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JUNE 1952

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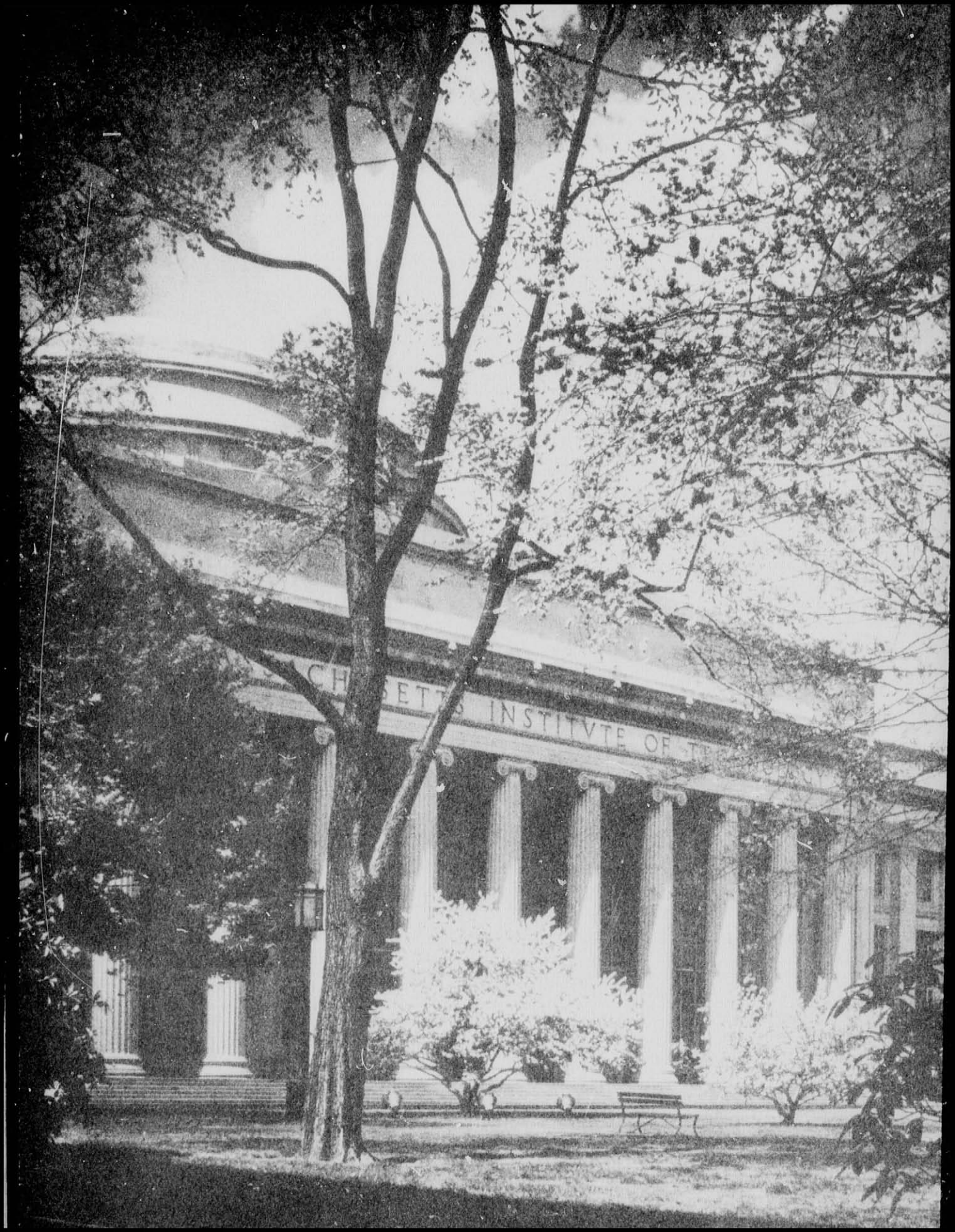
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The Institute reserves the right to make changes in the regulations and courses announced in this Bulletin

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY BULLETIN

JUNE 1952

CATALOGUE ISSUE
1952-1953 SESSION

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

VOLUME 87 NUMBER 4



PUBLISHED BY THE INSTITUTE
CAMBRIDGE, MASSACHUSETTS

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CALENDAR

CALENDAR 1952-1953

FOR ACADEMIC YEAR 1952-1953

		1952
Fall Term Begins for Freshmen		Sept. 18
Fall Term Begins for Upperclassmen and Graduate School		Sept. 22
Columbus Day (*Holiday*) (*Exercises omitted Monday, Oct. 13*)		Oct. 12
Field Day		Nov. 1
Armistice Day (*Holiday*)		Nov. 11
Thanksgiving Vacation	Nov. 27 through	Nov. 29
Christmas Vacation	Dec. 20 through	Jan. 4
		1953
Last Exercises, Fall Term		Jan. 21
Reading Period	Jan. 22 through	Jan. 24
Examination Period	Jan. 26 through	Jan. 30
Spring Term Begins		Feb. 9
Washington's Birthday (*Holiday*) (*Exercises omitted Monday, Feb. 23*)		Feb. 22
Spring Vacation	March 30 through	April 5
Patriots' Day (*Holiday*) (*Exercises omitted Monday, April 20*)		April 19
Last Exercises, Spring Term		May 26
Reading Period	May 27 through	May 29
Memorial Day (*Holiday*)		May 30
Examination Period	June 1 through	June 5
Commencement Day		June 12
Summer Session 1953 Begins		June 15
Fall Term 1953 Begins		Sept. 21

1952

JANUARY							FEBRUARY							MARCH						
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1953

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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 method of instruction as an indispensable educational technique. It virtually created the modern profession of chemical engineering; its courses in electrical engineering, in aeronautical engineering, and in applied physics 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 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 sense of social responsibility, 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

and the social sciences 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 extracurricular 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 emphasizes 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 cooperative 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, engineering, economics, or management for which he is qualified, with opportunity to map out his own path with the aid and counsel of the Staff.

James R. Killian, Jr.

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BUILDING ENGINEERING AND CONSTRUCTION

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Professor of Structural Engineering

James Albert Murray, S.B.
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Howard Simpson, S.M.
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Herman Christian Fischer, S.M.
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James Edwin Roberts, S.B.
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CHEMICAL ENGINEERING

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HAROLD CHRISTIAN WEBER, D.SC.
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ERNST ALFRED HAUSER, PH.D.
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HERMAN PAUL MEISSNER, D.SC.
Professor of Chemical Engineering

MANSON BENEDICT, PH.D.
Professor of Nuclear Engineering

JOHNSON EDWARD VIVIAN, Sc.D.
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ALAN SHERMAN MICHAELS, Sc.D.
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HENRY CHASEN

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ALFRED PATON COLEMAN CUMMING, PH.D.

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WALTER CECIL SCHUMB, PH.D.
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GEORGE SCATCHARD, PH.D., Sc.D.
Professor of Physical Chemistry

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

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

CHARLES DUBOIS CORYELL, PH.D.
Professor of Chemistry

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JOHN CLARK SHEEHAN, PH.D.
Professor of Chemistry

WALTER HUGO STOCKMAYER, PH.D.
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EWART RAY HERBERT JONES, D.Sc., PH.D.
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WILLIS RODNEY WHITNEY, PH.D., Sc.D., CH.D.
Non-Resident Professor of Chemical Research

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AVERY ALLEN ASHDOWN, PH.D.
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STEPHEN GERSHOM SIMPSON, PH.D.
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Associate Professor of Chemistry

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Associate Professor of Chemistry; Director of Spectroscopy Laboratory

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Elizabeth Johanna Jacoba Vander Pol, B.S.

CITY AND REGIONAL PLANNING

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John Tasker Howard, M.C.P.
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Kevin Andrew Lynch, B.C.P. (*Absent*)
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CIVIL AND SANITARY ENGINEERING

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JOHN BRAZER BABCOCK, 3D, S.B.
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MURRAY PHILIP HORWOOD, PH.D.
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FACULTY AND ADMINISTRATIVE OFFICERS EMERITI

AERONAUTICAL ENGINEERING

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

ARCHITECTURE

WILLIAM EMERSON, D.A.
Professor of Architecture, Emeritus

WILLIAM HENRY LAWRENCE, S.B.
Professor of Architectural Engineering, Emeritus

HARRY WENTWORTH GARDNER, S.B.
Professor of Architectural Design, Emeritus

HENRY LATIMER SEAVER, A.M.
Professor of History, Emeritus

WALTER ROY MACCORNACK, SC.D.
Professor of Architecture, Emeritus

BIOLOGY

SAMUEL CATE PRESCOTT, SC.D.
Professor of Industrial Biology, Emeritus

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

CLAIR ELSMERE TURNER, DR.P.H., SC.D.
Professor of Public Health, Emeritus

CHEMICAL ENGINEERING

WARREN KENDALL LEWIS, PH.D., D.SC., D.ENG.
Professor of Chemical Engineering, Emeritus; Lecturer

CHEMISTRY

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

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

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

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

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

GERHARD DIETRICHSON, PH.D.
Associate Professor of Physical Chemistry, Emeritus; Lecturer

CIVIL AND SANITARY ENGINEERING

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

CHARLES BLANEY BREED, S.B.
Professor of Civil Engineering, Emeritus

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

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

ECONOMICS AND SOCIAL SCIENCE

FLOYD ELMER ARMSTRONG, LL.D.
Professor of Economics and Finance, Emeritus

DONALD SKEELE TUCKER, PH.D.
Professor of Economics, Emeritus; Lecturer

ELECTRICAL ENGINEERING

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

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

HERBERT BRISTOL DWIGHT, D.SC.
Professor of Electrical Machinery, Emeritus; Lecturer

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

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

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

ENGLISH AND HISTORY

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

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

GEOLOGY AND GEOPHYSICS

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

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

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

SECTION OF GRAPHICS

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

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

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

SCHOOL OF INDUSTRIAL MANAGEMENT

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

MATHEMATICS

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

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

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

MECHANICAL ENGINEERING

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

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

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

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

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

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

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

METALLURGY

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

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

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

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

MODERN LANGUAGES

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

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

NAVAL ARCHITECTURE AND MARINE ENGINEERING

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

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

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

PHYSICS

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

ADMINISTRATION

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

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

WILLIAM NATHANAEL SEAVER, A.B.
Librarian, Emeritus

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

HORACE SAYFORD FORD
Treasurer Emeritus; Special Adviser to the President

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

FACULTY COMMITTEES, 1952–53

ACADEMIC REGULATIONS

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

	Term Expires
W. V. A. Clark, Jr.	1953
H. C. Hottel	1954
D. P. Campbell	1955
R. B. Greeley†	

ADMISSIONS

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

	Term Expires
L. S. Bryant	1953
S. J. Mason	1953
H. G. Steyer	1954
K. R. Wadleigh	1954
J. C. R. Licklider	1955
G. B. Thomas, Jr.	1955

COMMITTEE ON FIRST TWO YEARS

	Term Expires
P. M. Hurley (*Chairman*)	1953
T. H. D. Mahoney	1953
A. T. Ippen	1954
W. H. Stockmayer	1954
P. Franklin	1955
R. Schuhmann, Jr.	1955
J. T. Rule†	

DISCIPLINE

Dean of Students* (*Chairman*)
Dean of Freshmen*
Registrar*

	Term Expires
A. C. Bemis	1953
C. A. Myers	1954
D. L. Farnsworth	1955

EXAMINATIONS

	Term Expires
S. C. Brown (*Chairman*)	1953
J. N. Addoms	1953
J. C. R. Licklider	1953
J. B. Rae	1953
R. S. Bear	1954
R. L. Bisplinghoff	1954
W. E. Ritchie	1954
R. Schuhmann, Jr.	1954
N. C. Dahl	1955
L. J. Heidt	1955
G. C. Newton, Jr.	1955
E. Reissner	1955

GENERAL EDUCATION

	Term Expires
A. M. Gaudin (*Chairman*)	1953
D. S. Ballantine	1953
M. Deutsch	1954
E. Orowan	1954
J. R. Coleman	1955
A. H. Shapiro	1955
W. T. Martin†	

GRADUATE SCHOOL POLICY

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

W. P. Allis	K. A. Lynch
I. Amdur	J. T. Norton
J. M. Austin	S. Ober
W. H. Brown	S. C. Powell
J. P. Den Hartog	B. E. Proctor
A. G. H. Dietz	R. R. Shrock
W. M. Fife	I. W. Sizer
M. F. Gardner	W. E. Stanley
T. M. Hill	G. B. Thomas, Jr.
C. P. Kindleberger	G. C. Williams

INDUSTRIAL LIAISON COMMITTEE

	Term Expires
N. J. Grant (*Chairman*)	1955
R. L. Bisplinghoff	1953
W. H. Radford	1953
A. C. Cope	1954
H. P. Meissner	1955

LIBRARY

Executive Board

Director of Libraries*
Associate Librarian*

	Term Expires
S. H. Caldwell** (*Chairman*)	1953
I. W. Sizer	1953
M. B. Bever	1954
J. P. Den Hartog**	1955
P. Franklin	1955
P. M. Morse	1956

Advisory Board

I. Amdur	H. P. Meissner
H. R. Bartlett	E. Mirabelli
J. A. Beckett	S. Ober
M. J. Buerger	N. J. Padelford
J. H. Evans	B. E. Proctor
B. Kelly	J. R. Thompson
R. W. Kennedy	W. C. Voss
W. N. Locke	H. C. Willett

NOMINATING COMMITTEE 1952–1953

M. J. Buerger (*Chairman*)
A. M. Gaudin
J. H. Keenan
W. H. McAdams
C. A. Myers
G. Scatchard

STUDENT AID

	Term Expires
T. P. Pitré (*Chairman*)	
J. W. Irvine, Jr.	1953
E. P. Neumann	1953
W. P. Allis	1954
C. F. Floe	1954
E. C. Brown	1955
R. D. Parks	1955
E. S. Taylor†	

STUDENT ENVIRONMENT

Dean of Students* (*Chairman*)
Dean of Freshmen*

	Term Expires
R. M. Fano	1953
C. F. Taylor	1953
R. D. Evans	1954
C. P. Kindleberger	1954
L. B. Rogers	1955
T. Wood, Jr.	1955
H. L. Beckwith†	

UNDERGRADUATE COURSES

	Term Expires
H. S. Mickley (*Chairman*)	1954
F. Bitter	1953
C. H. Blake	1953
J. A. Beattie	1954
Ross M. Cunningham	1955
M. E. Shank	1955
R. B. Finch†	

UNDERGRADUATE POLICY

Chairman of Faculty*

	Term Expires
J. A. Hrones (*Chairman*)	
W. T. Martin	1953
H. Mueller	1953
D. V. Brown	1954
J. T. Rule	1954
H. L. Beckwith	1955
R. B. Greeley	1955
R. B. Finch	1956
E. S. Taylor	1956

COMMITTEES ON JOINT PROJECTS, 1952–53

SOLAR ENERGY CONVERSION

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

Advisory:
Dean of School of Engineering*
L. B. Anderson
A. G. H. Dietz
G. R. Harrison
L. J. Heidt
A. L. Hesselschwerdt, Jr.
J. T. Norton
G. Scatchard
G. B. Wilkes

PLASTICS

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

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

COMMITTEES ON INTERDEPARTMENTAL LABORATORIES, 1952-53

ACOUSTICS

R. H. Bolt (*Chairman*)
Provost*
L. B. Anderson
L. L. Beranek
R. D. Fay
P. M. Morse

ELECTRONICS

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

SPECTROSCOPY

R. C. Lord (*Chairman*)
G. R. Harrison

NUCLEAR SCIENCE

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

NUCLEAR ENGINEERING

M. Benedict (*Chairman*)
Dean of School of Engineering*
J. C. Chipman
E. R. Gilliland
H. L. Hazen
C. R. Soderberg
J. B. Wilbur
J. R. Zacharias

OTHER COMMITTEES AND BOARDS, 1952-53

ADVISORY COMMITTEE ON DINING AND HOUSING FACILITIES

	Term Expires
Dean of Students* (*Chairman*)	
Dean of Graduate School*	
Director of Division of Business Administration*	
L. F. Hamilton	1953
L. B. Rogers	1954
T. M. Hill	1955
D. S. Ballantine	1956

ATHLETIC ADMINISTRATIVE BOARD

R. D. Douglass (faculty member) (*Chairman*)
Dean of Students*
Medical Director*
Athletic Director*
B. L. Averbach (faculty member)
L. T. Jester (alumni member)
G. Roddy (alumni member)
M. J. Blair (student member)
T. L. Kelly (student member)
A. Lopez (student member)

BEMIS FOUNDATION COMMITTEE

B. Kelly (*Chairman*)
Dean of School of Architecture and Planning*
Dean of School of Humanities and Social Studies*
A. C. Bemis
A. G. H. Dietz
W. R. Maclaurin
B. S. Old (A. D. Little Co.)
L. Rodwin

BUILDING COMMITTEE

R. M. Kimball (*Chairman*)
P. Belluschi
J. E. Burchard
H. S. Ford
J. J. Snyder
J. A. Stratton

COMMENCEMENT

D. P. Severance (*Chairman*)
R. D. Evans
F. G. Fassett, Jr.
J. C. MacKinnon
E. R. Schwarz
C. L. Svenson
J. B. Wilbur

HOBBY SHOP

J. Holt (*Chairman*)
B. L. Averbach
I. J. Geiger
J. J. Rowlands

LOAN BOARD

H. E. Lobdell (*Chairman*)
D. L. Rhind (*Secretary*)
Provost*
T. P. Pitré
J. T. Rule
J. J. Snyder

FACULTY COMMITTEE ON INVENTIONS AND COPYRIGHTS

C. F. Floe (*Chairman*)
J. A. Beattie
R. L. Bisplinghoff
G. S. Brown
J. W. Daily
A. C. Hardy
J. Wulff

PATENT MANAGEMENT

C. F. Floe (*Chairman*)
M. G. Kispert
N. McL. Sage
T. K. Sherwood
J. J. Snyder
J. G. Trump

PERMANENT ART COLLECTION

P. Belluschi (*Chairman*)
H. L. Beckwith (*Curator*)
J. E. Burchard
W. C. Greene
G. Kepes
C. F. Taylor

PERSONNEL BOARD

J. J. Snyder (*Chairman*)
F. L. Foster
M. M. Hubbard
R. M. Kimball
R. C. Maclaurin
C. A. Myers
D. L. Rhind

SAFETY COUNCIL

E. R. Schwarz (*Chairman*)
J. W. M. Bunker
M. J. Dondero
H. L. Hardy
A. L. Hesselschwerdt, Jr.
W. A. Hokanson
R. M. Kimball
E. B. Millard
M. S. Stevens

STAFF — ADMINISTRATION

Staff	*Administration*
R. D. Douglass (*Chairman*)	P. Belluschi
S. C. Brown	E. F. Bowditch
R. B. Greeley	E. P. Brooks
J. A. Hrones	J. E. Burchard
J. G. Kelso	E. L. Cochrane
G. P. Shultz	G. R. Harrison
H. G. Stever	J. R. Killian, Jr.
	J. J. Snyder
	J. A. Stratton

STUDENT — FACULTY

D. V. Brown (*Chairman*)
Dean of Students* C. H. Norris
J. E. Arnold
J. A. Hrones
G. Putnam
F. W. Sears

TECHNOLOGY MUSEUM

H. R. Bartlett (*Chairman*)
H. L. Beckwith
G. C. Manning
H. B. Richmond*
E. R. Schwarz
F. W. Sears
V. D. Tate

TECHNOLOGY PRESS BOARD

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

UNDERGRADUATE BUDGET BOARD

M. G. Kispert (*Chairman*)
Chairman, Athletic Administrative Board*
T. M. Hill
R. T. Jope
D. L. Rhind
Dean of Students*

*Ex officio

GENERAL INFORMATION

LOCATION

THE Institute is located on the Cambridge side of the Charles River Basin on a tract of one hundred acres extending along the river. Here are concentrated for convenient relation its twenty-five educational buildings, research laboratories and Administration and Faculty offices. In this area are also the resident houses, cafeterias and dining halls, libraries, infirmary, gymnasiums, athletic fields and field houses, tennis courts, student union, swimming pool, sailing pavilion and boathouse.

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 Provost, Vice-President and Treasurer and, if eligible, the President of the Alumni Association *ex officiis*, of the *ex-officio* members as provided by act of the Legislature, of not less than twenty-five nor more than thirty-five life members, of fifteen alumni term members, and of not more than five special term members. . . . No professor, teacher or lecturer, under engagement for compensation to be paid by the Institute, shall be a member of the Corporation."

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

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

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

To aid the President and the Vice-President and Treasurer and the Vice-President and Provost there are other duly appointed officers of administration and instruction. Chief among the former are the Deans of Engineering, Science, Architecture and Planning, Humanities and Social Studies, Industrial Management, the Graduate School, and Students, and the Secretary of the Institute; the Director of the Division of Business Administration; the Bursar; and the Director of the Division of Industrial Cooperation. These, together with the Chairman of the Faculty, who is elected by that body, the President and the Executive Vice-President of the Alumni Association, the Director of Student Aid, the Director of Admissions, the Registrar, and the Medical Director compose the Administrative Council.

The Academic Council consists of the President as Chairman, the Vice-President and Provost as Vice-Chairman, the Deans of Engineering, Science, Architecture and Planning, Humanities and Social Studies, Industrial Management, Students, and the Graduate School, and the Chairman of the Faculty.

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

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

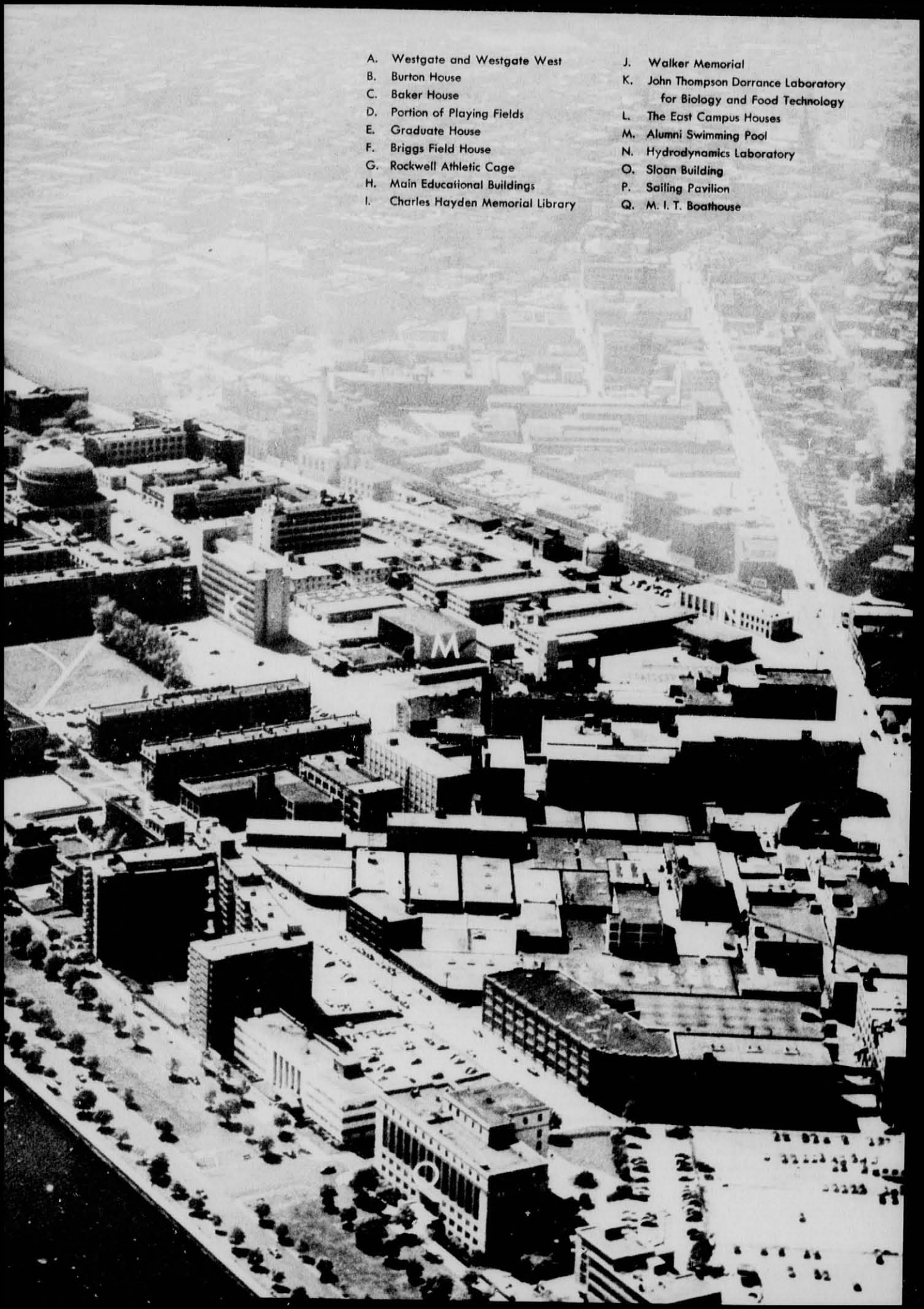
The grouping of the curricula of the Institute in the Schools is as follows:





In 1865, the Massachusetts Institute of Technology opened its doors for professional education in science, engineering and architecture. Fifty-one years later the Institute moved from Boston to its present location on the Charles River Basin in Cambridge, where today it offers undergraduate and graduate courses in science, engineering, architecture, city and regional planning, and industrial management to a student body drawn from all parts of the world.

