectady. Ralph C. Robinson, '01, Vacuum Tube Dept., Bldg. 37, General Electric Co.
Syracuse. Frederick W. Barker, '12, First Trust & Deposit Co., 201 S. Warren St.
Edwin A. Gruppe, '22, Central N. Y. Power Corp., 300 Erie Blvd., West.
Utica. Carl H. Anderson, '27, 280 Genesee St.

NORTH CAROLINA:

Charlotte. Beaumert Whitton, '33, Southeastern Construction Co., 218 W. Second St.

OHIO:

Akron. Parry Keller, '15, Goodyear Tire and Rubber Co.
Cincinnati. Stuart R. Miller, '07, William S. Merrell Co., Lockland Station.
Cleveland. Howard P. Ferguson, '27, Standard Oil Co., Room 1754, Midland Bldg.
William C. Sessions, '26, Bosworth & Sessions, 1337 Guardian Bldg.
Henry G. Steinbrenner, '27, Kinsman Transit Co., 706 Rockefeller Bldg.
Columbus. Clarence E. Richards, '18, American Education Press, Inc., 400 S. Front St.
Dayton. Michael J. Gibbons, '06, 116 Thruston Blvd.
Toledo. Herbert A. Barnby, '23, Owens-Illinois Glass Co.
Youngstown. James L. Wick, '06, Falcon Bronze Co., 218 S. Phelps St.

OKLAHOMA:

Oklahoma City. Charles B. Stuart, '34, 812 N. W. 39th St.
Tulsa. William J. Sherry, '21, 804 Kennedy Bldg.

OREGON:

Portland. Ernest B. MacNaughton, '02, First National Bank.
A. Glenn Stanton, '21, Railway Exchange Bldg.

PENNSYLVANIA:

Bethlehem. Charles H. Herty, Jr., '21, Bethlehem Steel Co.
Erie. John L. Parsons, '17, Hammermill Paper Co.
Harrisburg. Percy E. Tillson, '06, Bell Telephone Co. of Pennsylvania, 210 Pine St.
Lancaster. Charles K. Miller, '23, Armstrong Cork Co.
Philadelphia. Philip M. Alden, '22, Philadelphia Electric Co., 1000 Chestnut St.
H. W. Anderson, '15, Fidelity Machine Co., 3908 Frankford Ave.
Greville Haslam, '15, Episcopal Academy, Overbrook.
Henry W. Jones, '26, Atlantic Refining Co., 260 S. Broad St.
Pittsburgh. Charles M. Boardman, '25, Duquesne Light Co., 435 Sixth Ave.
Thomas Spooner, '09, Manager, Central Eng. Labs. and Stds. Dept., Westinghouse Elec. and Mfg. Co., E. Pittsburgh.
Reading. Allyn C. Taylor, '06, Consumers Gas Co., 441 Penn St.
Scranton. *Robert K. Moore, Jr., '34, 1703 Madison Ave.

SOUTH CAROLINA:

Charleston. James F. Crist, '24, South Carolina Power Co.

TENNESSEE:

Chattanooga. Richard S. Bicknell, '10, 1516 Sunset Rd., N. Chattanooga.
Knoxville. Van Court M. Hare, '23, 605 Union Bldg.
Memphis. C. W. Loomis, '16, Bemis Bro. Bag Co., P. O. Box 2566, De Soto Station.
Harry Webb, '09, Monteagle S. S. Assembly, Monteagle.
Nashville. Donald W. Southgate, '11, Nashville Trust Bldg.

TEXAS:

Dallas. Jonathan A. Noyes, '12, Sullivan Machinery Co., 1914 Commerce St.
El Paso. Charles I. Auer, '01, 902 Park Rd.

*Inactive.

Fort Worth. Count B. Capps, '20, W. B. Fishburn Cleaners Inc., 1212 Main St.
Houston. George B. Forristall, '11, 10002 S. Main St., P. O. Box 112.
San Antonio. Terrell Bartlett, '06, The Terrell Bartlett Engineers, 2700 Transit Tower.

UTAH:
Salt Lake City. George M. Gadsby, '09, Utah Power and Light Co., Kearns Bldg.

VERMONT:
Rutland. Birney C. Batcheller, '86, Wallingford.

VIRGINIA:
Lynchburg. Edward R. Harris, '25, The Mead Corp.
Norfolk. Chas. W. Johnston, '05, 214 Broad St., Portsmouth.
Richmond. Donald N. Frazier, '11, American Mutual Liability Insurance Co., 1223 Mutual Bldg.

WASHINGTON:
Seattle. H. W. McCurdy, '22, Puget Sound Bridge and Dredging Co., 2929 16th Ave., S.W.
Spokane. Edward E. Scofield, '19, Washington Water Power Co.

WEST VIRGINIA:
Charleston. William S. Brackett, '23, Carbide and Carbon Chemicals Corp., S. Charleston.

WISCONSIN:
Milwaukee. Philip N. Cristal, '17, Northwestern Mutual Life Insurance Co.
Mitchell Mackie, '05, Central Office Bldgs., Inc., 207 E. Michigan St.

U. S. TERRITORIES AND DEPENDENCIES

CANAL ZONE:
Balboa Heights. Meade Bolton, '16, Box 23.

HAWAII:
Honolulu. William C. Furer, '06, 1909 Aleo Pl.

FOREIGN COUNTRIES

ARGENTINA:
Buenos Aires. Jose Carlos Bertino, '23, Central Naval, Florida 801.
Herman F. Krantz, '28, Otis Elevator Co., Avenida Leandro N. Alem 1616.

AUSTRALIA:
Melbourne. Col. Lionel H. Lemaire, '13, Chief Inspector Army, L.H.Q., Victoria Barracks, Melbourne S. C. 1.

BRAZIL:
Rio de Janeiro. Alexandre H. Leal, '35, Cia Carris, Luz e Forca, Avenida Marechal Floriano 168.

CANADA:
Montreal, Que. Augustin Frigon, '11, Manager, Canadian Broadcasting Corp., 1440 St. Catherine St.
A. D. Ross, '22, A. D. Ross and Co., Room 413, 680 Sherbrooke St. West.
St. John, N. B. H. Usher Miller, '09, P. O. Box 796.
Toronto, Ont. John S. Keenan, '23, 29 Rosedale Heights Drive.
Winnipeg, Man. Richard C. Hugga.d, '30, Huggard & Moncrieff, Ltd., 1 Somerset Bldg.

CUBA:
Havana. Frank Sheldon, '40, Ruston Academy.

ENGLAND:
London. David A. Shepard, '26, 36 Queen Anne's Gate, Westminster, London S.W. 1.

INDIA:
Bombay. William F. Rivers, '26, c/o Standard-Vacuum Oil Co., P. O. Box 355.

MEXICO:
Mexico City. George D. Camp, '16, Apartado 1005.

PERU:
Lima. Commander Charles Hibbard, '09, Mision Naval Americana, Ministerio de Marina.

SALVADOR, C. A.
San Salvador. Ernesto de Sola, '33.

SWITZERLAND:
Zürich. Werner Schoop, '22, c/o Oelheizungs Ag. Flexflam, Splügenstr. 11.

APPENDIX C

STUDENT HOUSING

EFFECTIVE JULY 1, 1945 (*Subject to Change*)

THE houses of the undergraduate dormitories are available for occupancy upon application in accordance with the following memorandum which gives a summary of prewar dormitory policy, amended to conform to present circumstances. It is expected dormitory accommodations will be available in the future without interruption. The following information is effective, however, as of July 1, 1945, and subject to change.

The student housing facilities provided at the Massachusetts Institute of Technology have been carefully planned and organized to afford an economical, comfortable place in which to live, an environment conducive to study and an opportunity to participate in those social and extra-curricular activities which properly supplement scholastic work.

GOVERNMENT

The senior and undergraduate houses are administered as a part of the general plan of student self-government at the Massachusetts Institute of Technology, with the coöperation of the Dormitory Board, appointed by the President and acting in an advisory capacity. The student dormitory committee organizes and supervises all activities, athletic and social, and coöperates with all recognized undergraduate activities at the Institute.

The success of student self-government in the dormitories depends upon the willingness of every resident to coöperate and contribute, and therefore upon the responsibility 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 Committee and the Dormitory Board. The privilege of residence in the dormitories will therefore be denied to those who do not accept this responsibility.

THE GRADUATE HOUSE

The Graduate House, located at Memorial Drive and Massachusetts Avenue, Cambridge, directly across the Avenue from the main educational group, is being used exclusively by students of the United States Armed Services and is not available to civilian graduate students.