Photograph: Eastern Aerial Surveys, Inc.


A. Westgate and Westgate West
B. Burton House
C. Baker House
D. Portion of Playing Fields
E. Graduate House
F. Briggs Field House
G. Rockwell Athletic Cage
H. Main Educational Buildings
I. Charles Hayden Memorial Library
J. Walker Memorial
K. John Thompson Dorrance Laboratory for Biology and Food Technology
L. The East Campus Houses
M. Alumni Swimming Pool
N. Hydrodynamics Laboratory
O. Sloan Building
P. Sailing Pavilion
Q. M. I. T. Boathouse



THE SCHOOL OF ENGINEERING

Aeronautical Engineering, Course XVI. Cooperative Course in Aeronautical Engineering, Course XVI-B.
Building Engineering and Construction, Course XVII.
Chemical Engineering, Course X, and *Chemical Engineering Practice*, Courses X-A and X-B.
Civil Engineering, Course I, with options: Theory and Design (1), Planning and Administration (2), Construction and Management (3).
Electrical Engineering, Course VI, with options: Electric Power (1), Electrical Communications (3), Electronic Applications (4). Cooperative Course in Electrical Engineering, Course VI-A.
General Engineering, Course IX-B.
Mechanical Engineering, Course II. Cooperative Course in Mechanical Engineering, Course II-B.
Metallurgy, Course III, with options: Metallurgy (1), Mineral Engineering (2).
Meteorology, Course XIX.
Naval Architecture and Marine Engineering, Course XIII, *Naval Construction and Engineering*, Course XIII-A, and *Marine Transportation*, Course XIII-B (suspended 1952).
Nuclear Engineering.
Sanitary Engineering, Course XI.

THE SCHOOL OF SCIENCE

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

THE SCHOOL OF ARCHITECTURE AND PLANNING

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

THE SCHOOL OF HUMANITIES AND SOCIAL STUDIES

Economics and Engineering. Course XIV-A, based on Mechanical Engineering; Course XIV-B, based on Electrical Engineering; Course XIV-C, based on Chemical Engineering.

THE SCHOOL OF INDUSTRIAL MANAGEMENT

Industrial Management and Business and Engineering Administration. Course XV-A, based on Physical Sciences; Course XV-B, based on Chemical Sciences.

Graduate programs are coordinated and organized under the direction of the Dean of the Graduate School, another major administrative division of the Institute.

In the Division of Industrial Cooperation are centered the organized research activities of Departments and individual members of the staff which are devoted wholly or in part to the assistance of government and industry in the solution of particular problems of the development of new methods and products.

More effective administration and development of the teaching and research of the institution as a whole are achieved through the pattern of organization sketched above, as is better linkage of the work of Departments which are naturally similar in outlook. Those Departments whose professional Courses of study lead to degrees and which embody the primary educational objective of the Institute — the combination of general education with basic professional training — thus are distributed among the several Schools, though a single Faculty is responsible for the program of teaching and research on which the whole is based. This combination of a unified Faculty with an operating philosophy which affords variety of choice for the student fosters the best utilization of the curriculum for the development of the abilities of each student.

The student whose main concern is with architecture or with the planning of communities, or indeed whole regions, and who seeks a degree in Architecture or City Planning, studies under the supervision of the School of Architecture and Planning. If his interest lies in biology, chemistry, food technology, geology, mathematics, physics, or general science, his work is based in the School of Science. Similarly, those primarily concerned with the direct utilization of the fundamentals of science to the better control of the environment — the engineers — though they may be working daily side by side with theoretical scientists, are guided by Faculty mentors in the School of Engineering. Students of economics, psychology, and industrial relations who look forward to a degree in these fields work through the School of Humanities and Social Studies, whilst those interested in business organization with especial emphasis on the direction and coordination of industrial enterprises carry on their programs under the aegis of the School of Industrial Management. To complement the cultural values inherent in scientific and engineering studies, planned sequences of appropriate subjects are provided for all undergraduates, regardless of the School in which they take their degree program, in the broadening disciplines of the humanities and social studies, the principal responsibility for the teaching of which rests on the School of Humanities and Social Studies.

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.), Aeronautical Engineer (Aer.E.), Building Engineer (Bldg.E.), Chemical Engineer (Chem.E.), Civil Engineer (C.E.), Electrical Engineer (E.E.), Marine Mechanical Engineer (Mar.Mech.E.), Mechanical Engineer (Mech.E.), Metallurgical Engineer (Met.E.), Meteorologist (Meteor.), Mineral Engineer (Min.E.), Naval Architect (Nav.Arch.), Naval Engineer (Nav.E.), Sanitary Engineer (San.E.), Doctor of Philosophy (Ph.D.), or Doctor of Science (Sc.D.). It also affords to advanced students and to experienced investigators opportunities for the pursuit of original scientific investigations.

COMBINED PLAN OF STUDY WITH LIBERAL ARTS COLLEGES

While most prospective students of engineering, science, architecture, city planning, or industrial management enter the Institute directly from secondary school, some prefer to attend a liberal arts college before undertaking their professional training. A minimum of two years is generally required to qualify for the S.B. degree in engineering or the Bachelor in City Planning (B.C.P.) at M. I. T. after graduation from a liberal arts college. For architecture, three or four additional years are required. The total time and expense of this entire educational program may constitute serious obstacles, especially if the student then continues with post-graduate work, as more and more of the better students are finding it advisable to do.

In order, however, to facilitate the combination of residence in a liberal arts environment with residence at M. I. T. the Institute has entered into a combined 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 to include the basic sciences and humanities, a student of high standing may pursue a combined five-year program in which the first three years are spent at the college and the last two (or three, in the case of architecture) at the Institute, leading to the Bachelor's degree from each institution. Thus one year is saved, and the degrees of both institutions and the experience of residence in both are secured.

The academic program at M. I. T. consists of three basic elements: (1) education in the humanities and social sciences; (2) education in basic mathematics, science, and applied science; and (3) education in a professional field. A student may accomplish this program in four years at M. I. T. Or, through the Combined Plan, he may receive his education in the humanities and social sciences, basic mathematics, science, and in some cases applied science, at the liberal arts colleges. He receives further education in applied science and in a professional field at M. I. T. This alternative pattern offered by the Combined Plan extends his undergraduate education to only five years instead of a possible six or seven years.

A student who wishes to follow this program should seek admission to one of the colleges listed below. His later transfer to the Institute under this plan will be contingent on his receiving the recommendation of the college. A faculty adviser has been appointed by each college to assist students in planning their programs, and to serve in a liaison capacity with the Institute.

The following colleges have united with the Institute in this program:

Amherst College, Amherst, Massachusetts
Bowdoin College, Brunswick, Maine
Carleton College, Northfield, Minnesota
Miami University, Oxford, Ohio
Middlebury College, Middlebury, Vermont
Oberlin College, Oberlin, Ohio
Ohio Wesleyan University, Delaware, Ohio
Pomona College, Claremont, California
Reed College, Portland, Oregon
Ripon College, Ripon, Wisconsin
St. Lawrence University, Canton, New York
Washington and Jefferson College, Washington, Pennsylvania
Wesleyan University, Middletown, Connecticut
College of William and Mary, Williamsburg, Virginia
Williams College, Williamstown, Massachusetts
College of Wooster, Wooster, Ohio

EDUCATIONAL BUILDINGS

The characteristic spirit of the Institute finds its material embodiment in its extensive educational buildings 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 coordination of structure permit flexibility in the allotment of space to the departments and promote desirable cooperation 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 cooperative projects, to be studied and solved cooperatively.

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 Laboratory for Nuclear Science and Engineering, the Research Laboratory of Electronics, the Gas Turbine Laboratory, the Acoustics Laboratory, the Metals Processing Laboratory, the John Thompson Dorrance Laboratory for Biology and Food Technology, the Spectroscopy Laboratory, the Guggenheim Aeronautical Laboratory, the Wright Brothers Memorial Wind Tunnel, the Supersonic Wind Tunnel, the Pierce Engineering Laboratory, the Sloan Automotive and Aircraft Engine Laboratory, and the Laboratories of Steam and Compressed

Air, Refrigeration, Testing Materials, Hydraulics, Metallurgy, Chemical Engineering, Physical Chemistry, Applied Physics, Electrical Engineering, and Geology and Mineralogy.

THE LIBRARIES. The M. I. T. Library system, with resources in excess of 465,000 volumes, is designed to facilitate and extend Institute programs of study and research. A comprehensive current collection of about 2,500 periodicals, some 1,000 government document series, 2,800 transactions, yearbooks, and other serials, together with extensive back files, complement strong bibliographic and book holdings in all major fields of interest. Formerly the Libraries were organized around a central and nine relatively small branch libraries; by the opening of the fall term, 1952, a reorganization will consolidate the collections in a General Library and five large branches: Architecture (Rotch Library), Engineering, Humanities, Industrial Management (Dewey Library), and Science.

The General Library (Charles Hayden Memorial Library, second floor, south wing) is the administrative, bibliographic, and custodial center of the Library system. Book purchase, processing, reference, and circulation are centralized. The union catalogue of all books in Institute Libraries together with reference and bibliographic resources, maps, rare books, and a thesis collection are found in the General Library. In addition, large collections of books in all fields including lesser used titles are kept in the General collection. Special facilities include: the Boston Stein Club Map Room with the unique six-foot revolving relief globe, the Young collection of early American globes, the Theodore Schwarz and other map collections, and related books; a projection room for 16mm motion pictures; the Dard Hunter Museum of handmade paper and early printing; the Microreproduction Laboratory with facilities for making and using micro and other documentary reproductions.

The Arthur Rotch Library of Architecture and Planning (Room 7-238) contains the collections on Architecture, Housing, and City Planning with associated fine arts, pictorial material and lantern slides.

The Engineering Library (Room 10-550) comprises the Vail Library of Electrical Engineering, the major collections in Civil and Mechanical Engineering, Building Construction, Naval Architecture and Marine Engineering, and (in Room 33-304) Aeronautics.

The Humanities and Social Sciences Library (Charles Hayden Memorial Library, first floor, north, east, and west wings, and second floor, south wing) comprises a reserve book and reading room including the Tubby Rogers Collection of selected recreational reading, a well-equipped exhibition gallery, and an exceptional music library of recordings, transcriptions, scores and books, with a seminar and individual listening rooms. On the second floor in the General Library are advanced collections in literature, humanities, and social science.

The Dewey Library of Industrial Management (Sloan Building, third floor) contains the Industrial Relations collections and books in Economics, Management, Accounting, and related fields.

The Science Library (Charles Hayden Memorial Library, first floor, south wing) contains basic material in the fields of Science including the Eastman Library for advanced study in Mathematics, Physics, and Chemistry, the Lindgren Library of Geology, Ceramics, and Metallurgy, and the Biology-Food Technology Library.

Users of the Libraries are required to identify themselves by Bursar's cards or Library cards. Seniors, graduate students, and others engaged in thesis or advanced research are eligible for stack permits. Individual reference service, bibliographic aid, or assistance in using the card catalogue are available at the General Reference Desk where books and periodicals not in the Library can frequently be obtained on interlibrary loan or in the form of photostats or microfilms.

Library hours, formerly 9 to 9 weekdays and 9 to 4 Saturdays in regular session, are being reviewed and extended. The new schedule will be announced.

An Introduction to the Institute Libraries distributed to all new students with registration material should be supplemented by the more detailed handbook, *The M. I. T. Libraries: Organization, Resources, Facilities*, available in September at the Circulation or Reference desks, General Library.

MUSEUMS. Many departments have their own exhibits, along the corridors adjacent to their laboratories and offices. These exhibits, largely the result of the research or the ingenuity of the staff, broaden and enrich the educational program of the students. In addition, two of the most significant museums 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 the Allan Forbes and Arthur H. Clark print collections. The collections of ceramics and of minerals, though not fully displayed in public, are also distinguished.

In addition to the permanent exhibitions, the Institute provides monthly exhibitions covering the fields of art, of craft, and of the other works of man. These are displayed in the public lobbies of the Institute and in the New Gallery in the Hayden Library. These presentations are often the only showings in the Boston area, and range from handcraft to machine craft, from primitive art through that of the fully developed periods to the art of the experimental present. The New Gallery enables the Institute to have exhibitions of fine arts material of great value. The exhibition program is intended to introduce to the Institute family presentations of new ideas and to enrich the cultural life of the Institute community.

SUMMER SURVEYING CAMP. 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 seven weeks 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, and office accommodations for the Staff.

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.

ESTIMATED COST OF A COLLEGE YEAR

Before enrolling in the Institute, each student is urged to make an accurate estimate of his expenses. There are certain basic expenses that every student will have to meet irrespective of his resources or individual tastes. The following minimum estimate of expenses is for an academic year of two terms, including recesses and holidays which fall within and between these terms, making a total of 37 weeks.

Tuition, two terms (in 1953–54)	$ 900.00
Board, 37 weeks	525.00
Room	260.00
Books and Materials	68.00*
Insurance	22.00
	$1,775.00

Excluded from this estimate are variable and personal expenditures such as transportation, clothing, laundry, and recreation for which each individual should make his own estimates. The amount for board is based on actual meal costs (average) in the Institute cafeteria dining services; payment is by the meal, and individual variations are to be expected.

STUDENT RESIDENCES. The Institute has no specific regulations, at this time, as to the place where upperclassmen must live, and they are free to make whatever living arrangements they choose. However, the Institute believes that it is to the great advantage of all freshmen who do not live at home to live in Institute houses or in fraternities, and such residence is required unless other special arrangements are approved by the Dean of Students. Priority is given to entering freshmen in the twelve residence halls of the East Campus houses. In general, the living arrangements of the student body of the Institute divide into the following major groups:

First, there are some 2,000 men housed on the Campus in several units: the Baker House accommodates 350, with dining service; the East Campus residence halls 720, with dining service adjacent, in Walker Memorial; the Graduate House, with its own dining service, 450 graduate students; and the Burton House on the West Campus, approximately 600 men. The Women's Dormitory (across the Charles River from M. I. T.), at 120 Bay State Road, Boston, with a house mother in charge, accommodates 17 students, or one fourth of the women enrolled; meals are served in the house.

Second, the 26 fraternities accommodate about 800 undergraduates. All of these serve meals for members. Four of the fraternity houses adjoin the Campus, while most of the others lie within convenient walking distance. Freshmen who elect, upon invitation, to join fraternities, commonly do so early in their first year, and frequently take up immediate residence in the chapter houses.

Third, there are 270 married students, who, with their families, occupy houses in "Westgate" or apartments in "Westgate West," both on the Campus. First preference is given to veterans of World War II.

The fourth group consists of those students who live away from the campus, either at home, if that is within commuting distance, or in lodgings or apartments in the Cambridge and Boston areas. Upon receiving notice of admission, all new students are given opportunity to apply for living accommodations on the Campus.

The room cost given in the above yearly estimate is the minimum rate in the Institute houses, and the current maximum is $360. (See Appendix C, Housing.)

Outside lodgings, unless of inferior grade, can seldom be obtained below the rate in the Institute houses. The fraternities average approximately the same as the cost in the Institute houses, depending on the manner of living decided upon by the several groups.

FINANCIAL AIDS

SCHOLARSHIPS, LOANS, FELLOWSHIPS, PART-TIME EMPLOYMENT

Scholarships have been established by deeds of gift to aid needy and deserving students. All incoming and undergraduate students may apply for scholarship aid. Except for those students who enter under the Combined Plan, students who have attended another college will not be eligible for scholarship aid until they have satisfactorily completed one year's work. Applications for scholarship

*Not included in this estimate: $25 deposit for chemical supplies and breakage for all students who take chemistry. Incoming Freshmen should allow $40 more for non-recurring items, such as slide rule and drawing instruments. Books and supplies may be purchased at the Technology Store.

are thoroughly considered by the Faculty Committee on Student Aid which makes all awards.

ENTERING FRESHMEN: For students of limited means who need help in meeting their expenses, the Institute has available scholarship grants (full and part tuition) for the freshman year. Approximately one third of the entering class receive some aid from this source, which includes the William Barton Rogers and Desmond awards of $1,200 for the first year, Development Fund Scholarships, nineteen Alumni Regional scholarships of full tuition and other grants carrying stipends from $100 to $600. Application must be made before February 14. (See Appendix A for complete details.)

UPPERCLASSMEN: After one year of residence any undergraduate may apply for scholarship aid. Applications are made to the Faculty Committee on Student Aid and grants are made on the annual basis with stipends ranging from $100 to $500 per year dependent not only on academic excellence but also on satisfactory evidence of need. Also available after one year of residence for students with satisfactory academic records is the Technology Loan Fund. Awards are made from this fund, on application to the Technology Loan Fund Board, in addition to any scholarship grants and may reach full tuition for any one year with a maximum of $2,700 for the three later years of the Undergraduate Course. Loans bear interest at one per cent and are repayable at the rate of $50 every six months after graduation. (See Appendix A for complete details.)

GRADUATE STUDENTS: Graduate Scholarships and full- and part-time Assistantships are available for qualified students pursuing work leading to the Master's or Doctor's degrees. Graduate students are eligible for loans from the Technology Loan Fund under conditions similar to those outlined above for undergraduates. (See Appendix A for complete details.)

STUDENT EMPLOYMENT: An office of Student Personnel is maintained to assist students desiring to help themselves in meeting part of their expenses. It is to be understood, however, that the requirements of the Institute curriculum are such that only a limited amount of time may be given to employment, and prospective students are advised to have sufficient funds to cover the expenses of the first year at least. The maximum that can be earned through part-time employment does not usually exceed one hundred-fifty dollars per term and the general average earned is in the order of one hundred dollars. These amounts may be realized in a number of jobs on the Campus such as those in the dining services, the library, and residence halls. Some outside jobs are available in Boston and Cambridge but these are likely to be limited by the difficulty in scheduling them without conflict with academic appointments. Students from foreign lands, in particular, should clearly understand that the opportunities to secure remunerative employment are seriously restricted by their unfamiliarity with the English language and American business customs.

FEES, DEPOSITS, PAYMENTS, EXPENSES

The following tuition fees apply only to the academic year 1952–1953. All tuition fees beginning June 1953 will be at the rate of $450 per term.

TUITION FEES. The regular tuition fee is $400 per academic term.

No bills are sent. All payments should be made to D. L. Rhind, Bursar, Massachusetts Institute of Technology, Cambridge 39, Massachusetts, by the time specified in the registration instructions issued prior to the opening of each term. Students desiring periodic payments within each term, should consult with the Bursar or Assistant Bursar at least ten days prior to the beginning of each term. *Students are advised to make their payments by mail.*

Veterans under PL346 will file certificates of eligibility or re-entrance in the office of the Veterans' Division of the Bursar's Office.

(a) The tuition fee for students taking cooperative work in Course VI-A after the second year is $267 for each term including the summer term, provided that the student attends three consecutive terms in a twelve-month period, one of which must be at the works; otherwise, the regular term tuition of $400 is applicable.

(b) Students in Course II-B or XVI-B will pay the tuition fees as listed in the Summer Session Catalogue for the subjects they register for during the Summer Session they attend. They will also register and pay a $50 tuition fee for the six (6) months' period they are at the plant.

(c) For Course X-A (including three stations and Chemical Engineering Design 10.53) or for the Engineering Practice School at Oak Ridge, for the period July through January or February through July the tuition fee is $400. For a single X-A field station, the fee is $135; for subject 10.53 if taken separately, the fee is $95.

(d) Regular students (other than doctoral candidates) and Special Students, including D. I. C. staff appointees, taking only a few subjects or thesis (special students not permitted to do thesis) who apply to the Bursar for a reduction will be charged at the rate of $12 per unit credit (minimum $50 — maximum $400). A regular student is one who is enrolled as an applicant for an academic degree; others are special students (see page 45).

(e) The fee for the General Examination for the Graduate Engineering degree is $75.

(f) The fee for the extension or initiation of the doctoral thesis only, with or without writing, presentation, and final formalities or for the General Examination only, is $400 per term.

(g) The fee for thesis writing and presentation *only*, with or without thesis examination, is $50 for the Bachelor's, Master's or Graduate Engineering degree and $75 for the Doctor's degree.

TUITION REFUNDS. Full-time students withdrawing before the end of the term will be charged $30 per week up to last day of attendance; for others the charge will be proportionately adjusted.

Dormitory Rentals. All term rentals, both for the Graduate House and all Undergraduate Houses are to be paid to the Bursar or arrangements made with him for payment in advance of the beginning of the academic term under the same conditions pertaining to the payment of tuition fees. *No bills are sent.*

Commons Meals. All students taking commons meals must pay the required term fee to the Bursar or arrangement must be made with him in advance of the beginning of the academic term under the same conditions as those pertaining to the payment of tuition fees. *No bills are sent.*

Other Fees. A charge of $5 is made for each condition or advanced standing examination taken, and $5 for the removal of each deficiency. Health insurance is required of all students except Army, Navy and Air Force students, veterans enrolled under Public Law No. 16, and D.I.C. employees, unless a waiver is signed before September 15, 1952, the date the insurance goes into effect. Any student registering after September 15 will be insured only from the date of filing registration material. The insurance premium is $11 per term. (See under Health of Students, elsewhere on this page.)

Late Registration or Payment Fine. A fine of $5 is imposed for late registration or late payment of tuition, dormitory rent, or commons meals contract. Students should note that registration is not complete until all fees are paid or arranged for.

Deposits to Cover Chemical Supplies, Military Uniforms, etc. All first-year students and all students taking Military Science, MS21 and MS22, will be required to make a deposit of $25, from which the costs of laboratory chemicals and supplies, shoes, non-returnable equipment and damage to military uniforms are to be deducted.

All upperclassmen and graduate students taking subjects requiring the use of the Office of Chemical Laboratory Supplies will be required to make a deposit of $25 against which the cost of laboratory chemicals and supplies will be charged.

All deposits must be made at the beginning of the academic year.

If the total cost of chemicals and supplies used exceeds the amount of this deposit, an additional amount sufficient to cover this excess must be paid.

No refund of deposits will be made during the school year except to students leaving the Institute

Tuition Fees for Academic Staff Appointees

(a) An academic staff appointee shall be permitted to register as a student and to progress toward a degree in accord with the following scale of fees except as noted below under (b).

Appointment	*Tuition Per Term*
Full-time	$150
Half-time	240
Third-time	320

(b) A staff appointee whose conditions of employment give him the opportunity to progress at the rate of a full-time student as determined by his department and approved by the Dean of the Graduate School shall pay the full tuition fee of $400 per regular academic term irrespective of unit registration. This situation may arise, for example, when assigned research of an academic staff appointee is approved for thesis.

(c) The fee for the extension or initiation of doctoral thesis only, with or without writing, presentation, and final formalities, or for the General Examination only, is $150 for full-time staff appointees, $240 for half-time and $320 for third-time per term.

(d) The fee for thesis writing and presentation *only*, with or without thesis examination, is $50 for a Master's or Graduate Engineering degree and $75 for a Doctor's degree.

(e) A member of the academic staff (not D. I. C.) may attend classes in one or more subjects as a listener without credit and without payment of tuition if such attendance is recommended by the Head of his Department. No formal registration is required but admission to the classes is subject to the approval of the instructor in charge. The staff member should present a written request approved by the Head of his Department to the instructor in charge.

HEALTH OF STUDENTS

The Institute maintains a well-equipped Medical Department with headquarters in the Homberg Memorial Infirmary. Under the supervision of the Medical Director, a staff of twenty-four doctors conducts various clinics daily except Saturday and Sunday. Clinics are maintained in Internal Medicine, Surgery, Orthopedic Surgery, Psychiatry and Neurology, Ophthalmology, Otolaryngology, Dermatology and Occupational Medicine. In addition, the Dental Service supplies emergency, diagnostic, and prophylactic service daily.

The staff physicians are in attendance from 8.30 A.M. to 5 P.M. Monday through Friday, and a graduate nurse is on duty from 8:30 A.M. to 4:30 P.M. At other times emergency treatment is given in the Infirmary on the third floor, where a physician is either on duty or on call. In connection with the clinics adequate X-ray and laboratory facilities are maintained. Any student may receive routine medical care in the clinic without charge. If he is referred to one of the special clinics, a moderate fee is charged. Psychiatric service will be charged for after the fifth interview in any one academic year. Insured students are seen in the various special clinics, including psychiatry, without charge other than the insurance premium.

In addition to the clinics, the Homberg Memorial Infirmary building contains a hospital equipped to care for twenty-one bed patients. There are three finely appointed, attractive wards and six private rooms. In addition, an emergency ward is available for epidemic seasons with a capacity of thirty extra beds. A 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 in attendance.

The charges for students are low: food, nursing, and medical care in the wards cost six dollars a day, and the same service in a private room is furnished for eight dollars a day. For insured students the cost of these services is borne by the insuring agency.

A health insurance plan has been adopted by the Institute for all students for a premium of $11 per term. In return for this sum the insurance agency agrees with certain limitations to pay up to $1,000 toward meeting the cost of each illness or injury. Details of this plan may be secured at any time upon application to the Medical Department. If any student is already adequately protected by insurance or if for any other reason he does not wish to be enrolled in this plan, he may sign a waiver which is a part of the Bursar's Registration Card. To be effective, this must be done before September 15, 1952, the date the insurance goes into effect. No exceptions will be made after that time. Insurance is not required for Army, Navy or Air Force students or for those veterans enrolled under Public Law No. 16. Any student registering after September 15 will be insured only from the date of filing registration material. Insurance is not available to full-time D.I.C. staff employees taking one or more subjects.

Every entering student, undergraduate or graduate, is required to be immunized against tetanus and smallpox prior to matriculation. After registering, he is required to report to the Medical Department for a complete physical and dental examination within six weeks after matriculation. All other students are required to have an X-ray of the chest each calendar year, an appointment for which should be arranged with the Medical Department. This X-ray will be done without charge before December 15, 1952, but after that date there will be a charge of $5.00. For students entering the second semester, there will be no charge until after March 1, 1953. Each student should also have a physical examination in addition to his X-ray in the year prior to his graduation.

No student is permitted to engage in intercollegiate or intramural athletics without having had a physical examination sometime during the academic year in which he participates in the sport.

In case of serious illness involving major operations or complicated medical emergency procedures the student is transferred to one of the Boston or Cambridge hospitals, and then may return to the Infirmary for convalescence. Contagious disease cases are transferred to the Haynes Memorial Hospital in Brighton. Fees at these hospitals are paid by the student or his family, or if insured, by the insuring agency.

GENERAL REGULATIONS

ACADEMIC YEAR. Exercises of the Institute begin on the Monday prior to the last Monday in September and end early in June. In order that freshmen may be properly oriented to the Institute and take various tests administered to all freshmen, the Fall Term for freshmen will begin on the Thursday preceding Registration Day. The exercises are omitted on the following Massachusetts legal holidays: January 1, February 22, April 19, May 30, July 4, Labor Day, October 12, November 11, Thanksgiving Day and December 25.

OFFICIAL NOTICES. It is the student's responsibility to keep informed of all official notices on the Official Bulletin Boards.

REGISTRATION. At a date specified in the registration instructions, before the opening of each term, the student is required to fill in and present registration forms to the Registrar.

REGISTRATION OFFICERS AND ADVISERS. Each student is assigned to a Registration Officer who is a member of the Faculty having responsibility for, and control of, his academic program. Above the first year there is a Registration Officer for each Course for each year. These Registration Officers serve as academic advisers and insure that each student's particular problem will receive individual consideration.

The Dean of Students is the general consultant and adviser for all students and represents the President in all matters pertaining to student activities, group and individual relations. On request to his office, special advisers will be assigned to students. The Deans of Architecture and Planning, Engineering, Science, Humanities and Social Studies, and Industrial Management and the Heads of the several Departments also serve as consultants to students who seek advice relating to their choice of professional Courses. It is not intended that these advisers shall become, in any sense, guardians of students assigned to them, nor does the Faculty by this action assume any responsibility for the conduct of students outside the halls of the Institute. It is assumed that all students are self-reliant, responsible individuals capable of managing their own affairs and seeking such advice as from time to time they may require. The Office of the Dean of Students is the central clearing house for all matters pertaining to general student welfare.

ATTENDANCE. After approval of his registration, the student is required to attend all exercises, including the final examinations, in the subjects for which he is registered. Irregular attendance or habitual tardiness may lead to probation or suspension. Students are expected to follow the program assignments as published in the official Class Schedules between the hours of 9 A.M. and 5 P.M. There are no classroom exercises on Saturday after 1 P.M. Students who withdraw during the term should obtain the approval of the Dean of Students, the Associate Dean of Students, or the Dean of Freshmen and give notice to the Registrar.

FACULTY-STUDENT RELATIONS. The Faculty assumes that all students come to the Institute for a serious purpose, and that they will conform cheer-

fully to such regulations as, from time to time, may be made by the Faculty, Administration, the Institute Committee (student government), or the governing body of the Institute houses. It is the general policy to have as few rules and regulations as are consistent with efficient administration and the general welfare. Insofar as is possible, the regulation of the day-to-day affairs of students, residence in the Institute houses or fraternities, extra-curricular activities, including athletics, in fact, every phase of life at the Institute except the academic program, is the responsibility of student government.

In case of injury to any building, or to furniture, apparatus, or other property of the Institute, the damage will be charged to the student or students known to be immediately concerned; but if the persons who cause the damage are unknown, the cost of repairing it may be assessed equally upon all the students of the school.

Conduct inconsistent with general good order, or persistent neglect of work, or failure to respond to official notices, or to meet class or examination schedules may lead to probation or dismissal. Students placed on probation by the Committee on Discipline shall be required to report to the Dean of Students as directed.

It is the aim of the Faculty to maintain the highest standards of integrity. The attempt of any student to present as his own the work of another, or any work which he has not honestly performed, or to pass any examination by improper means, is regarded by the Faculty as a most serious offense, and renders the offender liable to immediate expulsion. The aiding or abetting of a student in any dishonesty is also held to be a grave breach of discipline.

The Faculty has approved an experimental program for section quizzes in which as many sections of the Freshman Class as may elect to do so, by unanimous vote, may operate under "the Honor System." There is no disparagement of students who do not participate in this privilege. All students not under the Honor System are proctored in order that no individual student in competition with all others may by dishonest means gain higher grades than he deserves.

A Faculty-Student Committee composed of an equal number of representatives from both groups meets regularly for discussion of matters pertaining to the curriculum, teaching methods, schedules, and, in fact, all relations of students and Faculty.

Examinations. *Final Examinations* are held at the end of each term, the schedule being issued about a month prior to the examination period. Each student is held responsible for obtaining an examination schedule at the Information Office, Room 7-111; for attending the final examinations required in the subjects for which he is registered; and for reporting any conflicts in his examinations *before* the time limit given on the examination schedule.

No member of the instructing staff is empowered to grant excuse from a final examination. Absence from any final examination is equivalent to complete failure except as, on presentation in writing of adequate evidence of sickness or other valid reason for the absence, the Dean of Students may permit a student whose term work has been satisfactory to take an ensuing examination on the subject.

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

Condition Examinations. A conditional grade received by a student as a term record can only be removed by examination or repetition of the subject. These examinations will be held in March for conditions of the first term; condition examinations for subjects taken in the second term will be given in September, prior to the opening of the fall term. Each student is held responsible for obtaining an examination schedule and filing an application card for the condition examination *before* the time limit given on the schedule.

A student not taking an examination at the scheduled time forfeits the right to the examination. A student who takes a condition or advanced standing examination in a given term, and fails to pass it, is not allowed to register for that subject in the same term.

Examinations for Advanced Standing. Registered undergraduate students of all classes, with a cumulative rating of 3.50 and above, may take examinations for advanced standing during the condition examination periods in each term provided that they have never been registered for the subjects, or have never attended classes in the particular subjects. Notice of intention must be filed with the Registrar on the usual petition forms, and must be submitted at least two weeks before the day of the first scheduled examination of the examination period. Endorsement by members of the Faculty is not necessary except that examination in a subject which involves laboratory instruction or drawing, must be approved by the Faculty member in charge.

Petitions. The Committee on Academic Regulations is the Faculty body through which the student may appeal for special consideration of his individual case. All requests must be submitted in writing on petition blanks which may be obtained at the Information Office, Room 7-111.

RECREATIONAL FACILITIES

Walker Memorial, built in memory of President Francis Amasa Walker, is the center of the social activities of the Institute. The building was finished in 1917 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 various student activities, and a fencing room. Below are recreation and reading rooms, and a comfortable and interesting recreation center with a small dance floor and soda bar where students can bring their "dates." On the first floor are a large

dining hall with cafeteria service, a comfortable lounge and reading room, and the office of the governing undergraduate body, the Institute Committee. In the basement are bowling alleys, student activity offices, and a lounge room for the "5:15 Club," an organization of commuting students.

Adjacent to this building and the East Campus houses are four clay tennis courts, and the Alumni Swimming Pool completed in 1940, which contains a deep pool for recreational swimming, and a shallow one for use by beginners.

The Barbour Field House has, in addition to modern shower and locker facilities, special rooms for visiting teams and offices of the Athletic Association. Connected with the Field House is a modern building containing eight squash courts.

On the land west of Massachusetts Avenue are fields for soccer, lacrosse, baseball, softball and football; eight hard surface tennis courts, a quarter-mile cinder track with a 220-yard straightaway, and a standard one-twelfth mile banked board track with a 60-yard straightaway. The John Rockwell Athletic Cage provides an indoor area 165 x 200 feet for recreational and varsity athletics during the winter months. By arrangement with the Commonwealth of Massachusetts the State Armory located adjacent to the Athletic Cage provides additional facilities for athletics, especially intramural basketball and volleyball. Briggs Field House provides excellent additional locker and shower facilities serving the Armory, the Rockwell Athletic Cage and the playing fields.

A boathouse on the Charles River, supplied with indoor rowing machines, offers to all undergraduates the opportunity to learn under competent coaching how to row in an eight-oared shell. The Sailing Pavilion, located on the Charles River in front of Walker Memorial, is the headquarters of the Nautical Association.

Students who wish to pursue or develop hobbies as a recreation have access to the Hobby Shop — a name describing both a physical facility and the group of students brought together by it. Since the shop was opened in 1938, with space and equipment provided by the Institute, it has been doubled in size. The shop is equipped with all the tools necessary for woodworking, metal working, gem cutting, bookbinding, radio, photography, electroplating, and telescope making.

UNDERGRADUATE ACTIVITIES

To complement and aid its educational work and to enrich its community life, the Institute provides extensive opportunities for students to participate in those extra-curricular pursuits — athletic, literary, musical, dramatic, and social — which further the development of character and personality, and yield health, pleasure and friendship. These enterprises are administered by the students themselves, under a well-organized system of student government, which inculcates responsibility, leadership and initiative.

THE INSTITUTE COMMITTEE. All student activities are supervised by the Institute Committee, the legislative and judicial body of the M. I. T. Undergraduate Association. On this Committee sit elected representatives of the four classes and delegates from twenty-five of the more important student activities. The full Committee, numbering thirty-seven members, meets at least bi-weekly to consider all matters pertaining to undergraduate affairs. It has jurisdiction over all undergraduate organizations.

Subcommittees of the Institute Committee supervise the finances of undergraduate activities allocating all funds appropriated by the Institute for the support of student organizations, investigate infractions of the community rules and standards and recommend remedial action, consider jointly with Faculty and Administration matters affecting students, represent the M. I. T. Undergraduate Association in the National Student Association, administer Walker Memorial, supervise all elections, and control the publicity and public relations of student organizations and activities.

The headquarters of the Institute Committee are on the first floor of Walker Memorial.

ATHLETICS. The purpose of athletics at the Institute is not especially to develop highly trained athletes, but rather to encourage all students to participate competently in some form of physical recreation. Control is vested in an Athletic Board composed of Alumni, Faculty and Student Members, and the M. I. T. Athletic Association, an undergraduate organization composed of all captains and managers of varsity teams as working members, and assistant managers and officials of class teams as associate members. Funds are appropriated by the Institute and disbursed by the Undergraduate Association.

No attempt is made to concentrate on coaching the few men composing a single varsity team, but instruction is given to all men reporting for a sport. As a corollary to this, the success of a given athletic activity is gauged by the number of men it attracts. Sports represented by both Varsity and Freshman teams in intercollegiate competition are: track and field, cross-country running, rowing, baseball, skiing, hockey, basketball, fencing, golf, lacrosse, rifle, swimming, tennis, soccer, squash racquets, pistol, sailing, wrestling. Spirited intramural league competitions are held annually in the sports of touch football, basketball, softball, volleyball, swimming, track, tennis, squash racquets, table tennis, and bowling.

NAUTICAL ASSOCIATION. The Nautical Association offers every student an opportunity to learn sailing. A fleet of forty-eight dinghies, constituting a special Technology class designed by Technology men, and four 24-foot sloops are available for sailing on the Charles River Basin. The Sailing Pavilion, located directly in front of Walker Memorial, provides a large landing float, a rigging and maintenance shop, and storage space.

The Association sponsors a shore school, offering instruction in the theory of sailing and in the handling and maintenance of yachts.

PUBLICATIONS. Undergraduate publishing activities offer opportunities for students to broaden contacts and to acquire practical experience in journalism which may in later years prove to be of material value. All work incident to the editing and financing of the publications is carried on by students, with an Alumni Advisory Council available for consultation.

There are four self-supporting undergraduate publications: *The Tech*, the student newspaper; *The Tech Engineering News*, a monthly technical journal; *Technique*, the yearbook; and *Voo Doo*, a comic magazine. *The Tech*, the official undergraduate news organ, is one of the oldest of college newspapers, having been founded in 1881. *The Tech Engineering News* is the undergraduate scientific magazine, to the editorial columns of which prominent graduates and professional men, as well as undergraduates, contribute. Quite frequently its articles are quoted in professional technical journals, and it has won numerous awards as an outstanding student journal. *Technique* is the yearbook containing pictures and records of seniors and graduate students and, in addition, accounts of all regular undergraduate activities and outstanding social functions of the year.

MUSIC, DRAMA AND DEBATING. The Combined Musical Clubs offer many opportunities to those who would like to sing or to keep up their skill in playing musical instruments. The glee club, the symphony orchestra, and the concert band rehearse weekly and present several concerts at M. I. T. as well as at various colleges in New England. The choral society, a mixed choral group, concentrates on madrigals, cantatas, oratorios, which are presented in public concerts with orchestra and soloists. A dance band consisting of M. I. T. students is in frequent demand for dances in and around Boston. For students interested in dramatics and theatricals, two different activities are available: the *Dramashop*, which produces several serious plays during the college year; and the annual musical comedy, *The Tech Show*, which is written, directed, and produced entirely by students. Opportunity to participate in intercollegiate debating is made available by the Debating Society. During the academic year the debaters make several trips to other colleges for exhibition debates and for tournaments. The annual New England Debate Tournament is held at M. I. T.

TECHNOLOGY CHRISTIAN ASSOCIATION. This organization aims to be of practical service and to foster among members of the Institute community the ideals of Christian living and active Christian service. It organizes students for social service and religious activity in Metropolitan Boston, maintains a theater ticket service and book exchange, manages the Tech House at Round Hill, South Dartmouth, and publishes the Freshman *Handbook*.

PROFESSIONAL, SOCIAL, HONORARY, AND SERVICE ACTIVITIES. In addition to these activities, there are some 70 others which have special appeal to smaller groups of the student body.

Each class elects its own officers who are responsible for the management of all class organizations and social functions. Each living group is governed by its own elected representatives: The Dormitory Committee for the Undergraduate Houses, the Inter-Fraternity Conference for the Fraternities, and the 5:15 Club for Commuters.

The Professional Societies, of which there are twenty-four, hold meetings to which outside lecturers are invited to discuss topics of professional interest. Their most important activity is the presentation of scientific papers by students, culminating in the Stratton Prize Contest.

The Honorary Societies are of two classifications. There are seven honorary professional societies such as Tau Beta Pi and Sigma Xi for scholarship; and there are honorary social and service societies.

The four religious organizations active on the campus offer opportunities for undergraduates of all faiths to meet socially and participate with others of similar concerns in cultural, social and religious work.

For foreign students, there are organizations where students of like nationalities may meet periodically to participate in cultural and social activities. Service groups, such as Alpha Phi Omega and the National Scouting fraternity, meet the need of students interested in such activities.

Hobbies, both scientific and recreational, are enjoyed by students participating in the many activities which exist to satisfy their desires for creative work. Some of these include: the Rocket Research Society, the Propeller Club; the Television Club; the Model R. R. Club; WIMX, the Radio Society; the Camera Club; the Flying Club; the Hobby Shop; and WMIT, the student radio station which affords those interested in directing and producing radio programs an opportunity to expand their talents.

Also extremely popular are organizations like the Outing Club, which promotes group activities (skiing, hiking, mountain climbing, square-dancing, etc.) with similar groups in other schools, and the Lecture Series Committee, which serves a very important function by arranging for distinguished lecturers to speak to the undergraduate body on non-technical topics of universal interest. A score of other organizations, social and honorary, furnish important adjuncts to student life.

RESERVE OFFICERS' TRAINING CORPS

A full explanation of the ROTC requirements for the United States Army and Air Force is given on page 86.

PLACEMENT

STUDENT. Without assuming responsibility for finding employment for its graduating class, 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 place-

ment 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 office is maintained to assist seniors and graduate students in obtaining interviews and opportunities with prospective employers.

ALUMNI. A Placement Bureau is also maintained by the Institute to assist alumni in securing positions for which they are particularly fitted, and to aid industry in selecting men for positions requiring engineering or scientific education. There is no charge for these services.

THE SOCIETY OF ARTS

The Society of Arts was provided for in the Charter of the Institute. In the early days, the meetings of the Society were given over to public lectures on new inventions and discoveries, followed by general discussions by the audience. Since 1917, the Society has presented an annual series of Popular Science Lectures. These discourses, always illustrated, are held in Huntington Hall on one week end in the months of December, January, February and March. The Friday and Saturday afternoon lectures are addressed primarily to seniors and science teachers in high and preparatory schools. On Sundays, the M. I. T. family and the general public make up the audience. Because they follow the lines of study and research for which the Institute is known, the lecturers explain many present-day developments in science and engineering.

THE LOWELL INSTITUTE SCHOOL

The Trustee of the Lowell Institute established in 1903, under the auspices of the Massachusetts Institute of Technology, a Free Evening School.

This School offers three regular courses — Mechanical Course, Electrical Course, and Structural Course each extending over two years; and a number of advanced or supplementary single subjects of varied length.

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

Circulars describing the courses of instruction, the nature of the entrance examinations, and other requirements may be obtained by sending a stamped, self-addressed envelope to Professor Arthur L. Townsend, Director, The Lowell Institute School, Massachusetts Institute of Technology, Cambridge 39, Massachusetts.

REQUIREMENTS FOR ADMISSION

ENTRANCE DATES

First Year students will enter only once a year, on the Monday prior to the last Monday in September.

ADMISSION FROM SECONDARY SCHOOLS

SELECTION OF APPLICANTS. Under the Institute's policy of stabilized enrollment, the size of the First Year class is limited. Since it is expected that the number of applications will exceed the number that can be accommodated, the Faculty Committee on Admissions will exercise discretionary powers of selection.

Preference will be accorded applicants whose evidence of academic fitness and of professional promise indicates that they are particularly qualified to pursue Institute Courses with success. It is the desire of the Faculty to admit only those candidates who possess qualities, both of character and intellect, which indicate their adaptability to an academic environment, and who show promise of their development into useful and forceful citizens.

CHOICE OF COURSE. The candidate is requested to indicate his tentative choice of professional Course at the time of filing his application. After admission, he may reconsider his choice; since every First Year student takes the same program of studies, he has the option of changing at any time during the first year. Continuation in a Course after the first year, or a change of Course, will depend upon the student's scholastic record, his apparent aptitudes for the particular field of work, and the facilities available at the Institute.

ACADEMIC PREPARATION. The better high and preparatory schools in the United States, and equivalent schools in other countries will, in general, provide suitable preparation to the student who takes full advantage of the opportunities which such schools afford. The candidate should bear in mind that the wider his intellectual development and the more extensive his attainments, the greater will be the advantages he may expect to gain from study at the Institute. The preparatory course should be a broad one, not confined to technical subjects.

Attention is called particularly to the necessity 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 for candidates from those states.

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. 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. Those who look forward to advanced work in research or design in a scientific or engineering field are likely to need a knowledge of German, Russian, or French, since there is an extensive and important technical literature in each of these languages.

APPLICATION PROCEDURE. A Preliminary Application form, which may be obtained from the Director of Admissions, should be filed as far as possible in advance of the anticipated date of entrance. This insures that the applicant will receive any 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 in January preceding 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.

INTERVIEWS. Applicants for admission to the First Year class, who live within one hundred miles of Cambridge, are expected to have a conference with the Director of Admissions. Office hours are nine to five, Monday through Friday; the office is closed on Saturday. It is not necessary to make an appointment in advance. All other applicants are expected to arrange a conference with the nearest Honorary Secretary, 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.

NOTIFICATION. 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. All candidates are required to take a one-day series of tests given by the College Entrance Examination Board. This includes the following tests: in the morning, the Scholastic Aptitude Test; in the afternoon, three one-hour achievement tests: (1) Advanced Mathematics, (2) English Composition, and (3) either Physics or Chemistry.

This group of tests forms a one-day examination sequence given in the principal cities of the United States and in foreign centers on the following dates:

Saturday,	December	6, 1952
Saturday,	January	10, 1953
Saturday,	March	14, 1953
Saturday,	May	16, 1953
Wednesday,	August	12, 1953

Candidates may choose any date they wish, or may divide the tests among two or more dates in the same year or in different years. However, March 14, 1953, is to be preferred, since notices of admission will be sent shortly after scores from these tests are received. A list of the places and dates of examinations is published each year by the Board. Application for the examinations must be made by the candidate on a form to be obtained from the College Entrance Examination Board, P. O. Box 592, Princeton, New Jersey. (Residents of Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming, should apply to the College Entrance Examination Board at P.O. Box 9896, Los Feliz Station, Los Angeles 27, California.) If the application is received sufficiently early the fee for the series is $12. 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.

SUMMER SESSION 1953. Preparatory subjects will be offered at the Institute from July 27 to September 4. These subjects are available for the following:

(a) students who have been admitted to the Institute but who wish to strengthen their preparation

(b) those whose preparation has failed to include certain subjects; such students may substitute the summer subjects for the corresponding entrance tests

(c) those not accepted who may wish reconsideration on the basis of achievement in Summer Session subjects.

Classes meet daily except Saturday. The following subjects will be offered:

5·00	Chemistry	1:00 P.M. to 5:00 P.M.
8·00	Physics	1:30 P.M. to 3:00 P.M.
E1	English	3:00 P.M. to 4:30 P.M.
M1	Algebra	8:00 A.M. to 9:30 A.M.
M3	Solid Geometry	9:30 A.M. to 11:00 A.M.
M4	Plane Trigonometry	11:00 A.M. to 12:30 P.M.

Admission to the Summer Session does not necessarily imply admission to the Freshman class.

ADMISSION WITH ADVANCED STANDING

A limited number of students whose previous studies entitle them to advanced standing credit will be accepted for the term beginning in September 1953.

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. Their eligibility for admission will be determined by the Committee on Admissions after a review of their records. They will be expected in every case to have completed the academic preparation required of students entering the Institute from secondary schools.

Applicants for admission with advanced standing should in general plan to take the College Transfer Test given by the Educational Testing Service on the mornings of the same dates as the College Entrance Examination Board tests. For information about the College Transfer Test, and for permission to take it, the applicant should write to the Educational Testing Service, Box 592, Princeton, New Jersey (or Box 9896, Los Feliz Station, Los Angeles 27, California). The fee for the College Transfer test is $6.00, payable to the Educational Testing Service. Advanced standing applicants who have not studied college mathematics or physics are in general requested also to take the College Board achievement tests in these subjects.

Students who plan to attend another college with the intention of later applying for admission to the Institute should note the Combined Plan of Study in effect between the Institute and certain colleges. (See page 33.)

ADVANCED CREDIT. Students admitted by transfer may expect to receive advanced credit for subjects of study completed elsewhere which are substantially equivalent to corresponding Institute subjects. A grade above the lowest passing grade is necessary.