THE SENIOR HOUSE

(*Temporary Graduate House*)

WARE, ATKINSON, RUNKLE, HOLMAN, NICHOLS, AND CRAFTS

The Senior House, located on Memorial Drive, east of Walker Memorial and near the President's House, has been completely reconditioned and is available as a temporary Graduate House. Accommodations are available for two hundred and six registered male students. The term "registered student" includes part-time or full-time graduate students, junior staff members and research workers taking substantial academic work for credit toward a degree, and Navy and Army officers whose assignment to M. I. T. is primarily for study.

The first floor rooms in all the halls except Crafts and Ware are designed for single occupancy. On the upper floors most of the quarters are suites, comprising a living room, a dressing room, and a sleeping room arranged for two students. Some of the suites accommodate three men. All rooms are equipped for immediate occupancy.

THE UNDERGRADUATE HOUSES

MUNROE, HAYDEN, WOOD, GOODALE, BEMIS, WALCOTT
FOR CIVILIAN UNDERGRADUATE STUDENTS

The six halls are situated on the main campus near Walker Memorial. They have accommodations for four hundred and nineteen men. Most of the rooms are for single occupancy — some interconnecting — 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 hall.

EQUIPMENT AND SERVICE

All the rooms in all the dormitory units at the Massachusetts Institute of Technology are *fully equipped for occupancy*, and additions by students are not permitted. All single rooms are equipped with a special bed or couch, all hair innerspring mattress with cover, pillow, bedspread, blankets, chiffonier, desk and chair, study chair, bookcase, rug, draperies, desk lamp, waste basket, light bulbs, extra electrical outlets, and interconnecting telephone. Double and triple suites are furnished in a manner similar to the single rooms, but in addition have study tables. Bed linen and towels are furnished and replaced regularly by porters who make up and clean the rooms each weekday.

In addition to space, the rental includes heat, light, continuous hot and cold water, intercommunicating telephone service, porter service, soap, towel and linen supply and laundry service for bed linen and towels. The dormitory buildings are of first-class construction and are fire proof. Steam heat is available throughout the year, day and night. The house service is directly in charge of the manager and is maintained by experienced porters. A representative of the Institute is on the premises day and night.

RENTAL AND OCCUPANCY

The standard rental for accommodations in all the undergraduate and senior houses is $105 per person per academic term, approximately $6 a week, payable in advance. This policy has been adopted as a war emergency and is subject to change. The majority of the rooms in Munroe, Hayden, Wood, Goodale, Bemis and Walcott are similar; there are differences in location, exposure, size of rooms, and so forth, in the Senior House, but the facilities, equipment, and service are standard throughout the dormitory system.

The period of occupancy for any academic term is from the Wednesday preceding Registration Day (Monday) through the Tuesday following the last day of the scheduled examination period. (See official M. I. T. calendar.)

APPLICATIONS AND RESERVATIONS

Applications for rooms must be accompanied by a deposit of $5, check made payable to D. L. Rhind, Bursar, forwarded to Mr. Henry K. Dow, Manager of the Undergraduate Dormitories, Massachusetts Institute of Technology, 3 Ames Street, Cambridge 39, Massachusetts. Applications will be accepted only from those who have been notified of their admission by the Director of Admissions and will be filed in order by date as received. Preference in the assignment of rooms will be in order from this list.

Notification of an assignment will be forwarded to successful applicants and a definite reservation made about thirty days prior to the opening of the term. The reservation and the $5 application fee entitle the applicant to occupy a room in the dormitories from the Wednesday preceding the date established for the opening of the term to 4 p.m. on Registration Day. The applicant must, however, appear in person at the Dormitory Office on Registration Day and extend the reservation by payment of the

balance of the rent ($100), which entitles him to occupancy until the Tuesday following the last day of the scheduled examination period for that term; otherwise, the reservation is automatically cancelled and the room made available to an applicant from the waiting list. The dormitory rental due on Registration Day should not be sent in advance nor included with other payments which are made directly to the Bursar.

Reservations may, however, be cancelled up to the Wednesday preceding Registration Day upon written notice to the Manager of the dormitories, and the application fee of $5 refunded in full.

The names of unsuccessful applicants remain on a waiting list and assignments are made as rooms become available. Due to the privilege in the cancellation of dormitory reservations extended to those who affiliate with recognized fraternities, a number of rooms become available for occupancy at the beginning of the term. Applicants on the waiting list should, therefore, report in person to the Dormitory Office (rear of Walker Memorial) on arrival, to apply for immediate assignment to rooms released by cancellation, to be assigned to temporary quarters in the dormitories pending the release of accommodations on Registration Day or thereafter, or to withdraw their names from the waiting list if accommodations have been secured elsewhere. Applicants who withdraw their names from the waiting list by 4 p.m. on Registration Day will be refunded the application fee of $5. The refund of $5 will be made directly to the applicant regardless of the source of the application fee.

ALLOTMENT OF ROOMS

The assignment of rooms by the Dormitory Board will be in order of application but the Board reserves the right to reject any applicant for sufficient reason. Priority in the assignment of rooms, except those especially reserved for entering first-year students, is granted to students in residence. Application forms for the next regular term will be distributed to residents about thirty days prior to the end of a term and must be returned to the Manager of the dormitories accompanied by a reservation fee of $5, check payable to D. L. Rhind, Bursar. Assignments will be made to these applicants immediately and a definite reservation made. The number of single rooms reserved for first-year students will vary from term to term depending upon circumstances, and a list will be available to residents at the time the application forms are distributed.

FRATERNITY AFFILIATION

The "recognized list" of fraternities at the Massachusetts Institute of Technology includes twenty or more chapters whose houses are situated on private property in Cambridge, Boston, and Brookline. Residence in the dormitories or fraternities offers advantages over local apartment and rooming houses in that the former provide a more intimate contact with Technology life and activities. Approximately ninety per cent of the new fraternity men are pledged prior to the end of the first week of the academic year, and in order that they may assume residence at the fraternity house of their choice immediately and thereby release accommodations to those on the waiting list who prefer residence in the dormitories, privileges in the cancellation of dormitory reservations are extended to those who make a decision on or before Registration Day. Parents who anticipate fraternity affiliation for their sons should, if possible, grant them permission to act on their own initiative. The satisfactory housing of a large group of entering students under present conditions can be accomplished only through the coöperation of parents, students, and fraternity and dormitory representatives in making early and prompt decisions so that temporary housing is reduced to a minimum. Students are therefore requested to withdraw applications for dormitory residence promptly if they are certain that such accommodations will not be required.

REFUNDS

Reservations are automatically cancelled upon withdrawal of a student from the Institute or transfer to a coöperative course, and a proportionate refund on a basis of $6 a week allowed.

Residents of the dormitories who desire to move to recognized fraternity houses after Registration Day and prior to the following Monday, and whose transfer is requested by authorized representatives of the fraternity, will be refunded the rental fee of $100 less a charge of $1 a day of occupancy less $10. If, however, another student is available on the waiting list to assume occupancy immediately, the charge of $10 will not be made.

Students, except transfers to fraternities, who desire to move from the dormitories prior to the Monday following Registration Day and who do not contemplate leaving the Institute, will be refunded the rental fee of $100 less a charge of $1 a day for occupancy, less $10.

Students who desire to move from the dormitories after the Monday following Registration Day, and who do not contemplate leaving the Institute will be refunded the rental fee of $100 less a charge of $1 a day for occupancy, less $25.

The student is not allowed, under any circumstances, to sublet or transfer his room or his share in a room, without the consent of the Dormitory Board.

REGULATIONS AND GENERAL INFORMATION

Key Deposits and Refund. A deposit of $1 is required for room and mail-box keys, subject to refund in full when returned.

Laundry and Valet Service. Laundry service is on a cash basis. Laundry bags, slips and tags are available at the office desk. Notification of return of laundry will be through the mail boxes. Laundry service one week, valet service four days. Prices reasonable.

Telephone and Western Union Service. Long-distance and local calls received through the dormitory switchboard will be relayed through telephones located on each floor. Intercommunicating and Institute service is available through the room telephones. Western Union messages may be sent from the office. *Telephone number is Kirkland 5300.*

Porter Service. Available Monday through Saturday only. Sunday porter service is limited under present conditions to cases of emergency only. Residents are required to care for their rooms on Sundays.

Visitors. The dormitories are for men only, and persons of the opposite sex are not permitted in the rooms or buildings, except the dormitory office, and the Burton Room, Munroe Hall. The use of liquor and the preparation of meals or cooking of any kind on the premises are prohibited. Violations of these regulations will result in the cancellation of room assignments.

Dining Service. Dining facilities are in the Walker Memorial, headquarters of student activities, adjacent to the dormitories, on a cafeteria basis. No board by the day or week is furnished, and no student is required to use this service. Because of the low cost and the excellent facilities, however, about 2000 meals a day are served. Under wartime conditions, the dining service operates six days a week. A sandwich and soda bar is, however, available seven days a week and there are suitable dining facilities in the vicinity which are open on Sundays.

Storage. Space is available in the basement for trunks and baggage at the owner's risk. The Institute assumes no liability, and articles must be removed when occupancy is cancelled. No boxes or trunks will be permitted in the rooms.

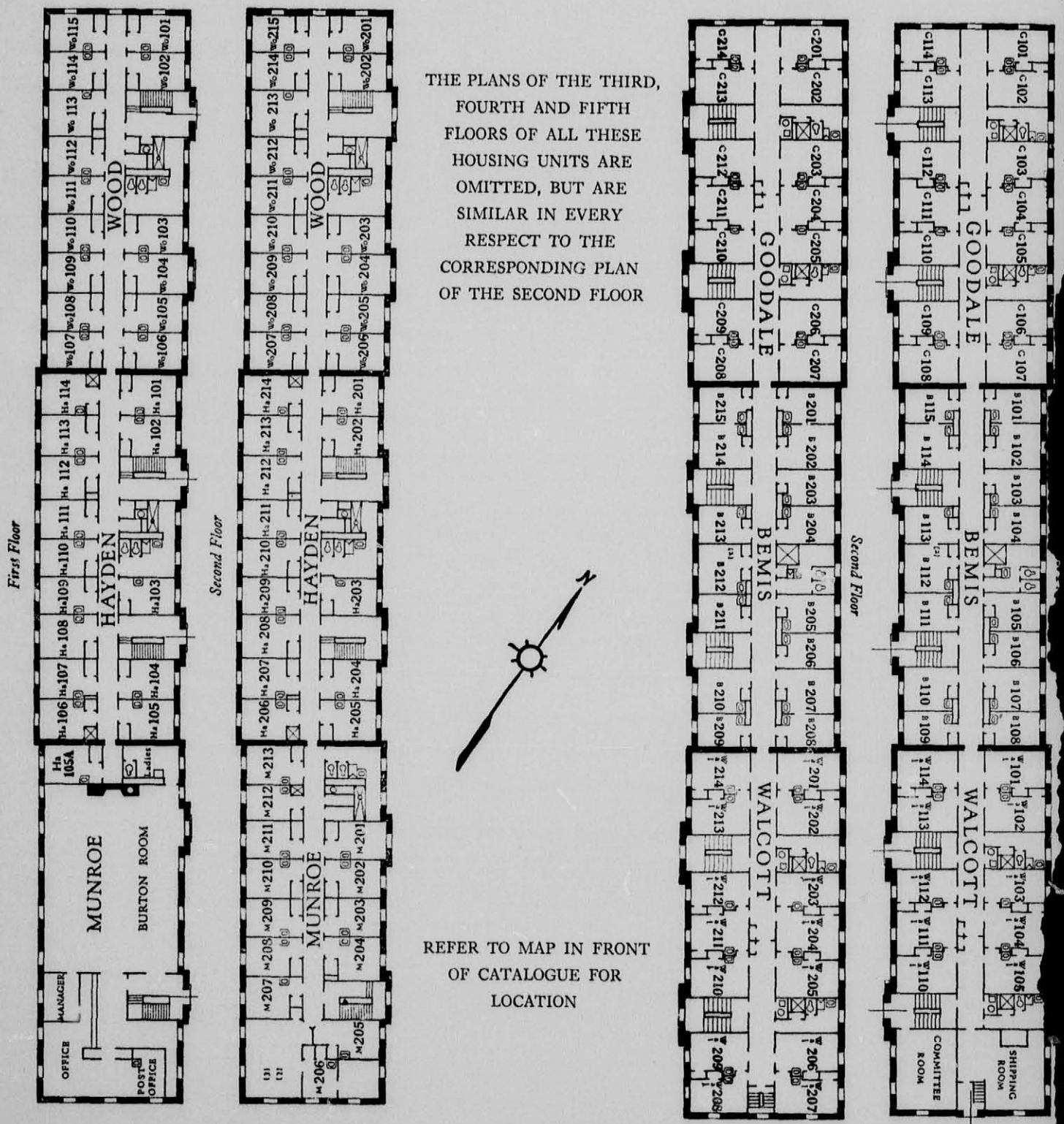
Mail and Express. Packages and mail should be addressed to Massachusetts Institute of Technology Dormitories, 3 Ames Street, Cambridge 39, Mass.

INQUIRIES

Address correspondence to Mr. Henry K. Dow, Manager of the Dormitories, Massachusetts Institute of Technology Dormitories, 3 Ames Street, Cambridge 39, Massachusetts. Telephone: Kirkland 5300, or Kirkland 6900 Extension 437.

UNDERGRADUATE HOUSES

MUNROE HAYDEN WOOD GOODALE BEMIS WALCOTT

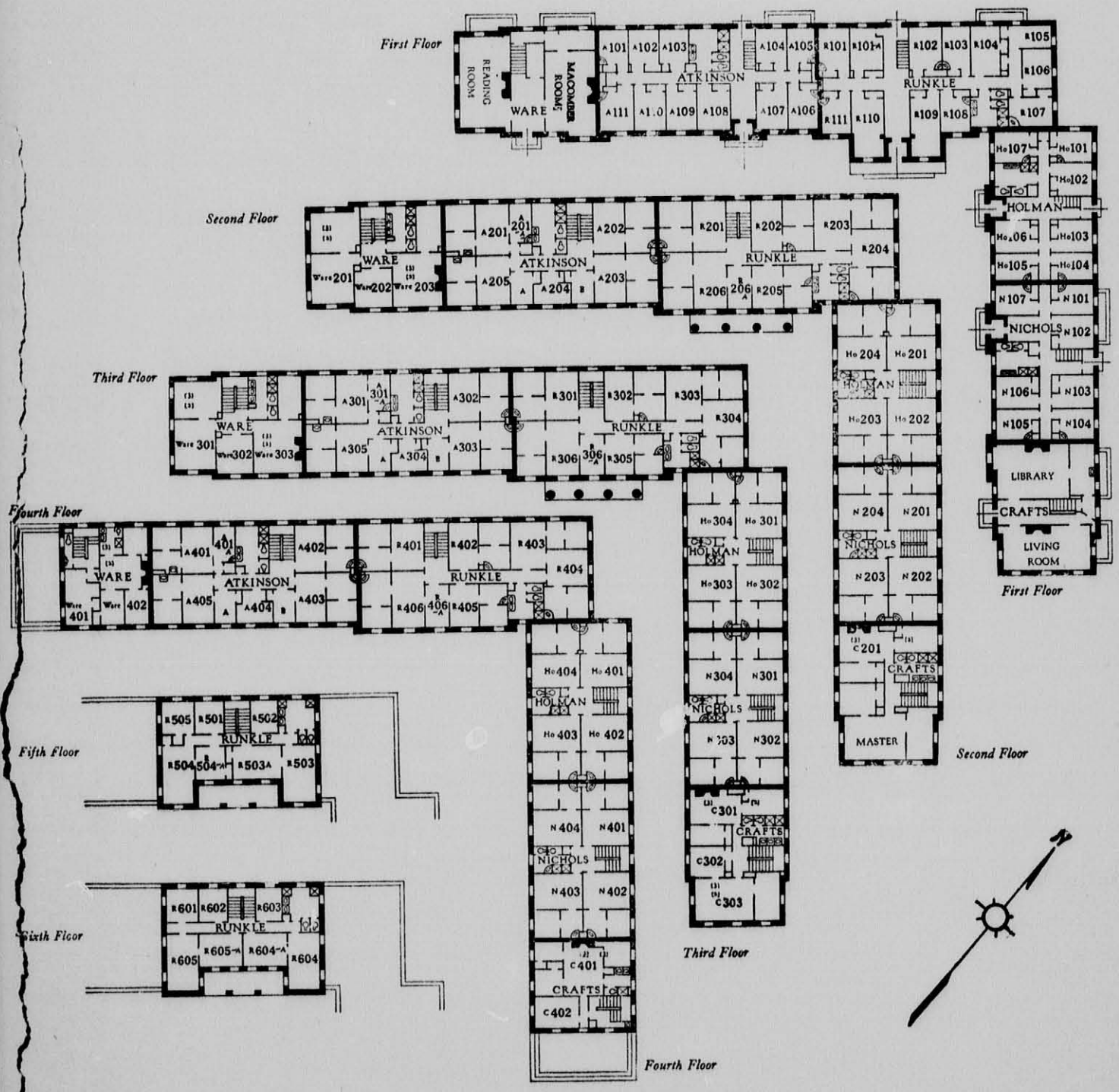


THE PLANS OF THE THIRD, FOURTH AND FIFTH FLOORS OF ALL THESE HOUSING UNITS ARE OMITTED, BUT ARE SIMILAR IN EVERY RESPECT TO THE CORRESPONDING PLAN OF THE SECOND FLOOR

REFER TO MAP IN FRONT OF CATALOGUE FOR LOCATION

SENIOR HOUSE

WARE ATKINSON RUNKLE
HOLMAN NICHOLS CRAFTS



INDEX TO SUBJECTS OF INSTRUCTION

(With reference to pages containing description)