All such credits are provisional and become final only after the student has demonstrated his ability to do satisfactory work in the Course of his choice. Students whose records appear not to warrant advanced credit in a subject may be permitted to demonstrate by passing an advanced standing examination that they are entitled to such credit.

A student in another college contemplating transfer to the Institute should so plan his program of study as to cover the basic subjects of the Course he expects to enter.

Application Procedure. A request should be sent to the Director of Admissions for a Preliminary Application form when the student first considers transferring to the Institute. By having the completed form filed with the Director of Admissions, the student will be assured of receiving any pertinent information as it becomes available. In January, 1953, final application material will be sent to the applicant. He should then submit to the Director of Admissions, enclosed in one envelope, the following:

1. Application for Admission with Advanced Standing, indicating all subjects which will have been completed at the time of transfer.
2. Certified transcript of college record to date, including a statement of honorable dismissal or its equivalent. A certified statement covering subjects subsequently taken should be sent as soon as it is available.
3. Catalogue pages describing all subjects which will have been completed; the applicant's name should be written on each page and each subject indicated by a check mark in the margin. Complete catalogues should not be sent.

As soon as the applicant's status is determined he will be informed whether or not he is admitted and how much advanced credit he will be granted. In some cases, it may be necessary to defer action until final grades are available.

All remaining questions about credits must be settled within two weeks after the opening of the academic year. In these cases, the student should consult the Director of Admissions.

Applicants desiring credit in Electrical Engineering Laboratory should present their reports as well as their college records in that subject.

Applicants seeking admission with advanced standing in Architecture will be graded in Design in accordance with their performance in their first problem.

SPECIAL STUDENTS

Qualified applicants wishing to carry on a special program of study with a clearly defined objective, may be admitted as Special Students. Such students are not candidates for a degree.

A prospective Special Student should first obtain an application form from the Director of Admissions. The application and program of study must be approved by the department in which the major part of his work is to be carried on, and by the Director of Admissions. The applicant must present academic credentials of high quality, or evidence of professional experience such as to justify the expectation that he can profitably undertake the program desired. In the absence of adequate academic preparation, Special Students will be required to take examinations in subjects prerequisite to those in which they wish to register.

FOREIGN STUDENTS

Students of foreign citizenship may enter the Institute only in the September term each year. Applications for admission will be reviewed on May 1. Completed applications should be in the Admissions Office by that date if a student wishes consideration for entrance the following September. Applications received before May 1, will be held until that date for action. Notices concerning admission will be sent out about May 20.

Action will not be taken on admission until complete application material has been received. Applications accompanied by incomplete credentials cannot be considered.

UNDERGRADUATE COURSES OF STUDY

THE purpose of the undergraduate Courses of Study is to prepare young men and women to accept the responsibilities of citizenship in a democracy and the challenge of opportunities for professional leadership. A wide choice of courses is offered, based on a large number of specified programs, each designed to provide the student with a sense of values and a broad training in one professional field. Flexibility in planning a program is provided by options and by the possibility of substitution of other subjects for certain of those specified in the principal courses of study described.

These Courses are designed to provide intellectual development in both non-technical and professional fields. Each Course has four principal parts: elementary science, including mathematics; basic subjects in the general fields of science, engineering, or architecture, but not specific to a single professional field; an integrated four-year program in the humanities and social studies; and a program of subjects within a single professional field. The scientific and professional subjects are basic in nature, stressing the development of the power to apply fundamental principles to the many different problems which the graduate may expect to meet. They are not designed to give detailed knowledge of industrial or professional practice, as such knowledge is best acquired in the course of subsequent employment or by advanced training in a professional field as provided by the Graduate School.

Elementary science, including mathematics, is represented by subjects taken in the first and second years; basic subjects in science, engineering, or architecture by subjects in the second and third years. An integrated program in general education runs through the four years. Professional subjects within the field of the student's special interest are generally taken in the third, fourth, and, in some cases, a fifth year. The program of the first year is common to all Courses, and the student need not decide upon his course of study until the end of the first year.

In the following list each Course is indicated by its name and the Roman numeral associated with it.

School of Architecture and Planning

SUBJECTS 4·00 TO 4·99

ARCHITECTURE, Course IV-A, leading to the degree of Bachelor in Architecture (B.Arch.).

CITY PLANNING, Course IV-B, leading to the degree of Bachelor in City Planning (B.C.P.).

School of Engineering

Courses leading to the degree of Bachelor of Science (S.B.)

AERONAUTICAL ENGINEERING, Course XVI. Cooperative Course in Aeronautical Engineering, Course XVI-B. Subjects 16·00 to 16·99.

BUILDING ENGINEERING AND CONSTRUCTION, Course XVII. Subjects 17·00 to 17·99.

CHEMICAL ENGINEERING, Course X, and CHEMICAL ENGINEERING PRACTICE, Course X-B. Subjects 10·00 to 10·99.

CIVIL ENGINEERING, Course I, with options: Theory and Design (1), Planning and Administration (2), Construction and Management (3). Subjects 1·00 to 1·99.

ELECTRICAL ENGINEERING, Course VI, with options: Electric Power (1), Electrical Communications (3), Electronic Applications (4). Cooperative Course in Electrical Engineering, Course VI-A. Subjects 6·00 to 6·99.

GENERAL ENGINEERING, Course IX-B.

MARINE TRANSPORTATION, Course XIII-C. Subjects 13·00 to 13·99 (suspended 1952).

MECHANICAL ENGINEERING, Course II. Cooperative Course in Mechanical Engineering, Course II-B. Subjects 2·00 to 2·99.

METALLURGY, Course III, with options: Metallurgy (1), Mineral Engineering (2). Subjects 3·00 to 3·99.

METEOROLOGY, Course XIX. Subjects 19·00 to 19·99.

NAVAL ARCHITECTURE AND MARINE ENGINEERING, Course XIII. Subjects 13·00 to 13·99.

SANITARY ENGINEERING. For undergraduate work see Civil Engineering, Course I.

School of Science

Courses leading to the degree of Bachelor of Science (S.B.)

CHEMISTRY, Course V. Subjects 5·00 to 5·99.

FOOD TECHNOLOGY, Courses XX and XX-A, and BIOCHEMICAL ENGINEERING, Course XX-B. Subjects 20·00 to 20·99.

GENERAL SCIENCE, Course IX-A.

GEOLOGY, Course XII-A, and Geophysics, Course XII-B. Subjects 12·00 to 12·99.

MATHEMATICS, Course XVIII. Subjects M1 to M99

PHYSICS, Course VIII. Subjects 8·00 to 8·99.

QUANTITATIVE BIOLOGY, Course VII, PHYSICAL BIOLOGY, Course VII-A, and CHEMICAL BIOLOGY, Course VII-B. Subjects 7·00 to 7·99.

SCIENCE TEACHING, Course IX-C.

School of Humanities and Social Studies

Courses leading to the degree of Bachelor of Science (S.B.)

ECONOMICS AND ENGINEERING. Course XIV-A, based on Mechanical Engineering; Course XIV-B, based on Electrical Engineering; Course XIV-C, based on Chemical Engineering. Subjects 14·00 to 14·99.

School of Industrial Management

Courses leading to the degree of Bachelor of Science (S.B.)

BUSINESS AND ENGINEERING ADMINISTRATION. Course XV-A, based on Physical Sciences; Course XV-B, based on Chemical Sciences. Subjects 15·00 to 15·99.

Roman numerals are used to designate courses of study. Individual subjects are numbered in arabic numerals according to the Department under which the instruction is given. Thus, subject 2·01 is a subject given by the Department of Mechanical Engineering; it is included in several Courses of Study other than that in Mechanical Engineering (Course II). Subjects given by Departments not offering courses of study include Graphics, subjects D1 to D99; English, subjects E1 to E99; History, subjects H1 to H99; Languages, subjects L1 to L99; Military Science and Tactics, subjects MS1 to MS99; and Music, subjects Mu1 to Mu99.

Architecture (Course IV-A) requires five years for the Bachelor's degree. Courses VI-A, VII-A, VII-B, and

XX-A are of five years' duration, and lead to two degrees: Bachelor of Science and Master of Science, awarded simultaneously. Course VI-A is a cooperative course involving an organized schedule of work in industry. Course IX-C is also of five years' duration and leads to the degree of Bachelor of Science from the Massachusetts Institute of Technology and the degree of Master of Arts in Teaching from Harvard University.

In addition to the prescribed curricula given during the regular academic year from late in September until early in June, certain courses require professional instruction during a summer period, as indicated under the appropriate undergraduate schedules.

MODIFICATIONS IN COURSES OF STUDY

Although the majority of students elect to follow one of the courses of study as outlined in detail in the next section, these programs may be modified in various ways. Substitutions may be made for some of the subjects listed in the several courses, subject to approval by the head of the Course and the Committee on Academic Regulations, especially when the student desires to follow a logical course of studies differing from those listed. Students may obtain credit for subjects by taking examinations for advanced standing. In this way students of superior ability may progress more rapidly, or may include extra elective subjects in the course of a four-year program.

Attention is called to Courses IX-A and IX-B, in which students may follow a logical program of studies designed to meet individual needs and interests not satisfied by one of the other more rigidly specified courses of study.

UNDERGRADUATE PROGRAM IN HUMANITIES AND SOCIAL SCIENCES

The humanities and social sciences are an integral part of education at M. I. T. Their purpose in the curriculum is to impress upon the student how important human relationships are in any society and to develop in him the first-rate human and social values which must accompany technical competence if an individual is to make his maximum contribution as a citizen.

The four-year program is based upon the theory that to achieve a well-balanced professional education a student should pursue these studies simultaneously with his studies in science and engineering. The program is constructed in a manner that will insure the student some breadth in the humanities and social sciences during his first two years and some depth in a more limited area in those fields during his third and fourth years.

In the first and second years each student will take a series of four subjects — H11, H12, H21, H22 — designed as an introduction to several areas in the humanities and social sciences and as a foundation for more advanced study in those areas during the third and fourth years.

The objectives of this basic program are:

1. To give the student an introductory knowledge of the most important issues, ideas, periods, and events of the past, selected on the basis of their relevance to the world today.
2. To emphasize the interrelation of the various humanities and social sciences as elements in human experience rather than the distinctive features which characterize them as different areas of academic study.
3. To introduce the student to the process of critical thought as applied in the humanities and social sciences.

Practice in written and oral expression is an integral part of the two-year basic program. Students whose written papers show a lack of knowledge of the fundamentals of composition will be expected to attend remedial sections until the deficiency is remedied. If, at the end of the first year, a student's written work is unsatisfactory, he may receive a deficiency in composition which can be removed by passing E25.

Each student in his third year will elect one of the eight fields listed below as an area for further study. Three subjects taken in the third and fourth years must normally fall within this area while the fourth will usually be a distributional subject in a different area. A student may, if he wishes, elect two additional term subjects in the humanities and social sciences in lieu of two professional electives.

Students enrolled in Courses I, II, II-B, III, IV-A, VI, VI-A, IX-A, IX-B, IX-C, XIII, XIII-C, XVI, XVI-B, XVII, XX, XX-A, XX-B are required to elect 14·01 sometime during their junior or senior years. Successful work in this subject will be credited either as the distributional requirement in humanities or as a part of an appropriate three-term combination.

Students enrolled in Courses IV-B, XV-A, or XV-B are required to elect 14·01, Economic Principles I, in the first term of their junior year under the same conditions as above. Students enrolled in Courses XV-A or XV-B will not receive credit toward their humanities requirements for any work in Field Seven, Labor Relations.

Students enrolled in Courses XIV-A, XIV-B, or XIV-C will not receive credit toward their humanities requirements for any work in Field Five, Economics, or Field Seven, Labor Relations, or for the subject 14·73.

SUBJECTS

First Year

First Term	H11	Introduction to Humanities and Social Sciences	3–5
Second Term	H12	Introduction to Humanities and Social Sciences	3–5

Second Year

First Term	H21	Introduction to Humanities and Social Sciences	3–5
Second Term	H22	Introduction to Humanities and Social Sciences	3–5

Third and Fourth Years

Any one of the following combinations of three subjects may be taken without the approval of a Humanities Adviser. Other combinations are not prohibited but must be specifically approved by a Humanities Adviser.

Subjects indicated by a dagger (†) may be taken as the single subject in a different field to satisfy the distributional requirement.

Students in the class of 1953 may satisfy the Fourth Year Humanities requirement by taking any two subjects from the list following, other than the two subjects used to satisfy the Humanities requirement for the third year for the class of 1953.

FIELD ONE: HISTORY OF IDEAS

H35† Nationalism and Growth of Nations in the West . . . 3–5
or
H71† Basic Ideas of West Politics & Ethics, 500 B.C. –1500 A.D. . . . 3–5

and

H36† Modern Europe . . . 3–5
or
H72 Rise of Mod. Pol. & Soc. Science, 1500–1914 . . . 3–5
or
14·92† Comp. Polit. & Ec. Systems 3–5

H73† Science & Phil. from Greeks to Copernicus . . . 3–5 and H74 Science & Phil. from Galileo to Present . . . 3–5 and

H81 Contemp. Ideas on Pol. & Econ. Dev. . . . 3–5
or
H82 Nat'lism & Nat'l Dev. . . . 3–5
or
H83 Phil. of Science . . . 3–5
or
H84 Topics in Hist. of Science . . . 3–5

H31† Topics in Amer. Civ. before 1860
or
H77† Amer. Intellectual Hist. to 1865 . . . 3–5

and

H32† Amer. Govt. & Society since 1860 . . . 3–5
or
H78† Amer. Intellectual Hist. from 1865 to the Present . . . 3–5
or
14·91† Amer. Pol. System . . . 3–5

FIELD TWO: POLITICAL, SOCIAL, AND ECONOMIC HISTORY

American History

H31† Topics in Amer. Civ. before 1860 . . . 3–5
or
H32† Amer. Govt. & Society since 1860 . . . 3–5

and

H31† Topics in Amer. Civ. before 1860 . . . 3–5
or
H32† Amer. Govt. & Society since 1860 . . . 3–5
or
14·91† Amer. Pol. System . . . 3–5

H61 American and British Leadership 3–5
or
H64 Historical Studies in Innovation 3–5
or
H67 Technology & Soc. in U. S. . . . 3–5

History of Foreign Relations

H33† Hist. of Amer. For. Policy . . . 3–5
or
H34† Rise of China and Japan . . . 3–5

and

H33† Hist. of Amer. For. Policy . . . 3–5
or
H34† Rise of China and Japan . . . 3–5
or
H36† Modern Europe . . . 3–5
or
14·51† Internat'l Relations . . . 3–5

H63 Topics in Amer. For. Policy . . . 3–5

European History

H35† Nationalism and Growth of Nations in the West . . . 3–5
or
H36† Modern Europe . . . 3–5

and

H33† Hist. of Amer. For. Policy . . . 3–5
or
H36† Modern Europe . . . 3–5
or
14·92† Comp. Polit. & Ec. Systems 3–5

H62 History of Russia . . . 3–5
or
H81 Contemp. Ideas on Pol. & Econ. or Dev. . . . 3–5
H82 Nat'lism & Nat'l Dev. . . . 3–5

Economic History

H51† Intro. to Econ. Development . . . 3–5
or
14.01† Econ. Principles I . . . 3–5

and

H52† Modern Industrial Society . . . 3–5 and H65 Contemporary Problems in Econ. Development . . . 3–5

History of Technology

H55† History of Engineering . . . 3–5 and H56 Technology and Society . . . 3–5 and

H64 Historical Studies in Innovation . . . 3–5
or
H67 Technology & Soc. in U. S. . . . 3–5

FIELD THREE: LITERATURE

E31† Books and Men . . . 3–5
or
E32† Books and Men . . . 3–5

and

E31† Books and Men . . . 3–5
or
E32† Books and Men . . . 3–5
or
E41T Literature of Greece . . . 3–5
or
E42T Non-Western Literature . . . 3–5
or
E43T Techniques of Drama . . . 3–5
or
E44T Nature of Poetry . . . 3–5
or
E45T Shakespeare & His Contemp. . . . 3–5
or
E46T Imaginative Mind since 1880 3–5
or
E47T Nineteenth Century Amer. Lit. . . . 3–5
or
E48T Twentieth Century Amer. Lit. . . . 3–5
or
E49T Russian Lit. of Nineteenth Century . . . 3–5
or
E50T The Bible . . . 3–5

and

E41T Literature of Greece . . . 3–5
or
E42T Non-Western Literature . . . 3–5
or
E43T Techniques of Drama . . . 3–5
or
E44T Nature of Poetry . . . 3–5
or
E45T Shakespeare & His Contemp. . . . 3–5
or
E46T Imaginative Mind since 1880 . . . 3–5
or
E47T Nineteenth Century Amer. Lit. . . . 3–5
or
E48T Twentieth Century Amer. Lit. . . . 3–5
or
E49T Russian Lit. of Nineteenth Century 3–5
or
E50T The Bible . . . 3–5

Any three of these subjects in German

- L14 Intermed. German 3–5
- L15T† Germ. Lit. 1919–1933 3–5
- L16T† Literature of Post-War Germany 3–5
- L20† Great Books & Authors in German Literature . . 3–5

Any three of these subjects in French

- L54 Intermed. French 3–5
- L55T† Contemp. Fr. Lit. 3–5
- L56T† Fr. Lit. of 3rd Republic 3–5
- L59† Great Books & Authors in French Literature 3–5

E31† Books and Men 3–5
or
E32† Books and Men 3–5
or
L15T† Germ. Lit. 1919–1933 3–5
or
L16T† Literature of Post-War Germany 3–5
or
L20† Great Books & Authors in German Literature 3–5
or
L55T† Contemp. Fr. Lit. 3–5
or
L56T† Fr. Lit. of 3rd Republic 3–5
or
L59† Great Books & Authors in French Literature 3–5

and L75† Language and Society . . . . . 3–5 and L76† Applied Semantics 3–5

FIELD FOUR: MUSIC

Mu31† Introduction to Music . . . . . 3–5 and Mu32 Western Music from Middle Ages to Present . . . . . 3–5 and

- Mu41 Classic String Quartet 3–5
  or
- Mu42 Twentieth Century Music 3–5

FIELD FIVE: ECONOMICS

14·01† Econ. Principles I . . . . . 3–5 and 14·02 Econ. Principles II . . . . . 3–5 and

- 14·03 Prices & Production 3–5
  or
- 14·09 Econ. Probs. Sem. 3–5
  or
- 14·21T Econ. of Patents and Invention . . 3–5
  or
- 14·40 Money and Income 3–5
  or
- 14·43 Public Finance 3–5
  or
- 14·54T International Trade 3–5
  or
- 14·95 Govt. & Econ. Pol. 3–5

14·01† Econ. Principles I . . . . . 3–5 and 14·51† Internatl. Relations . . . . . 3–5 and 14·54T Internatl. Trade 3–5

FIELD SIX: POLITICAL SCIENCE AND INTERNATIONAL RELATIONS

14·91† Amer. Pol. System 3–5
or
14·92† Comp. Polit. & Ec. Systems . . . 3–5

and

- 14·51† Internatl. Relations 3–5
  or
- 14·91† Amer. Pol. System 3–5
  or
- 14·92† Comp. Polit. & Ec. Systems 3–5

and 14·93 Issues in Contemp. Amer. Politics 3–5

14·01† Econ. Principles I 3–5
or
H31† Topics in Amer. Civ. before 1860 3–5
or
H32† Amer. Govt. & Society since 1860 3–5

and

- 14·91† Amer. Pol. System 3–5
  or
- 14·92† Comp. Polit. & Ec. Systems . 3–5

and 14·93 Issues in Contemp. Amer. Politics 3–5

14·01† Econ. Principles I 3–5
or
14·91† Amer. Pol. System 3–5
or
14·92† Comp. Polit. & Ec. Systems . . . 3–5
or
H32† Amer. Govt. & Society since 1860 3–5
or
H33† Hist. of Amer. For. Policy 3–5

and 14·51† Internatl. Relations . . . 3–5 and 14·52 Maj. Probs. in Contemp. World Politics 3–5

FIELD SEVEN: LABOR RELATIONS

14·01† Econ. Principles I 3–5
or
14·73† Organization & Communication in Groups . . 3–5
} and 14·63† Labor Relations . . . . . 3–5 and 14·64 Labor Economics & Public Policy 3–5

14·81† Personality & Social Structure . . . . . 3–5 and 14·63† Labor Relations . . . . . 3–5 and H64 Hist. Studies in Innovation 3–5

FIELD EIGHT: PSYCHOLOGY

14·70† Int. Psychology 3–5
or
14·73† Organization & Communication in Groups 3–5
and { 14·70† Int. Psychology . . . . . 3–5 or 14·73† Organization & Communication in Groups . . . . . 3–5 } and { 14·75 Experimental Psychology . . . . . 3–5 or 14·77 Psychology of Communication . 3–5 }

14·70† Int. Psychology . . . . . 3–5 and { 14·75 Experimental Psychology . . . 3–5 or 14·77 Psychology of Communication . . . . . 3–5 } and { 14·75 Experimental Psychology . . . . . 3–5 or 14·77 Psychology of Communication . 3–5 }

SELECTION OF COURSE OF STUDY

Incoming students generally have a well-defined preference for a specific field of professional interest, while others postpone a selection of a course of study until some time during their first year. The Institute is prepared to assist the latter group in formulating their plans by outlining the opportunities in many fields with which they may not be familiar. Students are urged to take the initiative and investigate the different fields of architecture, engineering, science, and management and consult with staff members in each department.

In general, students are permitted a free choice of the courses of study offered, except when the demand for admission to certain Courses beyond the first year exceeds the staff and facilities available.

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- or second-year programs, excluding professional subjects, or in the Humanities Programs of the third and fourth years. Substitution is not permitted for professional subjects in the second year and for subjects marked with an asterisk (*) in the third and fourth years unless the proposed subject has practically the same subject content, same objectives, and at least the same number of units as the subject in the curriculum.

The ability of the student to perform original research is considered an important feature of his degree requirements, and theses are included in all curricula. All theses and records of work done in preparation of theses are the permanent property of the Institute, and must not be published, either wholly or in part, except by authorization of the heads of the respective departments.

In order to qualify for continued attendance at the Institute, students must meet the minimum requirements of the scholastic rating system.

SYSTEM OF CREDITS

The credit hours associated with a subject indicate the *total* hours per week required in class and laboratory, and estimated outside preparation. The total credits for a subject are listed by two numbers: the first represents hours in class or laboratory, the second estimated preparation time for an average student. Thus the numbers 3–6 after a subject indicate that it involves three hours per week in class and an average of six hours per week of outside preparation. On this basis the normal student schedule is approximately 50 hours per week total time in class, laboratory, and in preparation. This means that a student taking a 50-hour schedule for a term of approximately 15 weeks is registered for 50 units credit, a unit being equivalent to 15 hours of work. The division of class time between lecture or recitation and drawing or laboratory is shown in the Tabulation of Subjects.

FIRST YEAR FOR ALL COURSES

First Term	5·01	Chemistry, General	7–4	*Second Term*	5·02	Chemistry, General	7–4
	8·01	Physics	6–5		8·02	Physics	6–5
	D11	Engineering Drawing	6–0		D12	Descriptive Geometry	6–0
	H11	Hum. & Soc. Sciences, Int.	3–5		H12	Hum. & Soc. Sciences, Int	3–5
	M11	Calculus	3–6		M12	Calculus	3–6
	MS11	Military Science	3–0		MS12	Military Science	3–0
	A1	Athletic Program	2–0		A2	Athletic Program	2–0
		Quiz Hour (Calc., Chem., Phys.)	1–0			Quiz Hour (Calc., Chem., Phys.)	1–0
			31–20				31–20

UNDERGRADUATE COURSE SCHEDULES

All undergraduate course schedules given on the following pages will be in effect in 1952–53, unless otherwise indicated.

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. Dealing, as he does, with both the forces of nature and with large projects that influence the economic and social conditions of many people, the Civil Engineer must combine fundamental knowledge of science and engineering with experience and judgment, and with personal characteristics of the highest order.

Sanitary Engineering, closely associated with Civil Engineering, deals with the purification of water, the treatment and disposal of domestic and industrial wastes, the control of stream and lake pollution, and other environmental factors that influence public health. By the proper choice of option and professional elective subjects, the Civil Engineering curriculum is adaptable to the needs of students who are primarily interested in Sanitary Engineering.

The curriculum in Civil Engineering is arranged so that all students receive training in the basic principles of mathematics and science, and in engineering applications such as Surveying, Hydraulics, Foundation Engineering, Engineering Geology, Electrical Engineering and Structural Theory and Design.

Civil Engineering projects involve three phases: Conception; Design; and Construction. Most Civil Engineers find that although their work is likely to include a consideration of all three, a large portion of their professional activity centers on one phase only. The curriculum is therefore arranged so that in addition to the basic subjects previously mentioned, the individual student may pursue further work adapted to his special interests and abilities by electing, at the middle of his third year, one of the following options:

OPTION 1. THEORY AND DESIGN. Emphasis is given to Structural Theory and Design, Fluid Mechanics (Hydraulics) and Soil Mechanics (Foundation Engineering). Professional elective subjects permit specialized work in Sanitary, Transportation or Hydraulic Engineering. This option prepares men for fields such as design, research and teaching, and for graduate work in either Civil or Sanitary Engineering. This program is also advantageous for students interested in an undergraduate approach to Sanitary Engineering.

OPTION 2. PLANNING AND ADMINISTRATION. Emphasis is given to a broad survey of Civil Engineering activities such as Sanitary, Transportation and Hydraulic Engineering, including the planning of projects and their administrative, social and economic aspects. Professional elective subjects permit an extension of general considerations or the introduction of further technical subjects. Designed to prepare men for the planning of Civil Engineering projects, including public works, this option serves as a general course in Civil Engineering.

OPTION 3. CONSTRUCTION AND MANAGEMENT. Emphasis is given to construction methods for Civil Engineering structures such as buildings, bridges, dams, highways and airports, and to their financial and legal aspects. Professional elective subjects permit abbreviated work in Sanitary, Transportation or Hydraulic Engineering, together with subjects dealing with job and business management. This option prepares men for the supervision of engineering construction of all types and for contracting.

The Civil Engineering Department maintains and operates, during the second half of each summer, the M. I. T. Summer Surveying Camp, located on Gardner Lake near East Machias, Maine. All Civil Engineering students attend this camp for a seven-week period, which is scheduled during the summer following the first year but may, when necessary, be postponed to the following summer.

All options of the Course lead to the degree of Bachelor of Science in Civil Engineering.

FIRST YEAR (See page 51)

REQUIRED DURING SUMMER AT CAMP TECHNOLOGY

1·00	Surveying	13–0
1·01	Surveying Fieldwork, Adv.	6–0
1·20	Route Surveying Fieldwork	5–0

SECOND YEAR

First Term	1·03	Surveying, Adv.	6–4
	2·00	Statics	3–5
	8·03	Physics	5–5
	H21	Hum. & Soc. Sciences, Int.	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
			23–25

Second Term	1·21	Route and Constr. Surveys	2–4
	2·01	Dynamics	3–5
	8·04	Physics	5–5
	12·321	Engineering Geology	4–4
	H22	Hum. & Soc. Sciences, Int.	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
			23–29

I. Civil Engineering Continued

Third Year††

First Term	*1·601	Fluid Mechanics	3–6	*Second Term*	*1·40	Structural Analysis	3–6
	*1·91	Engineering Construction	3–3		*1·44	Structural Design, Elem.	9–0
	*2·04	Strength of Materials	3–6		1·602	(1) Fluid Mechanics	2–4
	2·371	Testing Materials Lab.	2–2		1·90	(2) Conservation, Prin.	3–6
	*17·75	Materials	6–6		1·92	(3) Constr. Equip. & Methods	2–4
		§‡††Humanities	3–5		§2·41	(1) Heat Engineering	4–5
			20–28		*6·18	Electrical Eng., Fund.	4–6
					14·30	(2) Elementary Statistics	2–4
					15·50	(3) Accounting	5–4
						‡††Humanities	3–5
							(1) 25–26 (2) 24–27 (3) 26–25

Fourth Year

Option 1. Theory and Design

First Term	*1·35	Soil Mech. & Found. Eng.	6–6	*Second Term*	1·42	Structural Analysis	3–6
	*1·41	Structural Analysis	3–6		¶1·442T	Reinforced Concrete Des.	6–0
	1·441T	Structural Design	6–0		*1·94	Professional Problems	2–4
	1·621	Fluid Mechanics Lab.	6–0			*Thesis	9
		‡††Humanities	3–5			‡††Humanities	3–5
		Elective Subject	12			Elective Subject	9
			53				47

*First Term Elective Subjects***

1·271	Transportation Engineering	6–6
1·70	Hydrology & Flood Control	6–6
1·75	Water Supply & Purification	6–6

*Second Term Elective Subjects***

1·272	Transportation Engineering	6–3
1·71	Water Power Engineering	6–3
1·76	Sewerage & Sewage Treatment	6–3

Option 2. Planning and Administration

First Term	*1·351	Soil Mech. & Found. Eng.	4–4	*Second Term*	1·24	Transportation Planning	3–3
	*1·41	Structural Analysis	3–6		1·77	Water Supply & Sewerage	3–3
	1·72	Hydrology & Water Power Eng.	3–3		*1·94	Professional Problems	2–4
	4·63	Regional Plan., Prin.	2–4		4·12	Urban Sociology	2–4
		‡††Humanities	3–5			*Thesis	9
		Elective Subjects	14			‡††Humanities	3–5
			51			Elective Subject	8
							49

*First Term Elective Subjects***

1·441T	Structural Design	6–0
2·41	Heat Engineering	4–5
4·59	Govt. & Public Admin.	3–6
14·43	Public Finance	3–5
14·72	Union-Manage. Rel.	3–6

*Second Term Elective Subjects***

1·42	Structural Analysis	3–6
1·442T	Reinforced Concrete Des.	6–0
1·602	Fluid Mechanics	2–4
4·60	Plan. Legis. & Admin	2–4
E36	Seminar in Technical Writing	2–4

Option 3. Construction and Management

First Term	*1·35	Soil Mech. & Found. Eng.	6–6	*Second Term*	1·42	Structural Analysis	3–6
	*1·41	Structural Analysis	3–6		*1·94	Professional Problems	2–4
	1·441T	Structural Design	6–0			*Thesis	9
		‡††Humanities	3–5			‡††Humanities	3–5
		Elective Subjects	15			Elective Subjects	18
			50				50

*First Term Elective Subjects***

1·28	Highways & Airports	3–3
1·72	Hydrology & Water Power Eng.	3–3
2·41	Heat Engineering	4–5
15·41	Finance	3–6

*Second Term Elective Subjects***

1·442T	Reinforced Concrete Des.	6–0
1·602	Fluid Mechanics	2–4
1·77	Water Supply & Sewerage	3–3
15·11	Industrial Manage., Int.	3–6
15·61	Business Law	3–6
17·43	Building Construction	5–4

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.

¶ Students particularly interested in Sanitary Engineering may substitute 1·79 Sanitary Engineering Design, 6–0.

** The elective subjects have been selected as those most pertinent to the objectives of the three options. Students may, however, under special conditions, substitute electives from other options provided that they have the necessary prerequisites and the approval of their registration officer.

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

‡ 14·01 Economic Principles I, 3–5 is a requirement for graduation and must be one of the Humanities subjects taken.

§ Students particularly interested in Sanitary Engineering may substitute 1·831 Sanitary Chemistry, 6–4 in place of Humanities in the first term and take ‡††Humanities, 3–5 in place of 2·41 in the second term.

II. MECHANICAL ENGINEERING

THE course in Mechanical Engineering is planned to provide a foundation of basic science applied to engineering methods and techniques to prepare the graduate to enter any industry dealing with heat, power, materials or machinery. The Course does not attempt to give a complete training in current commercial practice, nor does it give complete specialized knowledge of the product of any one industry. The training is focused not only on mastery of principles and facts, but attention is also given to development of personality and the ability to make critical judgments.

The curriculum during the first two years provides a thorough training in the basic subjects of mathematics, chemistry, physics and materials. During the junior and senior years the student becomes familiar with the mechanics of fluids and solids, thermodynamics, properties of materials, materials processing and certain aspects of electrical engineering. Applications of these fundamental subjects are made in the analysis and design of mechanical equipment and processing. Instruction by lectures is paralleled by laboratory work. The student is given opportunity not only to familiarize himself with materials, machinery and instrumentation but also to develop his ability to apply theory and judgment to the solution of engineering problems with due consideration to the economic factors involved.

In the fourth year the students are encouraged to select a field of major interest around which their study program is centered. For this purpose certain subjects have been arranged in a number of groups, each representing a field of endeavor which is of importance in contemporary industry and which has been found to attract student enthusiasm. The developments of laboratories and staff facilities which have taken place in this department during the last few years have made possible the new elective group system.

All students of the Mechanical Engineering Department are urged to obtain six months, or at least one summer, of practical experience in some industrial activity of their own choice before graduation.

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

Honors Course

The opportunity will be afforded a limited number of students of superior ability to join an Honors Course group. The selection of members of this group will be made by the Department from students who may wish to avail themselves of the opportunity to pursue a coordinated schedule of studies through the senior and graduate years.

A member of the Department will serve as adviser to aid the members of the group in selecting the senior and graduate schedules which may be best suited to their individual interests. The program of subjects selected must (1) have the approval of the Department adviser, (2) fulfill the unit requirements of both the senior year (including the time allotted to Bachelor's thesis) and the graduate year, and (3) include a thesis of not less than 30 units in the graduate year. Before registration for the graduate year, the students selected under this plan must have had at least two months of industrial employment satisfactory to the Department.

The Honors Course leads to the degrees of Bachelor of Science and Master of Science in Mechanical Engineering awarded simultaneously at the end of the graduate year.

First Year (See page 51)

Second Year

First Term	2·001	Applied Mechanics I	3–5
	2·701	Machine Drawing	6–0
	2·85	Machine Tools, Int.	4–1
	8·03	Physics	5–5
	H21	Hum. & Soc. Sciences, Int.	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
			27–22
Second Term	2·002	Applied Mechanics II	3–5
	3·11	Engineering Metals	6–4
	8·04	Physics	5–5
	H22	Hum. & Soc. Sciences, Int.	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
			23–25

Third Year

First Term	*2·003	Applied Mechanics III	4–8
	*2·403	Heat Engineering	4–8
	*2·73	Machine Design	4–2
	*6·18	Electrical Eng., Fund	4–6
	‡†Humanities		3–5
			19–29
Second Term	*2·25	Fluid Mechanics	4–8
	*2·37	Mech. Behavior of Materials	4–4
	*2·42	Heat Engineering	3–6
	*2·731	Machine Design	5–4
	*2·86	Machine Tool Fund.	3–2
	‡†Humanities		3–5
			22–29

Students registered in the third year, first term, in the Fall term 1952–53: Omit 2·003 and 2·403. Add *2·04 Strength of Materials, 3–6; *2·251 Fluid Mechanics, 3–6; and *2·40 Heat Engineering, 4–5.

Students registered in the third year, second term, in the Spring term 1953: Omit 2·25 and 2·86. Add *2·06 Dynamics, 3–6, and *2·252 Fluid Mechanics, 2–4.

*See Requirements for Bachelor's Degree, page 51. †See page 48 for list of subjects.
‡ 14·01 Economic Principles I, 3–5 is a requirement for graduation and must be one of the Humanities subjects taken.

II. Mechanical Engineering Continued

Fourth Year

Each student is required to take 2·082, 8 units of laboratory in an engineering field, thesis or project, and two terms of Humanities. In addition, each student must take a total of at least 52 units of approved Elective Subjects, irrespective of the time division between the two terms of the fourth year. The following programs in the fields of interest listed below are suggested. The "Additional Subjects" may be any choice approved by the Registration Officer, and may include two Humanities subjects.

Group 1. Power

First Term	2·252T	Fluid Mechanics	3–6	*Second Term*	2·082	Mech. Eng. Problems	3–6
	2·43	Heat Engineering	3–6		2·56	Power Plant Eng.	6–6
	2·68	Engineering Laboratory	4–4			*Thesis	9
		‡†Humanities	3–5			‡†Humanities	3–5
		Additional Subjects	17			Additional Subject	8
			51				46

Students taking the Group 1 program in the Fall terms 1952–53 or 1953–54: Omit 2·252T. Add Additional Subject, 9.

Group 2. Jet Propulsion

First Term	2·252T	Fluid Mechanics	3–6	*Second Term*	2·082	Mech. Eng. Problems	3–6
	2·47	Jet Propulsion	3–6			*Thesis	9
	2·68	Engineering Laboratory	4–4			‡†Humanities	3–5
		‡†Humanities	3–5			Additional Subjects	20
		Additional Subjects	17				46
			51				

Students taking the Group 2 program in the Fall terms 1952–53 or 1953–54: Omit 2·252T. Add Additional Subject, 9.

Group 3. Air Conditioning and Refrigeration

First Term	2·252T	Fluid Mechanics	3–6	*Second Term*	2·082	Mech. Eng. Problems	3–6
	2·43	Heat Engineering	3–6		2·621	Refrigeration	3–6
	2·663	Air Conditioning	3–6			*Thesis	9
	2·68	Engineering Laboratory	4–4			‡†Humanities	3–5
		‡†Humanities	3–5			Additional Subjects	12
		Additional Subject	8				47
			51				

Students taking the Group 3 program in the Fall terms 1952–53 or 1953–54: Omit 2·252T. Add Additional Subject, 9.

Group 4. Internal Combustion Engines

First Term	2·081	Strength of Materials	3–6	*Second Term*	2·082	Mech. Eng. Problems	3–6
	2·791	Internal Combustion Eng.	3–6		2·792	Internal Combustion Eng.	3–6
	2·7941	Internal Combustion Eng. Lab.	2–2		2·7942	Internal Combustion Eng. Lab.	2–2
		‡†Humanities	3–5			*Thesis	9
		Additional Subjects	21			‡†Humanities	3–5
			51			Additional Subject	8
							47

Group 5. Materials and Materials Processing

First Term	2·081	Strength of Materials	3–6	*Second Term*	2·082	Mech. Eng. Problems	3–6
	2·31	Mech. Prop. of Materials	4–6		2·32	Mech. Prop. of Materials	4–6
	2·68	Engineering Laboratory	4–4			*Thesis	9
		‡†Humanities	3–5			‡†Humanities	3–5
		Additional Subjects	14			Additional Subjects	15
			49				51

Group 6. Design

First Term	2·081	Strength of Materials	3–6	*Second Term*	2·082	Mech. Eng. Problems	3–6
	2·732	Machine Design	4–4		2·68	Engineering Laboratory	4–4
		‡†Humanities	3–5		2·78	Indust. Hydraulic Machinery, Des.	5–4
		Additional Subjects	24			*Thesis	9
			49			‡†Humanities	3–5
						Additional Subject	8
							51

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.
‡ 14·01 Economic Principles I, 3–5 is a requirement for graduation and must be one of the Humanities subjects taken.

II. Mechanical Engineering Continued

Group 7. Production

First Term	2·732	Machine Design	4–4	*Second Term*	2·082	Mech. Eng. Problems	3–6
	15·70	Production	3–6		2·68	Engineering Laboratory	4–4
		‡†Humanities	3–5		15·71	Production Management	3–6
		Additional Subjects	24			*Thesis	9
			49			‡†Humanities	3–5
						Additional Subject	8
							51

Group 8. Textiles

First Term	2·081	Strength of Materials	3–6	*Second Term*	2·082	Mech. Eng. Problems	3–6
	2·901	Fabric Structure, Prin.	3–6		2·68	Engineering Laboratory	4–4
	2·903	Textile Manufacturing, Elem.	3–6		2·904	Textile Manufacturing, Prin.	3–6
		‡†Humanities	3–5			*Thesis	9
		Additional Subjects	14			‡†Humanities	3–5
			49			Additional Subject	8
							51

Group 9. Nuclear Engineering§

First Term	2·43	Heat Engineering	3–6	*Second Term*	2·082	Mech. Eng. Problems	3–6
	2·68	Engineering Laboratory	4–4		8·06	Nuclear Physics	4–6
	8·05	Atomic Physics	4–6			*Thesis	9
		‡†Humanities	3–5			‡†Humanities	3–5
		Additional Subjects	14			Additional Subjects	15
			49				51

II-B. MECHANICAL ENGINEERING

Cooperative Course (Four Years)

THE objective of the II-B Cooperative Course in Mechanical Engineering is to give students the opportunity to acquire a background of industrial experience prior to the professional work of the fourth year. It provides a period of approximately six months of practical experience, between the end of the sophomore year and the beginning of the senior year, with a selected industrial concern. This is accomplished by rearranging the schedule of subjects taken in the junior year. The academic program is the same as that of the regular Course in Mechanical Engineering. Except for the period when the student is away from the Institute he is able to participate in all extracurricular activities with his own classmates.

The activities of the students away from the Institute vary for each company. The principal objective is to give the students a background for the environment in which they are likely to work after graduation. The cooperating companies have been invited to participate in this program on the basis of their progressive and sympathetic attitude towards this form of training and the benefit which it provides.

The number of students which can be accommodated is limited and consequently registration in the cooperative course is restricted to students of marked aptitude with clear records in the first two years. Admission to the Course is subject to the approval of the Institute and the cooperating companies. College transfer students may be admitted under equivalent conditions.

Students who are interested in this program should apply to Department Headquarters for a set of application forms not later than January 2 of their sophomore year. These forms should be completed and returned by January 15. A statement indicating preference for location and class group desired should be included. A list of cooperating companies is available at the Headquarters of the Department of Mechanical Engineering.

Representatives of the cooperating companies are invited to interview interested students. They will determine, jointly with the Department representative, the distribution of those selected. Students thus chosen become regularly paid employees of a company during the period at the plant and are subject to the usual regulations of that company. They are expected to carry the Course through to completion unless prevented from doing so by exceptional circumstances.

Juniors in the Cooperative Course are also eligible for selection to the Honors Course described under Course II, Mechanical Engineering.

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

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.

§ Primarily for students intending to specialize in Nuclear Engineering in their graduate work. It is suggested that M351 and M352 Advanced Calculus for Engineers be among the Additional Subjects elected.

‡ 14·01 Economic Principles I, 3–5 is a requirement for graduation and must be one of the Humanities subjects taken.

II-B. Mechanical Engineering Continued

(Same as Course II through Second Year)

Group A

Third Year

Summer

At M. I. T. (First 6 weeks)

*2·37	Mech. Behavior of Materials	4–4
*2·403	Heat Engineering	4–8
*2·73	Machine Design	4–2
		12–14

Vacation (Approximately 2 weeks)

At Plants (Remainder of Summer)

*2·951 Industrial Practice ..... 40 h.p.w.

Regular Academic Year

		At Plants		*At M. I. T.*	
First Term		*2·952 Industrial Practice ..... 40 h.p.w.	*Second Term*	*2·25 Fluid Mechanics	4–8
				*2·42 Heat Engineering	3–6
				*2·731 Machine Design	5–4
				*6·18 Electrical Eng., Fund.	4–6
				‡†Humanities	3–5
					19–29

Students registered in the third year, second term, in the Spring term 1953: Omit 2·25 and 2·731. Add *2·06 Dynamics, 3–6; *2·251 Fluid Mechanics, 3–6; and *2·37 Mech. Behavior of Materials, 4–4.

Fourth Year

Summer

Vacation (First 6 weeks)

At M. I. T. (Second 6 weeks)

*2·003	Applied Mechanics III	4–8
*2·86	Machine Tool Fund	3–2
‡†Humanities		3–5
		10–15

Students registered in the fourth year Summer, in the Summer 1953: Omit 2·003 and 2·86. Add *2·252 Fluid Mechanics, 2–4, and *2·731 Machine Design, 5–4.

Regular Academic Year

Same as Fourth Year in Course II

Group B

Third Year

Summer

At M. I. T. (First 6 weeks)

*2·37	Mech. Behavior of Materials	4–4
*2·403	Heat Engineering	4–8
*2·73	Machine Design	4–2
		12–14

Vacation (Remainder of Summer)

Regular Academic Year

		At M. I. T.		*At Plants*
First Term		*2·25 Fluid Mechanics	*Second Term*	*2.952 Industrial Practice ..... 40 h.p.w.
		*2·42 Heat Engineering		
		*2·731 Machine Design		
		*6·18 Electrical Eng., Fund.		
		‡†Humanities		
		19–29		

Students registered in the third year, first term, in the Fall term 1952-53: Omit 2·25 and 2·731. Add *2·06 Dynamics, 3–6; *2·251 Fluid Mechanics, 3–6; and *2·37 Mech. Behavior of Materials, 4–4.

*See Requirement for Bachelor's Degree, page 51. †See page 48 for list of subjects.
‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken.

II-B. Mechanical Engineering Continued

FOURTH YEAR

Summer

At Plants (Approximately 4 weeks)

*2.951 Industrial Practice ..... 40 h.p.w.

Vacation (Approximately 2 weeks)

At M. I. T. (Second 6 weeks)

*2.003	Applied Mechanics III	4–8
*2.86	Machine Tool Fund	3–2
‡†	Humanities	3–5
		10–15

Students registered in the fourth year Summer, in the Summer 1953: Omit 2.003 and 2.86. Add *2.252 Fluid Mechanics, 2–4, and *2.731 Machine Design, 5–4.

Regular Academic Year

Same as Fourth Year in Course II

III. METALLURGY

THE Course in Metallurgy offers two options, one in Metallurgy and the other in Mineral Engineering.

OPTION 1. METALLURGY

The course of study in Metallurgy provides a broad training in the field which includes both the science of the metals themselves and the engineering involved in their production and conversion to useful products. Instruction in physical metallurgy is concerned with the nature of the metallic state, the structure and properties of metals and alloys, their treatment and suitability for various purposes. The engineering portions of the course are concerned with the winning of metals from their ores, refining and production of alloys, and with the forming and shaping of them. The curriculum provides basic training in this broad field and permits a limited amount of specialization by the choice of elective subjects and by a thesis in the fourth year. Facilities are available so that this specialized training may be directed toward work in the metal producing industry, the foundry industry, the welding industry, the metal forming and fabricating industry and the many manufacturing industries which use metal parts and products.

OPTION 2. MINERAL ENGINEERING

The course of study in Mineral Engineering provides training in all phases of beneficiation, extraction and purification — physical or chemical — of valuable constituents from ores, solid fuels, ceramic raw materials and other mineral materials. As such, it provides training toward an activity that is at the very core of our mineral civilization. This is a field of engineering which, until recently, had been distributed among the fields of Metallurgy, Mineral Dressing, Mining Engineering, Chemical Engineering, Ceramics and Fuel Technology. It is now becoming recognized that the work of extracting any metal from its ores differs only in degree from that of extracting or beneficiating any non-metallic mineral, cleaning a coal, or making coke. Training in the engineering of mineral substances is designed to give the student a broad grasp of the field, rather than detailed descriptions of certain of its facets. Accordingly, it is taught from the unit-process and unit-operation point of view.

Mineral Engineering is related to Geology by its sequence of mineralogical and geological subjects; similarly, it is related to Metallurgy by its sequence of subjects in metallurgical engineering; and yet, its approach to the characteristic subjects is substantially that of chemical engineers.

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 51)

SECOND YEAR

First Term	2.011	Statics & Dynamics	3–5
	5.11	Qualitative Analysis	7–3
	8.03	Physics	5–5
	H21	Hum. & Soc. Sciences, Int.	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
			24–24

Second Term	2.04	Strength of Materials	3–6
	5.12	Quantitative Analysis	7–3
	8.04	Physics	5–5
	H22	Hum. & Soc. Sciences, Int.	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
			24–25

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.
‡ 14.01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken.