Subjects	Page
Absorption and Extraction	103
Absorption, Distillation and	103
Accounting	110
Accounting Control, Problems in	110
Accounting, Industrial	110
Accounting Policy, Problems in	110
Acoustics, Architectural	101
Acoustics, Experimental	101
Acoustics, Special Problems in	101
Administrative Theory and Practice	111
Aerodynamic Laboratory	113
Aerodynamics	111, 112, 113
Aerodynamics, Applied	112
Aeromechanics, Advanced Topics in	112
Aeronautical and Meteorological Instruments, Special Problems in	113
Aeronautical and Production Engineering	113
Aeronautical Engineering	113
Aeronautical Mechanics	111
Aeronautical Problems, Advanced	113
Aeronautics	113
Air Conditioning	87
Aircraft, Construction Details of	113
Aircraft Electrical Systems and Machines	98
Aircraft Instruments	113
Aircraft Propeller Design	113
Aircraft, Rotating Wing	113
Aircraft Structures	112
Airplane Design	112
Airplane Design Practice	112
Airplane Design Problems	112
Airplane Engine Design, Advanced	113
Airplane Performance	112
Airplane Stability and Control	112
Airport Design	82
Airports, Highways and	82
Algebra, Entrance	119
Algebra, Modern	120
Alloys, Atomic Arrangements in	90
Alloys, Corrosion and Heat Resisting	90
Alloys, Industrial Non-Ferrous	90
Alternating-Current Machinery, Advanced	97
American Government	116
Amino Acids and Proteins	93
Analysis	120
Anatomy, Comparative	99
Antennas and Propagation, Radio Lines	98
Architectural Design	92
Architectural Illumination	91
Architecture, History of	91
Armament, Protection and	107
Art, European Civilization and	91
Astronomy, Engineering	81
Atmosphere, Elementary Physics of	109
Atmosphere, Thermodynamics of the	109
Atomic Arrangements in Alloys	90
Atomic Physics in Electrical Engineering, Applications of	98
Atomic Structure	102
Atomic Structure Laboratory	102
Automotive Dynamics	88
Automotive Fuels	104
Bacteria, Biology of	100
Bacteriological Examination of Water and Sewage	84
Bacteriology	100
Bacteriology, Advanced Sanitary	84
Bacteriology of Foods	100
Ballistics, Theory of Interior	103
Banking and Finance	115
Banking, Money and	115
Basic Mechanics	84
Biochemistry	100
Biochemistry of Micro-organisms	100
Biography, Seminar in	118
Biological Materials, Spectroscopy of	100
Biology, General	99
Biology of Bacteria	100
Biology, Instrumentation in	101
Biology, Selected Topics in	101
Biophysics	100
Biophysics Laboratory	101
Bridge Design	82
Building Construction	113, 114
Building Economics	116
Building Materials, Special Problems in	114
Buildings, Electrical Equipment of	96
Business Administration, Seminar in	111
Business Cycles	115
Business Management, Introduction to	109
Calculus	119
Calculus for Engineers, Advanced	119
Calculus of Variations	120
Calculus, Tensor	120
Carbohydrates	93
Cargo Handling and Stowage	108
Catalysis and High Pressure Processes	104
Ceramic Processes, Fundamental	90
Ceramic Products, Physical Properties of	90
Ceramics	90
Ceramics, Optical	90
Ceramics, Special Problems in	90
Characteristic Value Problems	120
Chemical Engineering	103
Chemical Engineering Design	103
Chemical Engineering Practice, School of	104
Chemical Engineering Processes, Analytical Treatment of	103
Chemical Engineering, Seminar in	104
Chemical Engineering Thermodynamics	103
Chemical Industry, Economic Balance in	104
Chemical Reactions, Kinetics of	94
Chemical Thermodynamics	94
Chemical Thermodynamics, Applied	104
Chemistry	92
Chemistry, Analytical	93
Chemistry, Applied	93
Chemistry, Applied Colloid, Introduction to	104
Chemistry, Colloid	104
Chemistry, Colloid, Introduction to	104
Chemistry, Colloid, Surface and	94
Chemistry, Entrance	92
Chemistry, General	92
Chemistry, Industrial	103, 104
Chemistry, Inorganic, Advanced	92
Chemistry, Inorganic, Journal Meeting in	94
Chemistry of Foods	100
Chemistry of Food Supplies, Technology and	100
Chemistry of Heterocyclic Compounds	93
Chemistry, Inorganic, Special Topics in	92
Chemistry of Micro-organisms	100
Chemistry of Nutrition	100
Chemistry of Nutrition Laboratory	100
Chemistry, Organic	93
Chemistry, Organic, Functional Groups in	93
Chemistry, Organic, Journal Meeting in	94
Chemistry, Organic, Laboratory	93
Chemistry, Organic, Recent Advances in	93
Chemistry, Physical	93, 94
Chemistry, Physical, Laboratory	93, 94
Chemistry, Physical, of High Polymers	94
Chemistry, Physical, Seminar in	94
Chemistry, Radiation	94
Chemistry, Radiation, Introduction to	94
Chemistry, Research Conference	94
Chemistry, Sanitary	84
Chemistry, Special Problems in	94
Chemistry, Surface and Colloid	94
City and Regional Planning	92
City Planning Design	92
City Planning, Principles of	91
City Planning Research	91
City Planning, Theory and Practice of	91
Climatology, General	108
Climatology, Regional	108
Coal and Petroleum, Geology of	106
Colloid Chemistry	104
Colloid Chemistry, Applied, Introduction to	104
Colloid Chemistry, Introduction to	104
Colloid Chemistry Laboratory	104
Colloid Chemistry, Surface and	94
Color, Freehand and	91
Color Measurements	101
Combustion, Principles of	104
Communications, Electrical, Laboratory	96
Communications, Electrical, Principles of	96, 98
Communications, Electrical, Sound in	98
Communications Laboratory	97
Communications Practice	99
Communications, Wire, Principles of	96
Complex Variable, Functions of	120
Concrete Design, Reinforced	82, 114
Construction, Building	113, 114
Construction, Engineering	84
Construction Problems	114
Construction, Site Planning and	91
Construction Surveying Fieldwork	81
Contemporary Problems Seminar	111
Continuous Groups	120
Contracts, Law of	110
Corporations	115
Corrosion	104
Corrosion and Heat Resisting Alloys	90
Crystallographic Research	105
Crystallography, Elementary	105
Crystallography, Optical	105
Crystallography, Theoretical	105
Crystallography, X-ray	105
Cytology, General	99
Debating, Principles of	118
Descriptive Geometry	114
Diesel Engineering	108
Diesel Engines	88
Differential Equations	119, 120
Differential Geometry	119
Distillation	103
Distillation and Absorption	103
Drawing, Engineering	114
Drawing, Freehand	91
Drawing, Machine	87
Drawing, Naval Architecture	107
Drawing, Topographical	81
Dynamic Meteorology	109
Dynamics	84, 85
Dynamics, Automotive	88
Dynamics of Engines	88
Dynamics, Strength of Materials and	84, 85
Dynamics, Statics and	84
Economic Analysis	115
Economic and Industrial History, Seminar in	116
Economic Balance	104
Economic Balance in Chemical Industry	104
Economic Geography	118
Economic Geography of the World	105
Economic Geology	105
Economic Geology, Applied	105
Economic Geology Laboratory	105
Economic Geology of Fuels	105
Economic Principles	115, 117
Economic Seminar	116
Economic Statistics	115
Economic Thought, Schools of	115
Economics, Building	116
Economics, Industrial	115, 117
Economics, Industrial, Problems in	115
Economics, International	115
Economics, Land	116
Economics, Mathematical Approach to	115
Economics, Mineral	106
Economics of Technological Change	115
Economics, Power System	97
Elasticity, Theoretical and Applied	120
Elasticity, Theory of	85
Electric Furnaces	89
Electric Insulation	95
Electric Machine Development, Principles of	98
Electric Machinery Design	95
Electric Power Circuits	96
Electric Power Distribution	98
Electric Power Generation	95, 97
Electric Traction, Railroad	97
Electrical Communications in the United States, Patent Background of	98
Electrical Communications Laboratory	96
Electrical Communications, Principles of	96, 98
Electrical Communications, Sound in	98
Electrical Engineering	95, 96
Electrical Engineering, Applications of Atomic Physics in	98
Electrical Engineering, Applications of Integral Equations in	97
Electrical Engineering Laboratory	99
Electrical Engineering, Principles of	94, 95
Electrical Engineering Seminar	96
Electrical Engineering, Special Problems in	98
Electrical Equipment of Buildings	96
Electrical Implementation	95
Electrical Implementation Laboratory	99
Electrical Measurements Laboratory	98
Electricity	95
Electricity, Applications of, to Industry	95
Electromagnetic Wave Theory	102
Electronic Control and Measurement	95
Electronic Engineering Laboratory	99
Electronic Phenomena	102
Electronics, Engineering	98
Electronics, Experimental	102
Electronics Laboratory	102

Subjects	Page
Electronics, Special Problems in	102
Embryology	99
Engine Design, Airplane, Advanced	113
Engine Installation	112
Engineering Applications of Field Theory	97
Engineering Astronomy	81
Engineering Construction	84
Engineering Drawing	114
Engineering Electronics	98
Engineering Equipment	103
Engineering Laboratory	87
Engineering Materials	82, 85, 86
Engineering Metals	86
Engines, Diesel	88
English Composition	116, 117
English, Entrance	116
Enzymology	100
Estimating and Job Management	114
European Civilization and Art	91
Evolution, Organic, Advanced	105
Executive Control, Technique of	110
Experimental Research Problem	104
Experimental Stress Analysis	85
Explosives Plant Engineering	103
Extraction, Absorption and	103
Fabric Structure, Principles of	88
Fatigue of Metals	86
Ferromagnetism	90
Field Theory, Engineering Applications of	97
Finance	109
Finance, Banking and	115
Finance, Investment	115
Finance, Public	115
Financial Administration of Industry	109
Financial Problems	109
Fine Arts	91, 117
Fire Control, Special Problems in	98
Flood Control, Hydrology and	83
Fluid Mechanics	83, 85
Flutter Mechanics	111
Food Engineering	87
Food Products, Technology of	100
Food Supplies, Technology and Chemistry of	100
Food Technology, Adv	100
Food Technology Seminar	100
Foods, Bacteriology of	100
Foods, Chemistry of	100
Forecasting, Long Range Weather	108
Fossils, Index	105
Foundation Engineering, Soil Mechanics and	82
Fourier Series and Integrals	120
Freehand and Color	91
Freehand Drawing	91
French	118, 119
Fuel Engineering	104
Fuels, Automotive	104
Fuels, Economic Geology of	105
Functional Groups in Organic Chemistry	93
Functions of a Complex Variable	120
Functions of a Real Variable	120
Functions, Theory of	119
Furnace Design	104
Furnaces, Electric	89
Gas Turbine Engineering	87
Gas Turbine Problems, Advanced	85
Generation and Utilization of Super-Voltages	98
Genetics	99
Geology	81
Geodetic Surveying	81
Geography, Economic	118
Geography, Economic, of the World	105
Geology	118
Geology, Economic	105
Geology, Economic, Applied	105
Geology, Economic, Laboratory	105
Geology, Economic, of Fuels	105
Geology, Engineering	105
Geology, General	105
Geology, Glacial	106
Geology of Coal and Petroleum	106
Geology of North America	106
Geology of Petroleum, Advanced	106
Geology, Physical, Seminar	106
Geology Seminar, Problems in	106
Geology, Structural	106
Geometry, Descriptive	114
Geometry, Differential	119
Geometry, Projective	119
Geometry, Solid, Entrance	119
Geomorphology	105
Geomorphology, Regional, of the Earth	105
Geophysical Prospecting, Introduction to	106
Geophysics, Theoretical, Advanced	106
German	118
Government, American	116
Government and Public Administration	91
Government Control of Industry	116
Graphical Analysis	109
Group Psychology	116

Subjects	Page
Harbor Works, Design of	83
Heat Engineering	86, 87
Heat Measurements	87
Heat Transfer	103
Heat Transmission	103
Heat Transmission, Radiant, Seminar in	104
Heating and Ventilation	87
Heating and Ventilation Design	87
Heterocyclic Compounds, Chemistry of	93
Highway Transportation, Advanced	82
Highways and Airports	82
History of Architecture	91
History, Economic and Industrial	116
History of Science	117
History of Thought	116, 117
History of Warship Design	106
History, World, United States in	116, 117
Housing Seminar	91
Hull Engineering	107
Human Relations	118
Hydraulic Laboratory	87
Hydraulic Laboratory, River	83
Hydraulic Machinery, Design of	88
Hydraulic Transmission and Control	85
Hydraulics	83
Hydrology and Flood Control	83
Hydrology and Water Power Engineering	83
Hydromechanics	85
Identification of Organic Compounds	93
Illuminating Engineering, Principles of	95, 97
Illumination	95
Illumination, Architectural	91
Index Fossils	105
Industrial Accounting	110
Industrial Chemical Laboratory	103
Industrial Chemistry	103, 104
Industrial Economics	115, 117
Industrial Economics, Problems in	115
Industrial Economics Seminar	116
Industrial History, Economic and, Seminar in	116
Industrial Law	110
Industrial Non-Ferrous Alloys	90
Industrial Physical Metallurgy	90
Industrial Plant Engineering	85
Industrial Practice	99
Industrial Problems	111
Industrial Relations	115
Industrial Relations, Seminar in	115
Industrial Statistics	115
Industrial Traffic Management	109
Industry, Financial Administration of	109
Industry, Government Control of	116
Inorganic Chemistry	92
Inorganic Chemistry, Journal Meeting in	94
Inorganic Chemistry, Special Topics in	92
Inorganic Laboratory, Advanced	92
Instrument Design Practice	113
Instrumentation	113
Instrumentation in Biology	101
Instruments	113
Instruments, Aircraft	113
Instruments Laboratory	113
Instruments, Meteorological	113
Instruments, Special Problems in Aeronautical and Meteorological	113
Insulation, Electric	95
Integral Equations in Electrical Engineering, Applications of	97
Integral Equations, Partial Differential and	120
Interior Ballistics, Theory of	103
Internal Combustion Engine Design	88
Internal Combustion Engine Laboratory	88
Internal Combustion Engine Problems, Adv	88
Internal Combustion Engines	88
International Economics	115
International Relations	115, 117
Investment Analysis	115
Investment Finance	115
Italian	119
Job Management	114
Journal Meeting in Inorganic Chemistry	94
Journal Meeting in Organic Chemistry	94
Kinetic Theory	94
Kinetics of Chemical Reactions	94
Labor Law	110
Labor Problems, Seminar in	115
Labor Relations	115, 117
Law, Industrial	110
Law of Contracts	110
Law of the Market	110
Law, Patent	110
Line Spectra	102
Literature, Western World	116, 117
Long Range Weather Forecasting	108
Machine Design	87, 88
Machine Development, Electric, Principles of	98
Machine Drawing	87

Subjects	Page
Machine Tool Laboratory	88
Machine Tool Practice	88
Machinery, Alternating Current, Advanced	97
Machinery, Electric, Design of	95
Machinery, Hydraulic, Design of	88
Management, Estimating and Job	114
Management Laboratory	110
Management, Personnel	109
Management, Special Problems in	111
Manufacturing Analysis	110
Manufacturing Engineering	88
Manufacturing, Preparation for	88
Marine Engineering	107, 108
Marine Engineering Design	108
Market, Law of the	110
Marketing and Reports	110
Marketing Research	110
Marketing Seminar	111
Mass Production Methods	110
Materials	114
Materials, Building, Special Problems in	114
Materials, Engineering	82, 85, 86
Materials, Strength of	84, 85
Materials, Strength of, and Dynamics	84, 85
Materials, Testing, Laboratory	86
Mathematical Analysis by Mechanical Methods	97
Mathematical Approach to Economics	115
Mathematical Laboratory	120
Mathematical Reading	120
Mathematical Theory of Statistics	119
Mathematics	119, 120
Mathematics, Applied, Seminar in	120
Mathematics, Mechanized, Special Applications of	97
Mechanical Engineering Practice	87
Mechanical Engineering Problems, Advanced	85
Mechanical Engineering Seminar	89
Mechanical Properties of Metals	86
Mechanical Systems, Design of	88
Mechanical Vibration	108
Mechanics	120
Mechanics, Aeronautical	111
Mechanics, Analytical	120
Mechanics, Basic	84
Mechanics, Fluid	83, 85
Mechanics, Flutter	111
Mechanics, Quantum	102
Mechanics, Statistical	94, 102
Mechanism and Structure, Reactivity	93
Mechanized Mathematics, Special Applications of	97
Metal Processing	86
Metallography	89
Metallography, X-ray	90
Metallurgical Calculations	89
Metallurgical Laboratory	89
Metallurgical Plant Visits	89
Metallurgical Thermodynamics	89
Metallurgy	90
Metallurgy, General	89
Metallurgy, Industrial Physical	90
Metallurgy: Iron and Steel	89
Metallurgy, Non-Ferrous	89
Metallurgy of Common Metals	89
Metallurgy, Physical	89, 90
Metallurgy, Powder	90
Metallurgy, Special Problems in	90
Metal Processing	86
Metals, Metallurgy of	89
Metals, Engineering	86
Metals, Fatigue of	86
Metals, Mechanical Properties of	86
Metals, Physics of	90
Metals, Properties of	90
Meteorological Instruments	113
Meteorological Instruments, Aeronautical and, Special Problems in	113
Meteorological Observations	113
Meteorological Seminar	109
Meteorology, Descriptive	108
Meteorology, Dynamic	109
Meteorology Laboratory, Introductory	109
Meteorology, Physical	109
Meteorology, Special Problems in	109
Meteorology, Synoptic	108, 109
Metrology and Dimensional Engineering Standardization	88
Microbiology, Industrial	100
Micro-organisms, Chemistry of	100
Micropaleontology	105
Military Science	121
Mine Valuation	106
Mineragraphy, Quantitative	90
Mineral Dressing	90, 91
Mineral Dressing Design	91
Mineral Dressing Laboratory, Advanced	91
Mineral Dressing Practice	91
Mineral Economics	106
Mineral Economics Seminar	106
Mineralogical Research	105
Mineralogical Seminar	105
Mineralogy	105
Mining, Elements of	106