III. Metallurgy Continued

THIRD YEAR§

First Term	*3·31	Physical Metallurgy I	6–4	*Second Term*	2·50	Heat Measurements	3–1
	*3·81	Mineral Engineering I	4–4		*3·01	Metallurgical Engineering I	4–4
	*5·61	Physical Chemistry I	4–4		*3·12	(1) Metal Processing	4–4
	6·18	Electrical Eng., Fund.	4–6		*3·32	(1) Physical Metallurgy II	6–6
	*12·011	Mineralogy	3–1		*3·82	(2) Mineral Engineering II	6–4
	*12·20	Elem. Crystallography	2–2		*5·62	Physical Chemistry II	4–4
		‡†Humanities	3–5		12·301	(2) Physical Geology	7–3
			26–26			‡†Humanities	3–5
							(1) 24–24
							(2) 27–21

REQUIRED DURING SUMMER

3·10 Metallurgical Plant Visits 3–1

FOURTH YEAR

OPTION 1. METALLURGY

First Term	2·371	Testing Materials Lab.	2–2	*Second Term*	*3·33	Physical Metallurgy III	6–4
	2·851	Machine Tool Lab.	4–0			*Thesis	12
	*3·02	Metallurgical Engineering II	3–6			‡†Humanities	3–5
	*3·021	Metallurgical Eng. Lab.	4–0			Elective Subjects	16
	3·20	Metal. Thermodynamics	4–4				46
	*3·50	X-ray Metallurgy	4–4				
		‡†Humanities	3–5				
		Elective Subject	8				
			53				

First Term Elective Subjects

3·16	Powder Metallurgy	2–4
3·18	Plastic Working of Metals	2–4
3·41	Light Alloys	2–4
3·42	Electrochemistry	2–4

Second Term Elective Subjects

3·03	Metallurgical Eng. III	2–4
3·13	Foundry Eng. I	2–4
3·15	Welding Eng.	2–4
3·51	Physics of Metals	2–4
3·70	Ceramics	5–4
3·82	Mineral Eng. II	6–4
3·85	Mineragraphy	4–2

OPTION 2. MINERAL ENGINEERING

First Term	3·02	Metallurgical Engineering II	3–6	*Second Term*	3·03	Metallurgical Engineering III	2–4
	3·021	Metallurgical Eng. Lab.	4–0		3·70	Ceramics	5–4
	3·20	Metal. Thermodynamics	4–4			*Thesis	10
	3·83	Mineral Engineering III	4–4			‡†Humanities	3–5
		‡†Humanities	3–5			Elective Subjects	16
		Elective Subjects	12				49
			49				

First Term Elective Subjects

2·251	Fluid Mechanics	3–6
2·681	Engineering Lab.	3–3
3·50	X-ray Metallurgy	4–4
3·85	Mineragraphy	4–2
3·87	Ore Testing	10–0
5·41	Organic Chemistry I	4–4
12·24	Theoretical Crystallog.	2–4
12·91	Mining, Elements	3–6
12·94	Mineral Economics	3–6
15·50	Accounting	5–4

Second Term Elective Subjects

3·32	Physical Metallurgy II	6–6
3·85	Mineragraphy	4–2
5·66	Surface & Colloid Chem.	2–4
15·11	Industrial Management, Int.	3–6
15·50	Accounting	5–4
15·61	Business Law	3–6
15·64	Patent Law	3–6

IV-A. 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, coordination of the general plan with a simple and economical structural system, research into best methods and materials of construction, control over proportions and details to achieve effective and eloquent

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.
§ Students planning to take a certain option in the fourth year, take the Group Electives indicated by the corresponding number.
‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken.

IV-A. Architecture Continued

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 51)

Second Year

First Term	2·011	Statics & Dynamics	3–5	*Second Term*	2·04	Strength of Materials	3–6
	4·721	Architectural Design	9–3		4·07	Shop	4–0
	8·032	Physics	5–5		4·12	Urban Sociology	2–4
	H21	Hum. & Soc. Sciences, Int.	3–5		4·722	Architectural Design	9–3
	M21	Calculus	3–6		17·73	Materials — Wood	3–3
	MS21	Military Science	3–0		H22	Hum. & Soc. Sciences, Int.	3–5
			26–24		MS22	Military Science	3–0
							27–21

Third Year

First Term	*1·771	Sanitation	2–4	*Second Term*	*2·662	Heating & Ventilation	2–4
	*2·661	Heating & Ventilation	2–4		*4·032	Visual Fundamentals	4–0
	*4·031	Visual Fundamentals	4–0		*4·641	City Planning, Prin.	2–4
	*4·731	Architectural Design	12–6		*4·732	Architectural Design	12–6
	*4·811	Structural Analysis	8–0		*4·812	Structural Analysis	8–0
	‡†Humanities		3–5		‡†Humanities		3–5
			31–19				31–19

Fourth Year

First Term	§4·741	Architectural Design	12–6	*Second Term*	4·041	Light and Color	6–0
	*6·16	Electricity	3–6		§*4·742	Architectural Design	12–6
	8·132	Architectural Acoustics	5–3		*6·17	Illumination	2–4
	*17·71T	Materials — Metals	2–4		*17·72	Materials — Masonry	6–4
	‡†Humanities		3–5		‡†Humanities		3–5
			25–24				29–19

Fifth Year

First Term	4·051	Graphic Presentation	6–0	*Second Term*	4·052	Graphic Presentation	6–0
	4·13	Land Economics	2–4		*4·452	History of Architecture	3–6
	*4·451	History of Architecture	3–6		14·20	Building Economics	2–4
	*4·751	Architectural Design	12–9			*Thesis	21
		Elective Subject	8			Elective Subject	8
			50				50

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 relation 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.

* See *Requirements for Bachelor's Degree, page 51.* † See page 48 for list of subjects.

‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken.

§ On the termination of 4·742 Architectural Design, the student's total progress in architectural design will be appraised by his instructors. If this progress is deemed to be insufficient, the student may be required to register for subjects in architectural design beyond the stated curriculum before being allowed to register for thesis.

IV-B. City Planning Continued

FIRST YEAR (See page 51)

REQUIRED DURING SUMMER. AT CAMP TECHNOLOGY

1·00	Surveying	13–0
1·01	Surveying Fieldwork, Adv.	6–0
1·20	Route Surveying Fieldwork	5–0

SECOND YEAR

First Term	4·721	Architectural Design	9–3	*Second Term*	4·641	City Planning, Prin.	2–4
	8·032	Physics	5–5		4·722	Architectural Design	9–3
	14·31T	Quant. Method, Int.	3–5		8·042	Physics	5–5
	E37	Public Speaking	3–3		12·321	Engineering Geology	4–4
	H21	Hum. & Soc. Sciences, Int.	3–5		H22	Hum. & Soc. Sciences, Int.	3–5
	MS21	Military Science	3–0		MS22	Military Science	3–0
			26–21				26–21

THIRD YEAR

First Term	1·771	Sanitation	2–4	*Second Term*	1·24	Transportation Planning	3–3
	4·59	Govt. & Public Admin.	3–6		4·12	Urban Sociology	2–4
	4·651	City Planning, Th. & Prac.	3–6		4·652	City Planning, Th. & Prac.	3–6
	4·681	City & Regional Plan.	12–6		4·682	City & Regional Plan.	12–9
	†14·01	Economic Prin. I — Humanities	3–5			†Humanities	3–5
			23–27				23–27

REQUIRED DURING SUMMER

4·50 Office Practice . . . . . 35 h.p.w.

FOURTH YEAR

First Term	4·13	Land Economics	2–4	*Second Term*	4·14	Land Economics	3–6
	4·62	Site Plan. & Constr.	9–3		4·60	Plan. Legis. & Admin.	2–4
	4·683	City & Regional Plan.	9–6			*Thesis	20
		†Humanities	3–5			†Humanities	3–5
		Elective Subject	8			Elective Subject	8
			49				51

V. CHEMISTRY

THE main objective of the Course in Chemistry is to provide a general and fundamental education based on science for those who seek the Bachelor's degree and a career in some field in which a sound knowledge of chemistry is important, and for those who wish to go on to graduate study and a professional career in chemistry.

Students receive thorough instruction in the principles of inorganic, analytical, organic and physical chemistry, supplemented by instruction in mathematics and physics, in the humanities, including English, History, German, French, and other nonprofessional subjects.

In the third and fourth years, elective time is available to enable the student to extend his knowledge in fields of special interest. Students intending to take graduate work, for example, may elect a series of subjects tending to increase their ability to utilize the opportunities in graduate study. Students intending to enter industry may take subjects which offer the fundamentals in a selected field of science or engineering. Elective time may be used for additional subjects in the humanities.

Elective series are available in advanced analytical, inorganic, organic, and physical chemistry; in chemical engineering, ceramics, sanitary engineering, textiles, economics, physics, mathematics, metallography, mineralogy and geology, biology and biochemistry, food technology, and metallurgy.

The Course aims to stimulate and develop the research attitude, and the schedule includes a thesis in the fourth year to provide an opportunity for the student to demonstrate his aptitude for creative effort.

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

FIRST YEAR (See page 51)

SECOND YEAR

First Term	5·10	Qualitative Analysis	11–3	*Second Term*	5·13	Quantitative Analysis	12–4
	8·03	Physics	5–5		8·04	Physics	5–5
	H21	Hum. & Soc. Sciences, Int.	3–5		H22	Hum. & Soc. Sciences, Int.	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
		§Language	3–5				26–20
			28–24				

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.
§ Students should acquire a reading knowledge of German and French. Additional subjects in German and French will be credited as Elective time.

V. Chemistry Continued

THIRD YEAR

First Term	*5·41	Organic Chemistry I	4–4	*Second Term*	*5·42	Organic Chemistry II	4–4
	*5·414	Organic Preparations I	9–0		*5·424	Organic Prep. II. & Anal.	9–0
	*5·63	Physical Chemistry I	4–6		*5·64	Physical Chemistry II	4–6
	*5·631	Physical Chem. Lab. I	6–2		*5·641	Physical Chem. Lab. II	6–2
		†Humanities	3–5			†Humanities	3–5
		Elective Subject	6			Elective Subject	6
			49				49

FOURTH YEAR

First Term	*5·061	Inorganic Chemistry, Adv.	2–4	*Second Term*	*5·062	Inorganic Chemistry, Adv.	2–4
	*5·43	Organic Chemistry III	2–4		*5·44	Organic Chemistry IV	2–4
		*Thesis	15			*Thesis	15
		†Humanities	3–5			†Humanities	3–5
		Elective Subjects	15			Elective Subjects	15
			50				50

Students must take as electives two of the following subjects: 5·66 Surface & Colloid Chem., 2–4; 5·67 Atomic & Molec. Struct., Int., 2–4; 5·68 Kinetics of Chem. React., 2–4. (5·75 may be substituted for 5·67.)

VI. ELECTRICAL ENGINEERING

THE objective of this Course is to provide the student with a foundation for a professional, industrial, or business career based on electrical engineering. This may involve either the progressive application of the present engineering art or 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. His ultimate level of responsibility is likely to be determined quite as much by his understanding of people, judgment, sense of values, and breadth of outlook as by his technical competence. The humanities and social studies therefore form an important part of his program.

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 standardized experiments. Small class sections, including students of similar interests and aptitudes, serve to encourage vigorous discussion.

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 three 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 3. ELECTRICAL COMMUNICATIONS. Emphasis is given to the principles and techniques underlying the translation, transmission, and reproduction of intelligence by electrical means. The basic professional studies include circuit theory, electronics and electromagnetic theory. Preparation is given for engineering work in the fields of radio and wire communications, electrical measurements, navigational aids, and related areas in which communications 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 implementation through electronic devices, and to the analysis of electromechanical and electrothermal systems by means of electrical analogs and models.

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 51)

SECOND YEAR

First Term	2·001	Applied Mechanics I	3–5	*Second Term*	2·002	Applied Mechanics II	3–5
	6·00T	Circuit Theory, Elem.	7–5		6·01T	Circuit Theory, Elem.	7–5
	8·031	Physics	5–5		8·041	Physics	5–5
	H21	Hum. & Soc. Sciences, Int.	3–5		H22	Hum. & Soc. Sciences, Int.	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			24–26				24–26

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.

VI. Electrical Engineering Continued

THIRD YEAR§ (1952–53 only)

First Term	*2·04	Strength of Materials	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
	*6·01	Electrical Eng., Prin.	3–6		*6·02	Electrical Eng., Prin.	4–5
	*6·75	Electrical Meas. Lab.	4–5		*6·031	Electrical Eng., Prin.	3–6
	*8·071	(3, 4) Thermo. & Statist. Mech.	4–5		*6·30	(3) Com. Network Theory	3–6
	M31	Differential Equations	2–4		*6·76	Eng. Electronics Lab.	3–3
		‡†Humanities	3–5		8·08	(3, 4) Electronics	4–5
			(1, 3, 4) 19–31			‡†Humanities	3–5
							(1) 19–31
							(3, 4) 20–30

FOURTH YEAR (1952–53 and 1953–54 only)

OPTION 1. ELECTRIC POWER

First Term	1·613	Fluid Mechanics	3–6	*Second Term*	6·04	Electrical Eng., Prin.	3–6
	2·681	Engineering Lab.	3–3		6·79	Electrical Mach. Lab.	3–3
	*6·032	Electrical Eng., Prin.	3–6			*Thesis	9
	*6·78	Electrical Mach. Lab.	4–4			‡†Humanities	3–5
		‡†Humanities	3–5			Prof. Elective Subject (see below)	9
		Hum. or Prof. Elec. Subj. (see below)	8			Hum. or Prof. Elec. Subj. (see below)	8
			48				49

Professional Elective Subjects

	6·20	(1, 3) Electronic Control & Meas.	3–6		6·202	Electronic Control & Meas.	3–6
	6·221	Elec. Power Syst.	3–6		6·213	Ind. Feedback Control Systems	3–6
	6·223	Elec. Equip. App. Eng.	3–6		6·222	Elec. Power Syst.	3–6
	6·23	(1,3) Elec. Implementation	3–6		6·224	Elec. Equip. App. Eng.	3–6
	6·241	Case Studies in Elec. Eng. Prac.	3–6		6·23	(1, 3) Electrical Implementation	3–6
	6·26¶	Insulators and Semi-Conductors	3–6		6·241	Case Studies in Elec. Eng. Prac.	3–6
	6·271	Illuminating Eng., Prin.	3–6		6·272	Illuminating Eng., Prin.	3–6
	6·281	Wire Communications, Prin.	3–6		6·292	Radar, Prin.	3–6
	6·291	Radar, Prin.	3–6		6·312	Electrical Communications, Prin.	3–6
	6·311	(1,4) Electrical Com., Prin.	3–6		6·322	(1, 4) Electrical Com., Prin.	3–6
	6·321	(1,4) Electrical Com., Prin.	3–6		6·37	Television, Prin.	3–6
	6·35	Engineering Acoustics	3–6		6·80	Electrical Meas. Lab.	Time arr.
	6·80	Electrical Meas. Lab.	Time arr.		6·86	Electrical Machinery Lab.	Time arr.
	6·86	Electrical Machinery Lab.	Time arr.		8·13	Vibration and Sound	3–6
					8·72	Int. to Theoret. Physics II	4–8

OPTION 3. ELECTRICAL COMMUNICATIONS

First Term	*6·032	Electrical Eng., Prin.	3–6	*Second Term*	*6·322	Electrical Com., Prin.	3–6
	*6·311	Electrical Com., Prin.	3–6		*6·332	Electrical Com. Lab.	4–5
	*6·321	Electrical Com., Prin.	3–6		*6·781	Electrical Mach. Lab.	3–3
	*6·331	Electrical Com. Lab.	3–3			*Thesis	9
		‡†Humanities	3–5			‡†Humanities	3–5
		Hum. or Prof. Elec. Subj. (See above)	8			Hum. or Prof. Elec. Subj. (See above)	8
			49				49

OPTION 4. ELECTRONIC APPLICATIONS

First Term	2·251	Fluid Mechanics	3–6	*Second Term*	*6·23	Elec. Implementation	3–6
	*6·032	Electrical Eng., Prin.	3–6		*6·781	Electrical Mach. 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	3–5			‡†Humanities	3–5
		Hum. or Prof. Elec. Subj. (See above)	8			Hum. or Prof. Elec. Subj. (See above)	8
			49				49

VI-A. ELECTRICAL ENGINEERING

COOPERATIVE COURSE

THE engineering graduate, before he can take responsibility for important industrial projects, must have an educational background of sound fundamental scientific and economic principles, and in addition, must be acquainted with industrial practices in his specialized field of employment. This interlinking of theory and practice is provided in the Cooperative Course in Electrical Engineering, in which a selected group of students pursues a course of study and practice which correlates the scientific and engineering principles of the classroom and laboratory with approximately seventy weeks of practical experience in the plants of a particular industry. This educational plan makes it possible for the student to do his "undergraduate" work in industry in parallel with his under-

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.
§ Students planning to take a certain option in the fourth year, take the Group Electives indicated by the corresponding number.
‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken.
¶ Not offered 1952–1953.

VI-A. Electrical Engineering Continued

graduate 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. As an alternative to the degree of Master of Science in Electrical Engineering, Cooperative Course students are permitted to pursue in their fifth year subjects in other departments of the Institute leading toward an additional Bachelor of Science degree, or a Master's degree without specification.

The following eight organizations cooperate with the Institute by offering practical experience in one or more of the fields represented by the three options of Course VI.

The General Electric Company affords practical experience in all three 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, Syracuse, Erie, Bridgeport and Philadelphia. The earlier assignments deal with the manufacturing processes and planning, and the testing of manufactured products. The later assignments may include research or development projects in the various laboratories and engineering offices.

The Boston Edison Company affords practical experience 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 Bell Telephone Laboratories offer experience in communications research and development. Students receive a total of three assignments, which are generally in the apparatus development, switching systems development, and transmission systems development departments. Special assignments in other development departments or in the research departments may be arranged if such appear to be to the best interest of the students and the Laboratories. Work locations will be in New York City or at the suburban laboratory in Murray Hill, New Jersey.

The General Radio Company provides practical experience in the manufacture of communications and electronic apparatus. The first period is spent in the factory where the student becomes acquainted with shop practices, materials and products of manufacture. The second term is spent in the instrument calibration laboratory, where the students learn to test the behavior of manufactured instruments or of experimental models which may be in the developmental stage. The third term is spent as Junior Engineering Assistant in the development laboratories, and the final term is specially arranged to meet the needs of the individual student.

The Philco Corporation offers laboratory experience in many fields of communication, including radio and television. Regular student assignments are in the radio engineering, factory engineering, and research departments. Special assignments are made to students having special interests. While regular assignments are directed toward training men for developmental and research work upon completion of the course, these special assignments may lead a man to many other departments of the company, including, for example, the patent department.

The American Gas and Electric Service Corporation offers practical experience in the construction, maintenance, operation and planning of a large power network. The first three assignments will be with only one of the three operating companies of the American Gas and Electric Company System with headquarters in Canton, Ohio; Roanoke, Virginia; or Fort Wayne, Indiana. These assignments include experience in system operation and maintenance with both field and engineering groups. The last assignment will be in New York City, where network problems are studied. Opportunities in the field of power research are offered.

The Naval Ordnance Laboratory carries out investigations in both pure and applied science. The Laboratory affords experience in research, development, design, and evaluation of mines, depth charges, fuzes, torpedo mechanisms, pyrotechnics, ammunition components, demolition outfits, and many other items of Naval Ordnance. Students may expect assignments in the Research, Engineering and Technical Evaluation Departments in the fields of acoustics, physical optics, terrestrial magnetism, piezoelectricity, explosive phenomena, interior ballistics, electrochemistry, X-ray techniques, mechanical computation, applied statistics, numerical mathematics methods, exterior ballistics, gas dynamics, supersonic aerodynamics, hydrodynamics, plastics research and technology. Assignments in other parts of the Laboratory will be made whenever there is a special interest indicated by the student.

The Air Force Cambridge Research Laboratories offer opportunity to participate in varied problems of organized research directed primarily toward National Defense. The work performed includes research in the field of microwave optics, solid state physics, geophysics, communication and radar electronics, as well as construction, maintenance, testing, analysis and circuit design.

Candidates for admission to the third year are selected from the second-year class at the Institute, and from transfer students who have completed substantially the equivalent of the first two years of Course VI. Since the Course leads to the Master's degree, acceptance into the cooperative year is made by the Institute on the basis of a promising scholastic record, and by the companies upon personal qualifications which indicate adaptability to the work of the company involved.

Each class is divided into two groups (A and B) which alternate after the second year, one group studying at the Institute in Cambridge while the other group is working at the plants of the cooperating companies.

The men when in training at the plants are subject to the usual company regulations. They receive regular compensation for their work, the total of which approximates one and three quarters of the tuition charges for the three years of cooperation. 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 cooperating company, nor is the company obligated to offer such employment.



The Sloan Building—new home of the School of Industrial Management—contains classroom and research facilities as well as the Dewey Library of Industrial Management.

In the Supersonic Wind Tunnel models, obse
through the portholes (center), may be tested at
Mach as high as four times that of sound (Mach

VI-A. Electrical Engineering Continued

(*Same as Course VI through Second Year*)

GROUP A

THIRD YEAR§

At M. I. T.

Summer Term	*2·04	Strength of Materials	3–6
	*2·40	(1) Heat Engineering	4–5
	*6·01	Electrical Eng., Prin.	3–6
	*6·75	Elec. Meas. Lab.	4–5
	*8·071	(3, 4) Thermo. & Statist. Mech.	4–5
		‡†Humanities	3–5
			(1, 3, 4) 17–27

At Plants

First Term	*6·02	Electrical Eng., Prin.	4–5
	6·901		
	6·911	Industrial Practice	40 h.p.w.
	6·941	(Students to register for one of these sub-	
	6·951	jects.)	
	6·961		
	6·971		
	6·981		
	6·991		

At M. I. T.

Second Term	1·613	(1) Fluid Mechanics	3–6
	*2·07	(1, 4) Dynamics	3–6
	2·42	(1) Heat Engineering	3–6
	*6·031	Electrical Eng., Prin.	3–6
	*6·20	(4) Elec. Cont. & Meas.	3–6
	*6·30	(3) Com. Network Theory	3–6
	*6·321	(3) Elec. Com., Prin.	3–6
	*6·76	Eng. Electronics Lab.	3–3
	8·08	(3, 4) Electronics	4–5
		‡†Humanities	3–5
			(1) 18–32
			(3,4) 19–31

FOURTH YEAR

OPTION 1. ELECTRIC POWER; OPTION 3. ELECTRICAL COMMUNICATIONS; OPTION 4. ELECTRONIC APPLICATIONS

At Plants

Summer Term	*6·032	Electrical. Eng., Prin.	3–6
	6·902		
	6·912	Industrial Practice	40 h.p.w.
	6·942	(Students to register for one of these sub-	
	6·952	jects.)	
	6·962		
	6·972		
	6·982		
	6·992		

At M. I. T

First Term	2·251	(4) Fluid Mechanics	3–6
	2·681	(1) Engineering Lab.	3–3
	6·04	(1) Elec. Eng., Prin.	3–6
	*6·23	(4) Elec. Implementation	3–6
	*6·311	(3) Elec. Com., Prin.	3–6
	*6·322	(3) Elec. Com., Prin.	3–6
	*6·332	(3) Elec. Com. Lab.	4–5
	*6·78	(1) Elec. Mach. Lab.	4–4
	*6·781	(3, 4) Elec. Mach. Lab.	3–3
	6·79	(1) Elec. Mach. Lab.	3–3
	*6·83	(4) Electronic Eng. Lab.	3–3
	*6·84	(4) Elec. Implement. Lab.	4–5
		‡†Humanities	3–5
		(1,3) Prof. Elective Subject	9
			(1) 46
			(3) 50
			(4) 47

At Plants

Second Term	M351	Advanced Calculus for Engineers	3–6
	6·903		
	6·913	Industrial Practice	40 h.p.w.
	6·943	(Students to register for one of these sub-	
	6·953	jects.)	
	6·963		
	6·973		
	6·983		
	6·993		

GRADUATE YEAR

At M. I. T.

Summer Term	‡†Humanities	3–5
	**Graduate Study and Thesis	36
		44

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.
** Students may substitute 16 units of additional Humanities in place of 16 units of Graduate study.
‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken.
§ Students planning to take a certain option in the fourth year, take the Group Electives indicated by the corresponding number.

VI A. Electrical Engineering Continued

At Plants

First Term		Thesis	10
	6·904 6·914 6·944 6·954 6·964 6·974 6·984 6·994	Industrial Practice .....40 h.p.w. (Students to register for one of these subjects.)	

At M. I. T.

Second Term		**Graduate Study and Thesis	50
			50

GROUP B

THIRD YEAR§

At Plants

Summer Term	*6·01	Electrical Eng., Prin.	3–6
	6·901 6·911 6·941 6·951 6·961 6·971 6·981 6·991	Industrial Practice .....40 h.p.w. (Students to register for one of these subjects.)	

At M. I. T.

First Term	*2·04	Strength of Materials	3–6
	*2·40	(1) Heat Engineering	4–5
	*6·02	Elec. Eng., Prin.	4–5
	*6·75	Elec. Meas. Lab.	4–5
	*6·76	Eng. Electronics Lab.	3–3
	*8·071	(3, 4) Thermo. & Statist. Mech.	4–5
		‡†Humanities	3–5
		(1, 3, 4)	21–29

At Plants

Second Term	M351	Advanced Calculus for Engineers	3–6
	6·902 6·912 6·942 6·952 6·962 6·972 6·982 6·992	Industrial Practice .....40 h.p.w. (Students to register for one of these subjects.)	

FOURTH YEAR

OPTION 1. ELECTRIC POWER; OPTION 3. ELECTRICAL COMMUNICATIONS; OPTION 4. ELECTRONIC APPLICATIONS

At M. I. T.