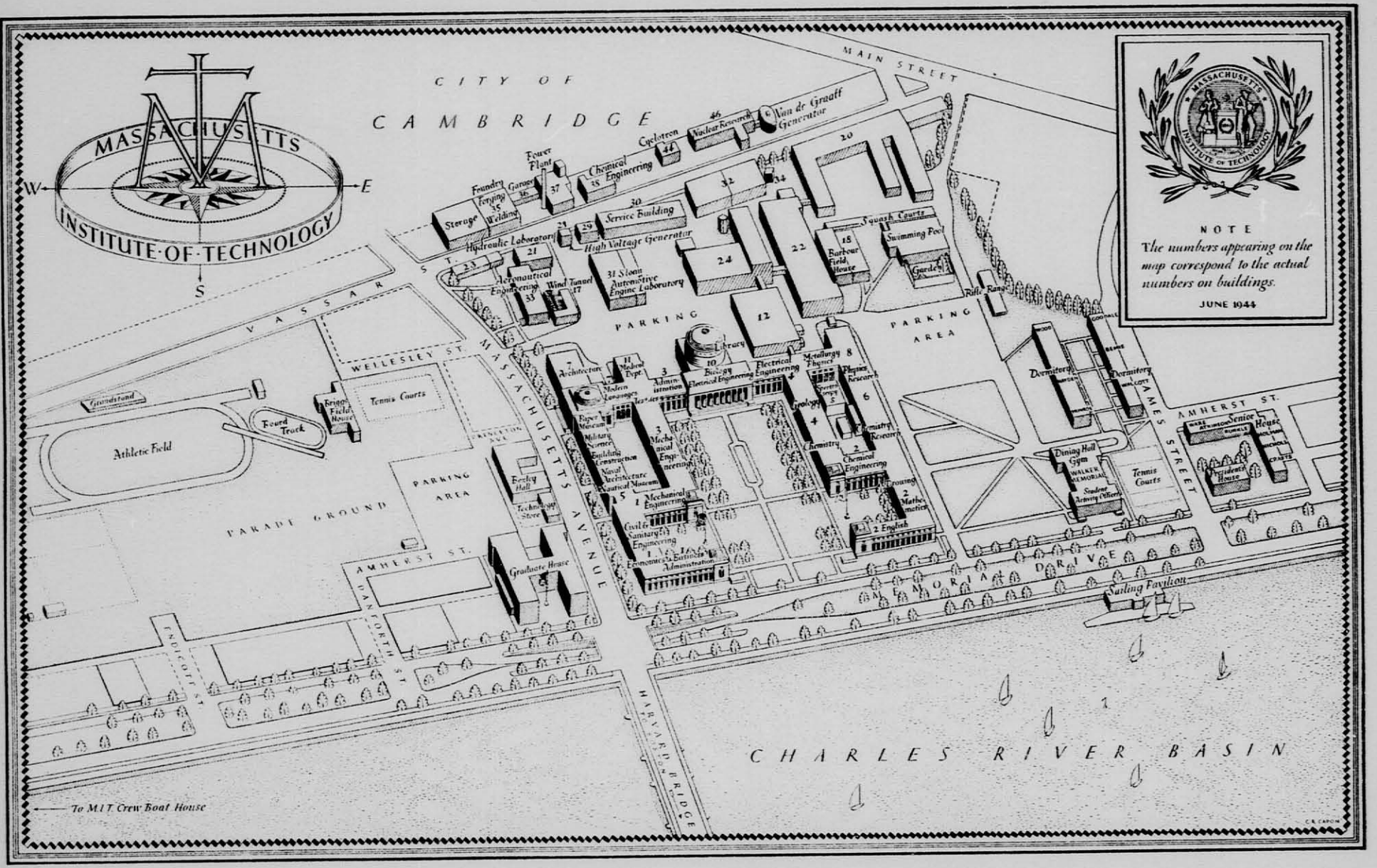
Subjects	Page
Mining Methods and Practice	106
Models, Theory of	83
Molecular Structure	102
Money and Banking	115
Motivation and Personality Development	115
Municipal Engineering	81
Music, Introduction to	116, 117
Natural Products	93
Naval Architecture	106
Naval Architecture and Ship Design	106
Naval Architecture Drawing	107
Naval Engineering	108
Naval Vessels, Basic Design of	107
Navigation	81
Network Theory, Advanced	97
New Product Appraisal and Development	111
Nomography	115
Non-Ferrous Alloys, Industrial	90
Non-Ferrous Metallurgy	89
Nuclear Physics	102
Nuclear Physics, Special Problems in	102
Nuclear Structures, Theory of	102
Nutrition, Advanced	100
Nutrition, Applied	100
Nutrition, Chemistry of	100
Nutrition Laboratory, Chemistry of	100
Oceanography	109
Ocean Shipping Administration	109
Office Practice	91
Optical Ceramics	90
Optical Crystallography	105
Optical Measurements	101
Optics	101
Optics, Special Problems in	101
Ordnance Engineering	85
Ore Testing	90
Organic Analysis, Quantitative	93
Organic Chemistry	93
Organic Chemistry, Functional Groups in	93
Organic Chemistry, Journal Meeting in	94
Organic Chemistry Laboratory	93
Organic Chemistry, Recent Advances in	93
Organic Compounds, Identification of	93
Organic Evolution, Advanced	105
Organic Laboratory, Advanced	93
Organic Preparations	93
Paleontology	105
Partial Differential and Integral Equations	120
Patent Background of Electrical Communications in the United States	98
Patent Law	110
Patents and their Relation to Science and Engineering	98
Perception and Action, Psychology of	115
Personality Development, Motivation and	115
Personnel Management	109
Petrography	105
Petroleum, Geology of, Adv.	106
Petroleum, Geology of Coal and	106
Petrology Seminar	105
Philosophy, History of	118
Philosophy, Modern, Problems of	118
Photoelasticity	85
Photoelasticity Research	85
Photogrammetry	81
Photography	101
Physical Chemistry	93, 94
Physical Chemistry Laboratory	93, 94
Physical Chemistry of High Polymers	94
Physical Chemistry, Seminar in	94
Physical Geology Seminar	106
Physical Measurements	101
Physical Metallurgy	89, 90
Physical Meteorology	109
Physico-Chemical Experimental Techniques	94
Physics	101
Physics, Atomic, Applications in Electrical Engineering	98
Physics, Crystal, Special Problems in	102
Physics, Crystal, X-rays and	102
Physics, Entrance	101
Physics, Experimental	101
Physics, Intermediate	101
Physics, Nuclear	102
Physics of Metals	90
Physics of the Atmosphere, Elementary	109
Physics, Theoretical, Introduction to	102
Physics, Theoretical, Methods of	102
Physics, Theoretical, Special Problems in	102
Physiology, General	99, 100
Physiology Laboratory, General	100
Planning Legislation and Administration	91
Planning Principles	92
Plant Engineering, Industrial	85
Plasticity	85
Plasticity Problems, Advanced	85
Plasticity Research	85
Plastics and Other High Polymeric Substances	104
Political Institutions, Comparative	118
Ports and Port Facilities	108
Postwar Problems	115
Powder Metallurgy	90
Powder Metallurgy Laboratory	90
Power Circuits, Electric	96
Power Distribution, Electric	98
Power Generation, Electric	95, 97
Power Plant Engineering	87
Power Plant Performance and Installation	112
Power Plants, Advanced	87
Power System Analysis	96
Power System Economics	97
Power Systems Laboratory	96
Probability, Theory of	120
Product, New, Appraisal and Development	111
Production	110
Production Methods, Mass	110
Professional Problems	84
Projective Geometry	119
Propeller Design	108
Propeller Design, Aircraft	113
Propeller Theory and Experimental Research	108
Properties of Metals	90
Prospecting, Geophysical, Introduction to	106
Protection and Armament	107
Proteins, Amino Acids and	93
Psychological Seminar, Advanced	116
Psychology, Group	116
Psychology, Introductory	115, 117
Psychology of Change, Social	116
Psychology of Perception and Action	115
Psychology, Topological, Seminar on	116
Public Administration, Government and	91
Public Finance	115
Public Health Administrative Practice	84
Public Health Engineering Fieldwork	84
Public Speaking	118
Public Utility Practice	99
Purification, Water Supply and	83
Qualitative Analysis	92, 93
Quantitative Analysis	93
Quantitative Mineragraphy	90
Quantitative Organic Analysis	93
Quantum Mechanics	102
Quantum Theory of the Solid State	102
Radar, Principles and Applications of	96
Radiant Heat Transmission, Seminar in	104
Radiation Chemistry	94
Radiation Chemistry, Introduction to	94
Radio Lines, Antennas and Propagation	98
Radiochemistry, Applied	102
Railroad Electric Traction	97
Railway Signaling	81
Railway Transportation, Advanced	82
Reactivity, Mechanism, and Structure	93
Reading Seminar	118
Real Variable, Functions of	120
Recent Advances in Organic Chemistry	93
Refrigeration	87
Refrigeration, Applied	87
Reinforced Concrete Design	82, 114
Report Writing	116
Reports	116
Reports, Marketing and	110
Research	94, 106
Research Conferences	94, 104
Research Methods, Laboratory in	116
Research Problems	101
River Engineering	83
River Hydraulic Laboratory	83
Rotating Wing Aircraft	113
Route and Construction Surveys	81
Route Surveying Fieldwork	81
Russian, Elementary	118
Sales Promotion Strategy and Methods	110
Sanitary Analysis	83
Sanitary Bacteriology, Adv.	84
Sanitary Chemistry	84
Sanitary Design, Adv.	84
Sanitary Engineering, Adv.	84
Sanitary Engineering Design	83
Sanitary Engineering Laboratory	84
Sanitary Science, Principles of	84
Sanitation	83
School of Chemical Engineering Practice	104
Science, History of	117
Sedimentation	106
Seismology, Elements of	106
Servomechanisms	97
Servomechanisms Laboratory	98
Sewage Analysis, Water and	84
Sewage, Bacteriological Examination of Water and	84
Sewerage and Sewage Treatment	83
Sewerage, Water Supply and	83
Ship Construction	107
Ship Design	107
Ship Design, Naval Architecture and	106
Ship Drawing	107
Ship Operation	108
Shipping Administration, Ocean	109
Shop	91
Signaling, Railway	81
Site Planning and Construction	91
Social Psychology of Change	116
Social Science Seminar	116
Sociology, Urban	116
Soil Engineering Special Studies	82
Soil Mechanics	82
Soil Mechanics and Foundation Engineering	82
Soil Mechanics Laboratory	82
Solid Geometry, Entrance	119
Solid State, Quantum Theory of the	102
Solid State, Theory of the	90
Sound in Electrical Communications	98
Sound, Vibration and	101
Spanish	119
Spectra, Line	102
Spectroscopy of Biological Materials	100
Spectroscopy of Biological Materials Laboratory	100
Spectroscopy, Special Problems in	102
Statically Indeterminate Structures	83
Statics	84, 115
Statics and Dynamics	84
Statistical Inference	115
Statistical Mechanics	94, 102
Statistical Theory, Modern	119
Statistics	119
Statistics, Economic	115
Statistics, Industrial	115
Statistics, Mathematical Theory of	119
Steam Turbine Engineering	87
Steel Making, Principles of	89
Stowage, Cargo Handling and	108
Strength of Materials	84, 85
Strength of Materials and Dynamics	84, 85
Stress Analysis, Experimental	85
Structural Analysis	92
Structural Design	82, 83, 114
Structural Design of Warships	106
Structural Geology	106
Structural Laboratory	82
Structural Problems	114
Structural Steel Design	114
Structural Theory, Advanced	83
Structure, Reactivity, Mechanism and	93
Structures	82, 112
Structures, Statically Indeterminate	83
Surface and Colloid Chemistry	94
Surveying	81
Surveying Fieldwork	81
Surveying Fieldwork, Construction	81
Surveying Fieldwork, Route	81
Surveying, Geodetic	81
Surveys, Route and Construction	81
Synoptic Laboratory	109
Synoptic Meteorology	108, 109
Technique of Executive Control	110
Tensor Calculus	120
Terpenes	93
Testing Materials Laboratory	
Textile Manufacturing, Elements of	
Textile Manufacturing, Principles of	
Textile Microscopy	
Textile Research Laboratory	
Textile Technical Analysis	
Textile Technology Seminar	
Textile Testing Laboratory	
Theory of Functions	119
Thermodynamics	
Thermodynamics and Engines	
Thermodynamics, Chemical	
Thermodynamics, Chemical, Applied	104
Thermodynamics, Chemical Engineering	103
Thermodynamics, Engineering, Advanced	
Thermodynamics, Introduction to	
Thermodynamics, Metallurgical	
Thermodynamics of the Atmosphere	
Thesis, Graduate	
Thesis Research	
Topographical Drawing	
Topography in the World War	
Topological Psychology, Seminar on	
Torpedoes	
Traffic Management, Industrial	
Transients in Linear Systems	
Transportation	
Transportation Engineering	
Transportation, Highway, Advanced	
Transportation, Railway, Advanced	
Trigonometry, Entrance	
United States in World History	
Value Problems, Characteristic	
Variations, Calculus of	
Vector Analysis	
Ventilation, Heating and	
Ventilation Design, Heating and	
Vibration and Sound	
Vibration Measurements	