Summer Term	*2·07	(1, 4) Dynamics	3–6
	2·42	(1) Heat Engineering	3–6
	*6·031	Electrical Eng. Prin.	3–6
	*6·20	(4) Elec. Cont. & Meas.	3–6
	*6·30	(3) Com. Network Theory	3–6
	*6·321	(3) Elec. Com., Prin.	3–6
	8·08	(3, 4) Electronics	4–5
		‡†Humanities	3–5
		(1) Prof. Elective Subject	9
			(1, 3, 4) 44

At Plants

First Term	*6·032	Electrical Eng., Prin.	3–6
	6·903 6·913 6·943 6·953 6·963 6·973 6·983 6·993	Industrial Practice .....40 h.p.w. (Students to register for one of these subjects.)	

At M. I. T.

Second Term	1·613	(1) Fluid Mechanics	3–6
	2·251	(4) Fluid Mechanics	3–6
	2·681	(1) Engineering Lab.	3–3
	6·04	(1) Elec. Eng., Prin.	3–6
	*6·23	(4) Elec. Implementation	3–6
	*6·311	(3) Elec. Com., Prin.	3–6
	*6·322	(3) Elec. Com., Prin.	3–6
	*6·332	(3) Elec. Com. Lab.	4–5
	*6·78	(1) Elec. Mach. Lab.	4–4
	*6·781	(3, 4) Elec. Mach. Lab.	3–3
	6·79	(1) Elec. Mach. Lab.	3–3
	*6·83	(4) Electronic Eng. Lab.	3–3
	*6·84	(4) Elec. Implementation Lab.	4–5
		‡†Humanities	3–5
		(3) Prof. Elective Subject	9
			(1) 19–27
			(3) 50
			(4) 19–28

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.
§ Students planning to take a certain option in the fourth year, take the Group Electives indicated by the corresponding number
** Students may substitute 16 units of additional Humanities in place of 16 units of Graduate study.
‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken.

VI-A. Electrical Engineering Continued

GRADUATE YEAR

At Plants

Summer Term	M352	Advanced Calculus for Engineers	3–6
	6·904, 6·914, 6·944, 6·954, 6·964, 6·974, 6·984, 6·994	Industrial Practice ..... 40 h.p.w. (Students to register for one of these subjects.)	

At M. I. T.				*At M. I. T.*			
First Term	**Graduate Study and Thesis		47	*Second Term*	‡‡Humanities		3–5
			47		**Graduate Study and Thesis		40
							48

VII. QUANTITATIVE BIOLOGY

THE curriculum in the biological sciences is devised to furnish fundamental training in pure and applied biology which may prepare students for professional careers in biology (teaching and research), for medical training, and for work involving technical applications in industries concerned with biological materials and fermentation processes. Stress is laid on the application of quantitative, analytical methods in the subjects 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. While the student is assured of a sound background in the basic sciences of mathematics, physics and chemistry, and the fundamentals of modern biology, provision is made in the third and fourth years for a wide choice of electives both in the biological sciences and in the humanities.

Modern medicine is rapidly becoming less empirical and more scientific so that it is especially important, for those who wish to prepare for medical research, to become acquainted with the quantitative approach to biological phenomena.

The Course leads to the degree of Bachelor of Science in Quantitative Biology.

FIRST YEAR (See page 51)

SECOND YEAR

First Term	5·41	Organic Chemistry I	4–4	*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
	H21	Hum. & Soc. Sciences, Int.	3–5		H22	Hum. & Soc. Sciences, Int.	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			24–24				27–23

THIRD YEAR

First Term	*5·416	Organic Preparations I	6–0	*Second Term*	*5·62	Physical Chemistry II	4–4
	*5·61	Physical Chemistry I	4–4		*5·621	Physical Chem. Lab. II	4–2
	*5·611	Physical Chem. Lab. I	4–2		*7·11	Embryology	8–4
	7·10	Genetic Cytology	6–4			†Humanities	3–5
	*7·80	Biochemistry	8–4			Elective Subject	12
		†Humanities	3–5				46
			31–19				

FOURTH YEAR

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

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.
** Students may substitute 16 units of additional Humanities in place of 16 units of Graduate study.
‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken.

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 applications 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, drugs, medical supplies and instrumentation, textiles, leather, 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. Physics and chemistry are taken in 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, 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 awarded simultaneously at the end of the graduate year.

(*Same as Course VII through Third Year*)

Fourth Year

First Term	*7·19	General Physiology I	2–4	*Second Term*	*7·20	General Physiology II	2–4
	*7·211	Gen. Physiol. Lab. I	4–0		*7·212	Gen. Physiol. Lab. II	4–0
	*7·85	Biophysics I	4–4		*8·06	Nuclear Physics	4–6
	*8·05	Atomic Physics	4–6		*8·09	Experimental Physics, Tech.	3–3
		†Humanities	3–5			†Humanities	3–5
		§Elective Subjects	12			§Elective Subjects	14
			48				48

Graduate Year

First Term	7·31	Biology Seminar	1–2	*Second Term*	7·32	Biology Seminar	1–2
	7·91	Instrument. in Biol. I	7–6		7·86	Biophysics II	2–4
		Thesis	16		7·882	Biophysics Lab.	4–0
		§Elective Subjects	16			Thesis	24
			48			§Elective Subjects	12
							49

§ A total of at least 18 units of Electives in the fourth and Graduate years must be selected from the following subjects:

First Term	7·81	Enzymology	2–4	*Second Term*	7·50	Phys. Chem. of Proteins	2–4
	7·811	Enzymology Lab.	4–2		7·51	Phys. Chem. of Proteins Lab.	4–0
	7·831	Biochem. of Microorganisms	7–4		7·82	Biochemistry, Adv.	6–4
	7·97	Tissue Ultrastructure	2–4		7·98	Tissue Ultrastructure	2–4

VII-B. CHEMICAL BIOLOGY

AS a companion to Course VII-A this course has as its purpose the preparation of promising students for work of a research character in those areas of biology, pure and applied, where advanced training in both chemistry and biology is required. The fields in which opportunities exist for graduates of this five-year program include, among others, the food industries, the biochemical and pharmaceutical industries, the fermentation industries, leather, glue, and gelatin industries, adhesives and plastics industries. Medical research and agricultural research also offer attractive opportunities, and many governmental research agencies constitute an area for rewarding employment and service. The five-year program can be used as a basis for further graduate work leading to the doctorate for those who are interested in careers in more advanced research or academic teaching in the fields of pure and applied biology.

The Course is so outlined that the student receives a foundation simultaneously in the fields of biology and chemistry with the first four years essentially as in Course VII but permitting in place of the bachelor's thesis the election of other subjects in a variety of fields in which the student may wish to concentrate. The fifth year is devoted to subjects of graduate level in enzymology, biochemistry, physical chemistry of proteins and spectroscopy. Provision is made for the election of further subjects in selected recommended areas such as biophysics. Training for research is provided during the fifth year during which time the student does active research work on a problem in pure or applied biology, the results of which are embodied in the Master's thesis.

Course VII-B leads to the degrees of Bachelor of Science in Quantitative Biology and Master of Science in Chemical Biology, awarded simultaneously at the end of the fifth year

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.

VII-B. Chemical Biology Continued

(Same as Course VII through Third Year)

FOURTH YEAR

First Term	5·67	Atomic & Molecular Struct., Int.	2–4	*Second Term*	5·42	Organic Chemistry II	4–4
	*7·19	General Physiology I	2–4		5·424	Org. Prep. II and Anal.	9–0
	*7·211	General Physiology Lab. I	4–0		*7·20	General Physiology II	2–4
	*7·831	Biochem. of Microorganisms	7–4		*7·212	General Physiology Lab. II	4–0
		†Humanities	3–5			†Humanities	3–5
		Elective Subjects	12			Elective Subjects	14
			47				49

GRADUATE YEAR

First Term	7·31	Biology Seminar	1–2	*Second Term*	7·32	Biology Seminar	1–2
	7·81	Enzymology	2–4		7·50	Phys. Chem. of Proteins	2–4
	7·811	Enzymology Lab.	4–2		7·51	Phys. Chem. of Proteins Lab.	4–0
		Thesis	14		7·82	Biochemistry, Adv.	6–4
		Elective Subjects	20			Thesis	26
			49				49

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 51)

SECOND YEAR

First Term	5·60	Physical Chemistry	3–6	*Second Term*	6·10	Elec. Circuit Theory, Elem.	4–8
	8·031	Physics	5–5		8·041	Physics	5–5
	H21	Hum. & Soc. Sciences, Int.	3–5		H22	Hum. & Soc. Sciences, Int.	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
			20–27				21–29

THIRD YEAR

First Term	6·02	Electrical Eng., Prin.	4–5	*Second Term*	*8·08	Electronics	4–5
	6·82	Elec. Measurements Lab.	3–3		*8·101	Atomic Structure Lab.	3–3
	*8·05	Atomic Physics	4–6		*8·102	Electronic Devices Lab.	3–3
	*8·09	Experimental Physics, Tech.	3–3		M352	Adv. Calculus for Eng.	3–6
	M351	Adv. Calculus for Eng.	3–6			†Humanities	3–5
		†Humanities	3–5			Prof. Elective Subject	9
			20–28				47
						Professional Elective Subjects	
					8·06	Nuclear Physics	4–6
					8·16	Optics	3–6

FOURTH YEAR

First Term	8·07	Thermodyn. & Statist. Mech.	4–5	*Second Term*	8·72	Int. Theoretical Physics II	4–8
	8·11	Experimental Physics	8–4			*Thesis	18
	8·71	Int. Theoretical Physics I	4–8			†Humanities	3–5
		†Humanities	3–5			Elective Subject	8
		Elective Subject	8				46
			49				

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.

IX-A. GENERAL SCIENCE

IX-B. GENERAL ENGINEERING

In the general areas of science and of engineering there are many fascinating and important professional fields which are, nevertheless, not of such major size as to warrant the establishment of a separate curriculum for each. Thorough training adapted to many of these fields is available in Courses IX-A and IX-B, both of which permit great flexibility in the choice of subjects.

These curricula may take many forms; for example, the student may prepare for a specific field of science or engineering, for entrance into a specific industry, or for a specific enterprise. Recognizing the key importance of trained liaison personnel equipped to deal with more than one specialty, he may develop a program combining two or more fields.

Whatever the student's ultimate objective, it is desirable that he have a strong basic training in either science or engineering. To assure this thorough groundwork, certain essential subjects are included in Course IX-A, General Science, and in Course IX-B, General Engineering. In addition, the electives in the third and fourth years must include at least 48 units in an appropriate field of science or engineering.

Additional electives enable the student to round out his major program and add such other subjects as may interest him. His choice of electives is subject to the approval of the Head of Courses IX-A and IX-B. The outlines below give the required subjects and a list of electives. In addition, a typical General Engineering program is presented, emphasizing conservation.

Course IX-A leads to the degree of Bachelor of Science in General Science.

Course IX-B leads to the degree of Bachelor of Science in General Engineering.

IX-A. GENERAL SCIENCE

First Year (See page 51)

Second Year

First Term	5·11	Qualitative Analysis	7–3	*Second Term*	5·12	Quantitative Analysis	7–3
	8·03	Physics	5–5		8·04	Physics	5–5
	H21	Hum. & Soc. Sciences, Int.	3–5		H22	Hum. & Soc. Sciences, Int.	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
		Elective Subject	8			Elective Subject	8
			48				48

Third Year

First Term	**5·61	Physical Chemistry I	4–4	*Second Term*	**5·62	Physical Chemistry II	4–4
	**8·07	Thermodyn. & Statist. Mech.	4–5		**8·08	Electronics	4–5
	**M36	Advanced Calculus	3–6		**M37	Advanced Calculus	3–6
		‡†Humanities	3–5			‡†Humanities	3–5
		§Elective Subjects	16			§Elective Subjects	16
			50				50

Fourth Year

First Term		*Thesis	4	*Second Term*		*Thesis	5
		‡†Humanities	3–5			‡†Humanities	3–5
		§Elective Subjects	36			§Elective Subjects	35
			48				48

Suggested Elective Subjects

	5·41	Organic Chemistry I	4–4		5·42	Organic Chemistry II	4–4
	5·414	Organic Preparations I	9–0		5·424	Org. Prep. II & Anal.	9–0
	5·611	Physical Chem. Lab. I	4–2		5·621	Physical Chem. Lab. II	4–2
	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
	7·831	Biochemistry of Microorganisms	7–4		8·15	Photography	2–1
	8·05	Atomic Physics	4–6		8·16	Optics	3–6
	8·09	Experimental Physics, Tech.	3–3		8·17	Color Measurements	3–2
	8·132	Architectural Acoustics	5–3		8·72	Int. Theoretical Physics II	4–8
	8·71	Int. Theoretical Physics I	4–8		12·321	Engineering Geology	4–4
	12·322	Engineering Geology	2–4				
	20·41	Bacteriology	6–2				
	M31	Differential Equations	2–4				

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.

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

§ Total elective subjects for the third and fourth years must include a total of at least 48 units in one field of science. Elective subjects other than those suggested will be approved if they conform to the student's general objective.

‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken.

IX-B. GENERAL ENGINEERING

FIRST YEAR (See page 51)

SECOND YEAR

First Term	2·00	Statics	3–5	*Second Term*	2·01	Dynamics	3–5
	8·03	Physics	5–5		8·04	Physics	5–5
	H21	Hum. & Soc. Sciences, Int.	3–5		H22	Hum. & Soc. Sciences, Int.	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
		Elective Subject	9			Elective Subject	9
			47				47

THIRD YEAR

First Term	**2·04	Strength of Materials	3–6	*Second Term*	**2·42	Heat Engineering	3–6
	**2·40	Heat Engineering	4–5			‡†Humanities	3–5
	**6·40	Electrical Eng., Elem.	4–6			§Elective Subjects	33
		‡†Humanities	3–5				50
		§Elective Subjects	14				
			50				

FOURTH YEAR

First Term		*Thesis	4	*Second Term*		*Thesis	5
		‡†Humanities	3–5			‡†Humanities	3–5
		§Elective Subjects	36			§Elective Subjects	35
			48				48

Suggested Elective Subjects

1·05	Surveying	3–1	1·40	Structural Analysis	3–6
1·613	Fluid Mechanics	3–6	2·06	Dynamics	3–6
2·081	Strength of Materials	3–6	2·50	Heat Measurements	3–1
2·663	Air Conditioning	3–6	2·621	Refrigeration	3–6
2·681	Engineering Laboratory	3–3	2·792	Internal Combustion Eng.	3–6
2·701	Machine Drawing	6–0	3·11	Engineering Metals	6–4
2·73	Machine Design	4–2	6·17	Illumination	2–4
2·791	Internal Combustion Eng.	3–6	6·19	Industrial Electronics	4–6
5·11	Qualitative Analysis	7–3	6·85	Electrical Eng. Lab.	2–3
6·221	Electric Power Systems	3–6	15·50	Accounting	5–4
E35	Reports	1–4	15·61	Business Law	3–6
M351	Adv. Calculus for Engineers	3–6	M352	Adv. Calculus for Engineers	3–6

CONSERVATION ENGINEERING — A SAMPLE CURRICULUM FOR COURSE IX-B

The growing importance of conservation in our national economy indicates an increasing demand for well-trained personnel. This field is concerned with one of the great problems of our time and will inevitably grow in importance and scope. In a program of this kind, the student acquires a knowledge of long-range planning methods which he will also find useful in many industries demanding such training.

A student in this field could take the following program within the framework of Course IX-B.

SECOND YEAR

Substitute, in the first term, 2·011 Statics and Dynamics, 3–5, in place of 2·00.
Substitute, in the second term, 2·04 Strength of Materials, 3–6, in place of 2·01.
In addition to the required subjects, other than 2·00 and 2·01, take as electives:

First Term	7·01	General Biology I	6–4	*Second Term*	7·02	General Biology II	6–4

THIRD YEAR

Omit 2·04. In addition to the required subjects, other than 2·04, take as electives:

First Term	1·05	Surveying	3–1	*Second Term*	1·602	Fluid Mechanics	2–4
	1·601	Fluid Mechanics	3–6		1·90	Conservation, Prin.	3–6
	4·59	Govt. and Public Admin.	3–6		12·321	Engineering Geology	4–4
					M32	Statistics, Elem.	3–6

FOURTH YEAR

In addition to the required subjects, take as electives:

First Term	1·72	Hydrology & Water Power Eng.	3–3	*Second Term*	1·06	Photogrammetry	4–4
	4·13	Land Economics	2–4		1·77	Water Supply & Sewerage	3–3
	12·94	Mineral Economics	3–6		4·14	Land Economics	3–6
	13·85	Cargoes in World Trade	3–6		4·60	Plan. Legis. & Admin.	2–4
		Additional Humanities	3–5			or	
						Additional Humanities	3–5
						Thesis (additional time)	6

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.
** Substitutions may be made only with subjects in the same field.
§ Total elective subjects for the third and fourth years must include a total of at least 48 units in one field of engineering. Elective subjects other than those suggested will be approved if they conform to the student's general objective.
‡ 14·01 Economic Principles I, 3–5 is a requirement for graduation and must be one of the Humanities subjects taken.

IX-C. SCIENCE TEACHING

(In cooperation with the Harvard Graduate School of Education)

WELL-trained and broadly educated teachers of science and mathematics in secondary schools and junior colleges are playing an increasingly important part in our society, and are in active demand in both public and independent schools. Such a teaching career requires, in addition to adequate general education, a background in mathematics and the natural sciences, with some concentration in one of these, as well as training in education as a professional field. The fact that M. I. T. and Harvard University are neighboring institutions in Cambridge makes it possible for the education subjects to be taken at the Harvard Graduate School of Education, under a cooperative agreement.

The first three years are spent mainly at the Institute, though some education subjects at Harvard University are introduced as early as the third year. The combined training continues in the fourth year, but entrance to this stage of the program is subject to the approval both of the Head of Course IX-C and the Harvard Graduate School of Education. The graduate year includes practice teaching in nearby secondary schools, as well as further studies in education at Harvard University, and more advanced work in mathematics and science at the Institute.

Course IX-C leads to the degree of Bachelor of Science in General Science from the Institute, and to the degree of Master of Arts in Teaching from Harvard University.

FIRST YEAR (See page 51)

SECOND YEAR

First Term	5·11	Qualitative Analysis	7–3	*Second Term*	7·02	General Biology II	6–4
	7·01	General Biology I	6–4		8·04	Physics	5–5
	8·03	Physics	5–5		14·70	Introductory Psychology	3–5
	H21	Hum. & Soc. Sciences, Int.	3–5		H22	Hum. & Soc. Sciences, Int.	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			27–23				23–25

THIRD YEAR

First Term	‡‡6·18	Electrical Eng., Fund.	4–6	*Second Term*	‡‡5·12	Quantitative Analysis	7–3
	‡‡7·10	Genetic Cytology	6–4			or	
		or			‡‡7·11	Embryology	8–4
		¶Elective Subject	10		M32	Statistics, Elementary	3–6
	‡‡8·071	Thermodyn. & Statist. Mech.	4–5			††Humanities	3–5
		††Humanities	3–5			¶Elective Subject	8
		§Educational Psych. & Meas. 1	4–8			§Teaching Math. 2	4–8
			49				47 or 49

FOURTH YEAR††

First Term		*Thesis	4	*Second Term*		*Thesis	5
		††Humanities	3–5			††Humanities	3–5
		¶Elective Subjects	18			¶Elective Subjects	24
		§History of Science 102	2–4			**§History of Education 1	4–8
		§Teaching of Mathematics 1	4–8				49
			48				

GRADUATE YEAR

First Term		¶Elective Subjects	18	*Second Term*		¶Elective Subjects	18
		§Phil. of Education 1	4–8			§Prin. of Teaching 3	2–4
		§Prin. of Teaching 3	2–4			§Prin. of Teaching 4	25
		§Science Education 1	4–8				49
			48				

X. CHEMICAL ENGINEERING

PROCESS industries such as chemicals and petroleum need men who can develop, design and operate new processes, men who can visualize the needs and outlets for new products and the possibilities of producing them, and men who have the potentialities for managerial responsibility in highly technical enterprises. Preparation for careers in these fields calls for a comprehension of both chemical and engineering principles. The

*See Requirements for Bachelor's Degree, page 51. †See page 48 for list of subjects.

§ Subjects taken at Harvard Graduate School of Education.

†† Entrance into the fourth year is subject to the approval of the Head of Course IX-C and the Harvard Graduate School of Education.

** The American School 1, 4–8, may be substituted. Given at Harvard Graduate School of Education.

¶ At least 16 units (2 subjects) must be taken in the Humanities at the Institute and at least 40 units must form a related pattern centered in physics, chemistry, biology, or mathematics. The remaining units are unrestricted. One, but not both, of the following pairs, to the extent of 12 units, may be considered as a part of the 40 units in the major area:

1. 12·307 Physical Geology, 3–3, and 12·308 Historical Geology, 3–3.
2. 13·85 Cargoes in World Trade, 3–6, and 1·90 Conservation, Prin., 3–6, of which 12 units may be considered as part of the major area and 6 units as unrestricted elective.

‡ 14·01 Economic Problems I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken.

‡‡ Certain specified substitutions in the same field may be made.

X. Chemical Engineering Continued

course in Chemical Engineering is planned to afford broad preparation in fundamentals and to cultivate the ability to handle the unconventional problems which characterize these expanding industries.

The work in chemistry, covering inorganic, analytical, physical and organic chemistry, is nearly the same as that given to students in chemistry during the first three years, except for some reduction in laboratory requirements. The subjects in mechanical and electrical engineering are intended to supply the fundamentals which are needed by the chemical engineer. The work in chemical engineering and in industrial chemistry is of a professional nature, designed to develop a capacity for original thought and action. Competent students may make substitutions in the curriculum with the approval of the Head of the Department.

A graduate year of the Course in Chemical Engineering Practice provides unique opportunity for the development and application of the basic professional principles.

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

FIRST YEAR (See page 51)

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
	10·11	Chemical Engineering	1–1		H22	Hum. & Soc. Sciences, Int.	3–5
	H21	Hum. & Soc. Sciences, Int.	3–5		M22	Differential Equations	3–6
	M21	Calculus	3–6		MS22	Military Science	3–0
	MS21	Military Science	3–0				
			25–25				24–25

THIRD YEAR

First Term	5·41	Organic Chemistry I	4–4	*Second Term*	5·42	Organic Chemistry II	4–4
	5·416	Organic Preparations I	6–0		5·426	Qual. Organic Analysis	6–0
	5·61	Physical Chemistry I	4–4		5·62	Physical Chemistry II	4–4
	5·612	Physical Chem. Lab. I	2–0		5·622	Physical Chem. Lab. II	2–0
	10·17	Industrial Chemistry	3–4		10·18	Industrial Chemistry	3–6
	10·28	Chemical Engineering	4–6		10·29	Chemical Engineering	4–6
		†Humanities	3–5			†Humanities	3–5
			26–23				26–25

FOURTH YEAR

First Term	6·18	Electrical Eng., Fund	4–6	*Second Term*	10·21	Industrial Chemistry	3–6
	10·15	Thesis Reports	3–0		10·32	Chemical Engineering	4–6
	10·26	Industrial Chem. Lab.	10–0			*Thesis	12
		or				†Humanities	3–5
	10·27	Chemical Eng. Lab.	10–0			Elective Subject	8
	10·31	Chemical Engineering	4–6				
		†Humanities	3–5				47
		Elective Subject	8				
			49				

Students registered in the fourth year, first term, in the Fall term 1952–53: Omit Elective, 8. Add 10·18 Industrial Chemistry, 3–6.

X-B. CHEMICAL ENGINEERING PRACTICE

THE facilities of the School of Chemical Engineering Practice are available for a selected group of undergraduates during the second half of the senior year. Students desiring to take this Course should register in the first term of the fourth year and those accepted will spend the second term at the Field Stations of the School of Chemical Engineering Practice. The nature of the work in the School of Chemical Engineering Practice is described under the section on Chemical Engineering in The Graduate School.

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

(*Same as Course X through Third Year*)

FOURTH YEAR

First Term	6·18	Electrical Eng., Fund	4–6	*Second Term*	10·30T	Engineering Equipment	9–0
	10·31	Chemical Engineering	4–6			School Chem. Eng. Practice	
	10·32	Chemical Engineering	4–6			§10·84 Bangor Station	12–0
		†Humanities	3–5			§10·85 Parlin Station	12–0
		†Humanities	3–5			§10·86 Buffalo Station	12–0
						*Thesis	15
			18–28				48

Students registered in the fourth year, first term, in the Fall term 1952–53: Omit one Humanities 3–5. Add 10·18 Industrial Chemistry, 3–6. Students registered in the Spring term 1953: Omit 10·30T. Add 10·30 Engineering Equipment, 6–0 and †Humanities, 3–5. Change Thesis to 13.

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects. § Students will take two of these stations.