Subjects	Page
Vibration, Mechanical	108
Vibration Problems	81
Vibration Theory, Introduction to	81
Vibrations	98
Voltages, Super-Generation and Utilization of	98
Warship Design	107
Warship Design, History of	106
Warship Design, Theory of	107
Warships, Structural Design of	106
Water and Sewage Analysis	84
Water and Sewage, Bacteriological Analysis of	84
Water Power Design, Advanced	83
Water Power Engineering	83
Water Power Engineering, Hydrology and	83
Water Supply and Purification	83
Water Supply and Sewerage	83
Weather Forecasting, Long Range	108
Wing Flutter, Introduction to	111
Wire Communications, Principles of	96
World History, United States in	116, 117
X-ray Crystallography	105
X-ray Diffraction	102
X-ray Metallography	90
X-rays and Crystal Physics	102

ALPHABETICAL INDEX

	Page
Academic Year	25
Administrative Council	9
Administration, Officers of	8
Admission from Secondary Schools	34
Academic Preparation	34
Application Procedure	35
Entrance Examinations	35
Selection of Applicants	34
Admission of Foreign Students	36
Admission of Special Students	36
Special Students in Architecture	36
Admission to Graduate School	64
Admission with Advanced Standing	35
Advanced Credit	35
Application Procedure	35
Selection of Students	35
Advisers	26
Aeronautical Engineering:	
Course Schedule	59
Description of Subjects	111
Graduate Study	78
Staff	10
Tabulation of Subjects	137
Architecture:	
Course Schedule	43
Description of Subjects	91
Graduate Study	68
Special Students	36
Staff	10
Tabulation of Subjects	127
Army Ordnance	68
Athletics	30
Attendance	25
Bemis, Albert Farwell, Foundation Staff	20
Biology:	
Course Schedule	48
Description of Subjects	99
Graduate Study	72
Staff	11
Tabulation of Subjects	131
Board, Cost of	27
Books, etc., Cost of	27
Building Engineering and Construction:	
Course Schedule	60
Description of Subjects	113
Staff	11
Tabulation of Subjects	138
Buildings, Description of	28
Business and Engineering Administration:	
Course Schedule	58
Description of Subjects	109
Graduate Study	77
Staff	11
Tabulation of Subjects	136
Calendar	2
Camp Technology	29
Ceramics	68
Chemical Engineering:	
Course Schedule	53
Description of Subjects	103
Graduate Study	74
Staff	12
Tabulation of Subjects	133
Chemical Engineering Practice	54
Graduate Study	74
Chemistry:	
Course Schedule	45
Description of Subjects	92
Graduate Study	69
Staff	12
Tabulation of Subjects	128
City Planning:	
Course Schedule	44
Graduate Study	69
Staff	11
City Planning Practice	44
Civil and Sanitary Engineering:	
Course Schedule	39
Description of Subjects	81
Graduate Study	66
Staff	13
Summer Surveying Camp	29
Tabulation of Subjects	122
College Entrance Examination Board:	
Dates of Examinations	35
Committees:	
Committees on Joint Projects	22
Faculty Committees	22
Other Committees and Boards	23
Conduct	26
Coöperative Arrangements with Liberal Arts Colleges	25
Corporation, Members of	7
Courses of Study, Undergraduate	37
Degrees:	
Advanced Degrees	64
Degrees Granted	25
Requirements for Bachelor's Degree	38
Deposits to cover Chemical Supplies, Military Uniforms, etc.	27
Description of Subjects	81
Dining Service	29
Division of Industrial Coöperation:	
Staff	19
Dormitories	154
Dormitory Board	22
Economics and Social Science:	
Description of Subjects	115
Graduate Study	79
Staff	13
Tabulation of Subjects	139
Educational Buildings	28
Laboratories	28
Library	28
Museums	28
Summer Surveying Camp	29
Electrical Communications:	
Course Schedule	47
Electrical Engineering:	
Course Schedule	45
Description of Subjects	94
Graduate Study	70
Staff	14
Tabulation of Subjects	129
Electrical Engineering, Coöperative	47
Electric Power:	
Course Schedule	46
Electronic Applications:	
Course Schedule	47
English and History:	
Description of Subjects	116
Staff	15
Tabulation of Subjects	140
Entrance:	
Admission by Examination	35
Admission without Examinations	35
Examination Subjects	35
Examinations of C. E. E. B.	35
Examinations:	
Advanced Standing	26
Final	25
Expenses for School Year	27
Faculty Committees	22
Faculty Council	9
Faculty Members, Ex-officiis	10
Fees, Deposits, Payments, Expenses:	
Activities	27
Deposits	27
Late Registration Fine	27
Other Fees	27
Payments	27
Tuition	27
Fellowships	148
First-Year Course Schedules	38
Food Technology:	
Course Schedules	50
Description of Subjects	90
Graduate Study	73
Staff	15
Tabulation of Subjects	131
Foreign Students, Admission of	36
French (See Modern Languages)	
Fuel Engineering	75
General Engineering:	
Course Schedule	52
General Information	24
General Regulations:	
Academic Year	25
Advisers	26
Attendance	25
Conduct	26
Examinations for Advanced Standing	26
Final Examinations	25
Health of Students	26
Petitions	26
Provisional Admission	25
Registration	25
General Science:	
Course Schedule	52
General Studies: Division of:	
Description of Subjects	117
Tabulation of Subjects	140
Geology:	
Course Schedule	54
Description of Subjects	105
Graduate Study	75
Staff	15
Tabulation of Subjects	134
German (See Modern Languages)	
Government and Administration	24
Graduate House	154
Graduate School:	
Administration	63
Chairmen of Committees	63
Committee on the Graduate School	63
Coöperation with Harvard University	64
Degrees:	
Doctor of Philosophy or Science	65
Master in Architecture	65
Master in City Planning	65
Master of Science	65
General Information	64
Requirements for Admission	64
Tuition	27
Graphics:	
Description of Subjects	114
Staff	20
Tabulation of Subjects	139
Group Psychology	80
Guest of the Institute	20
Harvard University, Coöperation with	64
Heads of Departments and Courses	9
Health of Students	26
Holidays	25
Homberg Memorial Infirmary	26
Honorary Secretaries	151
Hours of Attendance	25
Humanities, Division of	19, 37, 117
Humanities and Social Sciences Program	117
Hunter, Dard, Paper Museum Curator	20
Illumination Engineering:	
Course Schedule	47
Industrial Coöperation, Division of:	
Staff	19
Industrial Statistics:	
Course Schedule	61
Institute Committee	31
Instructing Staff	10
Italian (See Modern Languages)	
Laboratories	28
Library	28
Staff	20
Aeronautics Library	28
Dewey Library	28
Eastman Library	28
Lindgren Library	28
Rotch Library	28
Vail Library	72
Walker Library	28

	Page
Loans, Scholarships, Fellowships and Prizes	27, 143
Location	24
Lowell Institute School	31
Marine Engineering:	
Graduate Study	76
Marine Transportation:	
Course Schedule	56
Mathematics:	
Course Schedule	61
Description of Subjects	119
Graduate Study	79
Staff	15
Tabulation of Subjects	141
Mechanical Engineering:	
Course Schedule	40
Description of Subjects	84
Graduate Study	67
Staff	16
Tabulation of Subjects	123
Mechanical Engineering, Coöperative	41
Medical Department	26
Staff	17
Metallurgy:	
Course Schedule	42
Description of Subjects	89
Graduate Study	68
Staff	17
Tabulation of Subjects	126
Meteorology:	
Course Schedule	57
Description of Subjects	108
Graduate Study	77
Staff	18
Tabulation of Subjects	136
Military Science and Tactics	62
Description of Subjects	121
Staff	18
Tabulation of Subjects	142
Mineral Dressing	68
Course Schedule	43
Modern Languages:	
Description of Subjects	118
Staff	18
Tabulation of Subjects	141
Museums	29
Dard Hunter Paper	29
Nautical	29
Staff	20
Music, Drama and Public Speaking	30
Nautical Association	30
Naval Architecture and Marine Engineering:	
Course Schedule	55
Description of Subjects	106
Graduate Study	76
Staff	18
Tabulation of Subjects	135
Naval Construction	76
Naval Construction and Engineering	76
Naval Engineering	76
Numbering System	38
Objectives and Policies of the Institute	5
Officers:	
Administration	8
Instruction	10
Payments	27
Petitions	26
Physical Biology:	
Course Schedule	49
Physics:	
Course Schedule	51
Description of Subjects	101
Graduate Study	73
Staff	19
Tabulation of Subjects	132
Placement	28
Prizes	150
Professional Societies	30
Professional Summer Schools	38
Professors Emeriti	21
Publications, Student	30
Pure and Applied Mathematics:	
Course Schedule	61
Quantitative Biology:	
Course Schedule	48
Radcliffe College, Coöperation with	64
Recreational Facilities	29
Registration	25
Requirements for Admission	34
Requirements for Bachelor's Degree	38
Russian (See Modern Languages)	
Sanitary Engineering:	
Graduate Study	66
Schedules of Courses	39
Scholarships:	
Assistantships and Teaching Fellowships	148
Fellowships and Graduate	148
Freshman	143
Undergraduate	144
Semester Hour	38, 122
Senior House	154
Society of Arts	29
Spanish (See Modern Languages)	
Special Students	36
Staff, Instructing	10
Student Aid and Prizes	143
Student Housing	29, 154
Student Professional Societies	30
Subjects:	
Index	158
Of Instruction, Description	81
Of Instruction, Tabulated	122
Summer Camp	29
Summer Schools, Professional	38
Table of Contents	3
Teaching Fellows, Chemistry	69
Technology Christian Association	30
Technology Loan Fund	143, 149
Textile Technology	67
Staff	17
Torpedo Engineering	68
Tuition Fees	27
Undergraduate Activities:	
Athletics	30
Institute Committee	31
M. I. T. Athletic Association	30
Music, Drama and Public Speaking	30
Nautical Association	30
Publications	30
Student Professional Societies	30
Technology Christian Association	30
Undergraduate Courses of Study	37
Undergraduate Course Schedules	39
Undergraduate Houses	154
Vacations	2
Veterans, Information for:	
Adjustment of Credits	32
Former Institute Students	32
General Policy	32
Other Veterans	32
Postwar Calendar	33
Walker Memorial	29
Year, Academic	25


MASSACHUSETTS INSTITUTE OF TECHNOLOGY
W
E
S
CITY OF
CAMBRIDGE
MAIN STREET
Van de Graaff Generator
Cyclotron
Nuclear Research
Power Plant
Chemical Engineering
Foundry
Forging
Welding
Garage
Storage
Service Building
Hydraulic Laboratory
High Voltage Generator
Aeronautical Engineering
Wind Tunnel
31 Sloan Automotive Engine Laboratory
Squash Courts
Swimming Pool
Barbour Field House
Garden
Rifle Range
PARKING AREA
Library
Biology
Electrical Engineering
Metallurgy
Physics Research
Geology
Chemistry
Chemical Engineering
Mathematics
English
Mechanical Engineering
Civil & Sanitary Engineering
Economics & Business Administration
Architecture
Modern Languages
Paper Museum
Military Science
Building Construction
Naval Architecture
Nautical Museum
Administration
Dormitory
Dormitory
Dining Hall
Gym
WALKER MEMORIAL
Student Activities Offices
Tennis Courts
Senior House
Graduate House
Faculty Club
Technology Store
Rogers Field House
Grandstand
Athletic Field
Board Track
Tennis Courts
PARADE GROUND
PARKING AREA
WELLESLEY ST.
VASSAR
MASSACHUSETTS AVENUE
AMHERST ST.
MEMORIAL DRIVE
CHARLES RIVER BASIN
HARVARD BRIDGE
Sailing Pavilion
ENDICOTT ST.
VAN FORTH ST.
To M.I.T. Crew Boat House
NOTE
The numbers appearing on the map correspond to the actual numbers on buildings.
JUNE 1944