XI. SANITARY ENGINEERING

MUCH of the Institute's work in Sanitary Engineering is given at graduate level, but undergraduate training in Sanitary Engineering is obtained by enrolling in Course I, Civil Engineering. Option 1, Theory and Design, is best suited to this purpose. 1·831 Sanitary Chemistry should be substituted for 2·41 Heat Engineering in the third year; 1·75 Water Supply and Purification and 1·76 Sewerage and Sewage Treatment should be chosen as fourth year professional electives; and 1·79 Sanitary Engineering Design should be substituted for 1·442T Reinforced Concrete Design in the fourth year. Reference should be made to the Civil Engineering curriculum.

XII-A. GEOLOGY

THE objective of Course XII-A is to train students for careers in theoretical and applied geology. The program of study provides a broad and fundamental training that integrates classical geology with principles and techniques of mathematics, physics and chemistry needed for progressive advancement in modern geological science.

The program prepares students for geological work in scientific and academic institutions, in the petroleum and mineral industries, and in governmental agencies. By including appropriate electives a student's program may be directed toward one of the following fields: Basic Geology; Crystallography; Engineering Geology; Geochemistry; Mineralogy; Mineral Industry; Mineral Deposits; Mineral Fuels; Petrology; Sedimentation, Stratigraphy and Paleontology; Structural Geology.

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

First Year (See page 51)

Second Year

First Term	5·11	Qualitative Analysis	7–3	*Second Term*	2·851	Machine Tool Lab.	4–0
	8·03	Physics	5–5		8·04	Physics	5–5
	12·011	Mineralogy	3–1		12·012	Mineralogy	4–2
	12·20	Elem. Crystallography	2–2		12·301	Physical Geology	7–3
	H21	Hum. & Soc. Sciences, Int.	3–5		H22	Hum. & Soc. Sciences, Int.	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			26–22				29–21

Required During Summer at Nova Scotia Centre for Geological Sciences

12·303	Geological Surveying	5–0
12·304	Field Investigations & Reports	15–0
12·701	Structural Elements	4–0
		24–0

Third Year

First Term	5·60	Physical Chemistry	3–6	*Second Term*	12·14	Petrology	2–4
	12·231	Optical Crystallography	6–2		12·15T	Petrography	6–0
	12·302	Historical Geology	7–3		12·44	Geology of Oilfields	2–4
	12·702	Structural Geology	3–4		12·87	Geophysics, Int.	2–4
		†Humanities	3–5		M32	Statistics, Elementary	3–6
		Language or Humanities	3–5			†Humanities	3–5
			25–25			Language or Humanities	3–5
							21–28

Fourth Year

First Term	12·24	Theoretical Crystallography	2–4	*Second Term*	12·04	X-ray Mineralogy	4–2
	12·40	Mineral Deposits	2–4		12·45	Oilfield Reservoirs	2–4
	12·41	Mineral Deposits Lab.	4–0		12·80	Geochemistry	2–4
	12·581T	Sedimentology	4–2			*Thesis	15
	12·94	Mineral Economics	3–6			†Humanities	3–5
		†Humanities	3–5			§Elective Subject	8
		§Elective Subjects	8				49
			47				

Suggested Elective Subjects§

10·661	Colloid Chem. Int.	2–4
12·51	Paleontology	7–2
12·73	Regional Geology	2–4

Suggested Elective Subjects§

12·52	Paleontology, Adv.	Time arr.
12·582	Sedimentology, Adv.	Time arr.
12·86	Seismology, Elem.	2–4
12·89	Isotope Geology	2–4

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.
§ Other subjects may be arranged after conference with members of the staff and with the approval of the Registration Officer.

COURSE XII-B. GEOPHYSICS

GEOPHYSICS is the study of the physical properties and dynamics of the earth. The undergraduate course in geophysics provides basically a broad training in applied physics. The student is introduced to the various branches of geology with attention focused on the areas that can be developed best by the use of physical methods. At the present time there is a serious shortage of men trained in both the applied and research fields of geophysics, and the demand is not being adequately met by the numbers now in training.

The industrial expansion in recent times has placed heavy demands on the petroleum and mineral industries. Reserves of petroleum and metallic ores are increasingly difficult to maintain. The easy discoveries have been made, and the industries must rely on improvements and new developments in geophysical methods in their exploration programs. The industrial needs for men trained in this field are shared by research, governmental, military and atomic energy organizations engaged in a wide variety of problems related to raw materials, defense, global strategy, and pure scientific discovery.

The undergraduate program places special emphasis on electrical engineering and physics, with a basic coverage of geological subjects and field training. The summer following the sophomore year is spent at the M.I.T. - Nova Scotia Centre for Geological Sciences, where the student learns surveying, mapping, and geological field methods. An optional cooperative program of geophysical field training has been arranged with the Geophysical Service, Inc. of Dallas, Texas, for the summer following the third year. During this summer, the student who participates in the program is employed by the company as a regular employee and joins a field party engaged in seismic exploration in a part of the continent where active petroleum search is going on. This professional experience is considered to be an essential part of his undergraduate training.

The course of training leads to the degree of Bachelor of Science in Geophysics.

FIRST YEAR (See page 51)

SECOND YEAR

First Term	5·60	Physical Chemistry	3–6	*Second Term*	2·851	Machine Tool Lab.	4–0
	8·03	Physics	5–5		8·04	Physics	5–5
	12·011	Mineralogy	3–1		12·012	Mineralogy	4–2
	12·20	Elem. Crystallography	2–2		12·301	Physical Geology	7–3
	H21	Hum. & Soc. Sciences, Int.	3–5		H22	Hum. & Soc. Sciences, Int.	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			22–25				29–2

REQUIRED DURING SUMMER AT NOVA SCOTIA CENTRE FOR GEOLOGICAL SCIENCES

12·303	Geological Surveying	5–0
12·304	Field Investigations & Reports	15–0
12·701	Structural Elements	4–0
		24–0

THIRD YEAR

First Term	6·00T	Circuit Theory, Elem.	7–5	*Second Term*	6·01T	Circuit Theory, Elem.	7–5
	12·306	Historical Geology	5–3		12·44	Geology of Oilfields	2–4
	M32	Statistics, Elementary	3–6		12·87	Geophysics, Int.	2–4
	M351	Adv. Calculus for Eng.	3–6		M352	Adv. Calculus for Eng.	3–6
		†Humanities	3–5			†Humanities	3–5
						Language or Humanities	3–5
			21–25				20–29

FOURTH YEAR

First Term	6·75	Electrical Meas. Lab.	4–5	*Second Term*	6·02	Electrical Eng., Prin.	4–5
	8·07	Thermo. & Statist. Mech.	4–5		6·30	Com. Network Theory	3–6
	12·24	Theoretical Crystallography	2–4		6·76	Eng. Electronics Lab.	3–3
	12·40	Mineral Deposits	2–4			*Thesis	15
		†Humanities	3–5			†Humanities	3–5
		§Elective Subject (see next page)	8			§Elective Subject (see next page)	6
			46				5–3

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.
§ Other subjects may be arranged after conference with members of the staff and with the approval of the Registration Officer.

XII-B. Geophysics Continued

Suggested Elective Subjects§

8·71	Theoretical Physics, Int. I	4–8
12·581T	Sedimentology	4–2
12·702	Structural Geology	3–4
12·73	Regional Geology	2–4
M29T	Methods of App. Math.	3–9

Suggested Elective Subjects§

8·72	Theoretical Physics, Int. II	4–8
12·45	Oilfield Reservoirs	2–4
12·80	Geochemistry	2–4
12·86	Seismology, Elem.	2–4
12·89	Isotope Geology	2–4

XIII. NAVAL ARCHITECTURE AND MARINE ENGINEERING

STUDENTS desirous of preparing for a professional career in the design and building of ships and their propulsion machinery, or in allied industries, will find in this course a curriculum to meet their objectives.

For the first two years the program comprises mainly fundamental and basic subjects in science and the humanities, which provide an essential foundation for the professional subjects of the upper years. In the second year, however, there are included introductory subjects in ship construction which deal with the broad aspects of shipbuilding and the power plant equipment of vessels, and with the operation of shipyards.

In the third and fourth years instruction in naval architecture and ship design are carried on concurrently with instruction in marine engineering. The study of allied subjects such as applied and fluid mechanics, heat engineering and electrical engineering, is also taken up. Naval architecture and ship design include considerations such as: stability, subdivision of the hull, freeboard and tonnage, ship motions among waves, powering, steering, launching, and structural design, while marine engineering embraces steam machinery and Diesel engines, arrangement of machinery in the ship, and auxiliary equipment used in marine power plants.

The Course leads to the degree of Bachelor of Science in Naval Architecture and Marine Engineering.

FIRST YEAR (See page 51)

SECOND YEAR

First Term	2·00	Statics	3–5	*Second Term*	2·01	Dynamics	3–5
	2·851	Machine Tool Lab.	4–0		2·04	Strength of Materials	3–6
	8·03	Physics	5–5		8·04	Physics	5–5
	13·40	Naval Arch. & Marine Eng. I	3–3		13·41	Ship & Eng. Drawing	4–1
	H21	Hum. & Soc. Sciences, Int.	3–5		H22	Hum. & Soc. Sciences, Int.	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			24–24				24–28

THIRD YEAR

First Term	*2·081	Strength of Materials	3–6	*Second Term*	*2·42	Heat Engineering	3–6
	*2·251	Fluid Mechanics	3–6		*6·18	Electrical Eng., Fund.	4–6
	*2·40	Heat Engineering	4–5		*13·02	Naval Architecture II	4–5
	*13·01	Naval Architecture I	4–5		*13·45T	Ship Structures	3–6
	*13·42T	Hull Form Design	5–0		13·52T	Marine Engineering I	3–3
		‡†Humanities	3–5			‡†Humanities	3–5
			22–27				20–31

FOURTH YEAR
(In effect 1953–54)

First Term	*2·371	Testing Materials Lab.	2–2	*Second Term*	*13·46T	Ship Design	9–2
	*2·681	Engineering Lab.	3–3		*13·54	Marine Eng. Dynamics	2–4
	*3·11	Engineering Metals	6–4		*13·62T	Marine Eng. Des. IV	5–0
	*13·43	Ship Structural Drawing	3–0			*Thesis	10
	*13·53	Marine Engineering II	3–6			‡†Humanities	3–5
	*13·61T	Marine Eng. Des. III	3–0			Elective Subject	8
		‡†Humanities	3–5				48
		Elective Subject	8				
			51				

FOURTH YEAR (1952–53 only)

First Term	*2·681	Engineering Lab.	3–3	*Second Term*	*13·46	Ship Design	6–1
	*6·18	Electrical Eng., Fund.	4–6		*13·55	Marine Engineering	2–4
	*13·45	Ship Structures Design	6–3		*13·62	Marine Engineering Design	7–1
	*13·54	Marine Engineering Dynamics	2–4			*Thesis	10
	*13·61	Marine Engineering Design	5–1			†Humanities	3–5
		†Humanities	3–5			Elective Subject	8
		Elective Subject	8				47
			53				

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.
§ Other subjects may be arranged after conference with members of the staff and with the approval of the Registration Officer.
‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken.

XIII-C. MARINE TRANSPORTATION

(No students, unless previously registered in this course, will be accepted during the year 1952–53.)

IT is the intention in this 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 the students in this course are required to spend approximately six months at sea on merchant ships as part of the requirements for graduation.

A number of American steamship companies cooperate, as far as their facilities will allow, in placing the students at sea as cadets or student observers. Usually part of the time at sea is spent in the engine room and part on deck.

Ordinarily the students go to sea for approximately three months following their second year and again for three months following their third year. However, if the student chooses he may spend the fourth year in practical experience with the Merchant Marine. In this case it will take five years to complete the Course. In this case also he will be required to spend at least eight months at sea if he serves in a single ship and trade route, or six months if on two or more types of ships and trade routes. The remainder of the year away from the Institute may be spent, if the student chooses, partly at sea and partly 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. A student entering the Institute with the required sea experience will not be required to put in additional time at sea, but will be required to submit a report covering his time at sea.

In the second and third year, subjects are given in heat engineering, marine engineering, ports and port facilities, cargo handling and stowage, cargo movements in world trade, naval architecture, ship construction and a foreign language. These studies give the student the proper preparation for the summers at sea. During the fourth year the student takes advanced professional studies which he can then approach with the practical knowledge which he has gained at sea.

Marine engineering is given a prominent place in the Course, as a thorough knowledge of ships' power plants is essential to the ship operator who must have a large share in their economic operation and in the selection of machinery for new ships. Since the handling of ships' cargoes is one of the largest items of expense in connection with ship operation and also influences the length of a ship's stay in port, special attention is given to this phase of ship management.

While it is essential that the major portion of the program be of a technical nature, the knowledge of a steamship company's organization and its departmental functions illustrating the application of the technical training is of importance. To cover this subject, Steamship Management is given during the last term.

This course leads to the degree of Bachelor of Science in Marine Transportation.

First Year (See page 51)

Second Year

First Term	2·851	Machine Tool Lab.	4–0	*Second Term*	2·011	Statics & Dynamics	3–5
	8·03	Physics	5–5		8·04	Physics	5–5
	13·40	Naval Arch. & Marine Eng. I	3–3		13·41	Ship & Eng. Drawing	4–1
	H21	Hum. & Soc. Sciences, Int.	3–5		H22	Hum. & Soc. Sciences, Int.	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				24–27

Required During Summer

Three months at sea.
(See text above.)

Third Year

First Term	*2·04	Strength of Materials	3–6	*Second Term*	*6·18	Electrical Eng., Fund.	4–6
	*2·40	Heat Engineering	4–5		*13·02	Naval Architecture II	4–5
	*13·01	Naval Architecture I	4–5		*13·52T	Marine Engineering I	3–3
	*13·83	Ports & Port Facilities	2–4		*13·84	Cargo Handling & Stowage	3–4
	*13·85	Cargoes in World Trade	3–6		*15·50	Accounting	5–4
		††Humanities	3–5			††Humanities	3–5
			19–31				22–27

Required During Summer

Three months at sea.
(See text above.)

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.
‡14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken.

XIII-C. Marine Transportation Continued

FOURTH YEAR

First Term	*2·681	Engineering Lab.	3–3	*Second Term*	*2·665	Refrigeration, Applied	3–5
	*13·42T	Hull Form Design	5–0		*13·47T	Ship Design	5–0
	*13·56	Marine Engineering Economics	3–6		*13·82	Ship Operation II	2–4
	*13·81	Ship Operation I	3–6		*13·86	Steamship Management	3–3
	‡†Humanities		3–5		*Thesis		10
	Elective Subject		8		‡†Humanities		3–5
			45		Elective Subject		8
							51

Students registered in the fourth year, first term, in the Fall term 1952–53: Omit 13·42T. Add *6·18 Electrical Eng., Fund., 4–6.

Students registered in the fourth year, second term, in the Spring term 1953: Omit 13·47T and 2·665. Add *13·47 Ship Design, 8–2.

XIV-A, XIV-B, AND XIV-C. ECONOMICS AND ENGINEERING

THE Courses in Economics and Engineering offer a combination of basic training in engineering and in the social sciences. Through emphasis on the relationships among engineering, economic, and human relations problems, this combination provides the student with an understanding of both technical and non-technical aspects of our complex industrial society. Such training is aimed at preparation for a wide range of careers, particularly in the engineering, economics, personnel, and production departments of business, and in governmental and labor organizations. In addition, these Courses provide the necessary background for admission to graduate work in economics, industrial relations, and engineering.

On the engineering side, the student will elect one of three courses of coordinated subjects in Mechanical (XIV-A), Electrical (XIV-B), or Chemical Engineering (XIV-C).** Each of these courses includes the fundamental subjects taken by students majoring in that engineering field. Thus, the student will get a basic training in the fundamental concepts of the particular engineering field, as well as knowledge of some of the most important practical applications.

On the social science side of the program, the emphasis is upon an examination of the impact of the technologists' skills on fundamental social problems. The objectives here are threefold: (1) to convey an understanding of human behavior, particularly in industrial settings; (2) to analyze the organization and operation of our economic system; and (3) to develop an understanding of broad questions of social policy. In this way, the range of the student's insight will be broadened so that he will be able to recognize a maximum number of administrative choices in any given situation and be able to judge intelligently the probable consequences of each choice. Thus, he will develop his analytical powers in the social sciences to supplement his engineering skills.

Within the social science curriculum some differences in emphasis are possible, particularly in the directions of industrial relations or industrial economics. In the typical case, however, the student will take, through the use of professional electives, a substantial amount of work in both these fields.

These Courses lead to the degree of Bachelor of Science in Economics and Engineering.

XIV-A. ECONOMICS AND ENGINEERING (BASED ON MECHANICAL ENGINEERING)

FIRST YEAR (See page 51)

SECOND YEAR

First Term	2·011	Statics & Dynamics	3–5	*Second Term*	3·11	Engineering Metals	6–4
	2·851	Machine Tool Lab.	4–0		8·04	Physics	5–5
	8·03	Physics	5–5		14·02	Economic Principles II	3–5
	14·01	Economic Principles I	3–5		H22	Hum. & Soc. Sciences, Int.	3–5
	H21	Hum. & Soc. Sciences, Int.	3–5		M22	Differential Equations	3–6
	M21	Calculus	3–6		MS22	Military Science	3–0
	MS21	Military Science	3–0				23–25
			24–26				

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	2–4
	*2·40	Heat Engineering	4–5		*2·42	Heat Engineering	3–6
	*14·31T	Quant. Method, Int.	3–5		¶†Humanities		3–5
	*14·81	Personality & Soc. Struct.	3–5		§Professional Subjects		16
	¶†Humanities		3–5				48
			19–32				

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.

** In certain cases, at the discretion of the Registration Officer, students may combine with their economics subjects, an engineering program in other fields.

‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken.

§ It is recommended that students emphasizing industrial relations take 14·60 Labor Relations, 3–5 and 14·73 Organization and Communication in Groups, 3–5; and those emphasizing industrial economics take 14·03 Prices and Production, 3–5, and 14·40 Money and Income, 3–5.

¶ Students may not elect any combination nor single distributional subject in the fields of Economics or Labor Relations, nor 14·73 in the field of Psychology.

XIV-A, XIV-B, and XIV-C. Economics and Engineering Continued

Fourth Year

First Term	*6·18	Elec. Eng., Fund.	4–6	*Second Term*	*Thesis	5
		*Thesis	5		¶†Humanities	3–5
		¶†Humanities	3–5		**Engineering Elective Subject	9
		**Engineering Elective Subject	9		‡‡Prof. & Hum. Elective Subjects	24
		‡‡Prof. & Hum. Elective Subjects	16			46
			48			

Students registered in the fourth year, first term, in the Fall term 1952–53: Omit Engineering Elective, 9. Add 3·11 Engineering Metals, 6–4.

XIV-B. Economics and Engineering (Based on Electrical Engineering)

First Year (See page 51)

Second Year

First Term	2·011	Statics & Dynamics	3–5	*Second Term*	6·18	Electrical Eng., Fund.	4–6
	2·851	Machine Tool Lab.	4–0		8·04	Physics	5–5
	8·03	Physics	5–5		14·02	Economic Principles II	3–5
	14·01	Economic Principles I	3–5		H22	Hum. & Soc. Sciences, Int.	3–5
	H21	Hum. & Soc. Sciences, Int.	3–5		M22	Differential Equations	3–6
	M21	Calculus	3–6		MS22	Military Science	3–0
	MS21	Military Science	3–0				21–27
			24–26				

Third Year

First Term	*2·04	Strength of Materials	3–6	*Second Term*	*6·02	Electrical Eng., Prin.	4–5
	*6·01	Electrical Eng., Prin.	3–6		*6·031	Electrical Eng., Prin.	3–6
	*6·75	Electrical Meas. Lab.	4–5		*6·76	Eng. Electronics Lab.	3–3
	*14·31T	Quant. Method, Int.	3–5			¶†Humanities	3–5
	*14·81	Personality & Soc. Struct.	3–5			§Professional Subjects	16
		¶†Humanities	3–5				48
			19–32				

Fourth Year

First Term	*6·032	Electrical Eng., Prin.	3–6	*Second Term*		*Thesis	5
		*Thesis	5			¶†Humanities	3–5
		¶†Humanities	3–5			‡Engineering Elective Subject	9
		‡Engineering Elective Subject	9			‡‡Prof. & Hum. Elective Subjects	24
		‡‡Prof. & Hum. Elective Subjects	16				46
			47				

XIV-C. Economics and Engineering (Based on Chemical Engineering)

First Year (See Page 51)

Second Year

First Term	5·11	Qualitative Analysis	7–3	*Second Term*	5·12	Quantitative Analysis	7–3
	8·03	Physics	5–5		8·04	Physics	5–5
	14·01	Economic Principles I	3–5		14·02	Economic Principles II	3–5
	H21	Hum. & Soc. Sciences, Int.	3–5		H22	Hum. & Soc. Sciences, Int.	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			24–24				24–24

Third Year

First Term	*5·61	Physical Chemistry I	4–4	*Second Term*	*5·62	Physical Chemistry II	4–4
	*10·17	Industrial Chemistry	3–4		*6·18	Electrical Eng., Fund.	4–6
	*10·28	Chemical Engineering	4–6		*10·18	Industrial Chemistry	3–6
	*14·31T	Quant. Method, Int.	3–5			¶†Humanities	3–5
	*14·81	Personality & Soc. Struct.	3–5			§Professional Subjects	16
		¶†Humanities	3–5				51
			20–29				

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.

§ It is recommended that students emphasizing industrial relations take 14·60 Labor Relations, 3–5 and 14·73 Organization and Communication in Groups, 3–5; and those emphasizing industrial economics take 14·03 Prices and Production, 3–5, and 14·40 Money and Income, 3–5.

¶ Students may not elect any combination nor single distributional subject in the fields of Economics or Labor Relations, nor 14·73 in the field of Psychology.

‡‡ See page 80 for list of Professional Elective Subjects.

‡ To be selected from Professional Subjects of Course VI.

** To be selected from Professional Subjects of Course II.

XIV-A, XIV-B, and XIV-C. Economics and Engineering Continued

FOURTH YEAR

First Term	*5·41	Organic Chemistry I	4–4	*Second Term*	*10·32	Chemical Engineering	4–6
	*10·31	Chemical Engineering	4–6			*Thesis	5
		*Thesis	5			¶††Humanities	3–5
		¶††Humanities	3–5			Prof. & Hum. Elec. Subs. (see below)	24
		Prof. & Hum. Elec. Subj. (see below)	16				47
			47				

Students registered in the fourth year, first term, in the Fall term 1952–53: Omit 5·41. Add 10·18 Industrial Chemistry, 3–6.

Professional Elective Subjects

Each student must plan with his Registration Officer an integrated program based primarily on subjects selected from the list below. Certain graduate subjects in Economics and Social Science may also be taken as electives by properly qualified students.

14·03	Prices and Production	3–5		14·64	Labor Econ. & Pub. Policy	3–5
14·09	Econ. Prob. Sem.	3–5		14·72	Union-Manage. Relations	3–6
14·20	Building Economics	2–4		14·73	Org. & Commun. in Groups	3–5
14·21T	Econ. of Patents & Inv.	3–5		14·95	Govt. & Econ. Policy	3–5
14·32	Statistical Quality Control	3–6		15·41	Finance	3–6
14·33	Econometrics	3–6		15·50	Accounting	5–4
14·40	Money and Income	3–5		15·51	Indust. Accounting	5–4
14·43	Public Finance	3–5		15·73	Management Lab.	6–3
14·54T	International Trade	3–5		15·81	Marketing	3–6
14·60	Labor Relations	3–5				

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

(UNDERGRADUATE COURSES IN THE SCHOOL OF INDUSTRIAL MANAGEMENT)

THE Courses in Business and Engineering Administration are designed for those men in whom an initial aptitude for science and engineering combines with a potential capacity for subsequent managerial responsibilities. Not only is it apparent that the successful management of industrial enterprises demands ability to understand and cope with technological problems of ever-increasing complexity, but it is believed that fundamental training in science and engineering inculcates habits of precise thinking which are of great value in the study and practice of all aspects of business administration. An educational program which blends science and engineering with business administration and the humanities is believed to be good initial preparation for the difficult job of effectively coordinating industrial research, engineering application, practical economics, and personnel relationships.

These programs of study constitute the undergraduate courses in the School of Industrial Management. The School is currently enlarging its graduate and research programs. These plans for expansion directly benefit the undergraduate course, since the increased staff and facilities will be available to undergraduate as well as graduate students.

Business Administration Program

Courses XV-A and XV-B are identical in their content of business and humanities subject matter. The program of business subjects begins in the sophomore year with a two-term introduction to the nature of modern business and its management problems. This introduction is followed in the junior year by four required one-term subjects, each dealing with a major functional area of business management, emphasis being placed on an increasing depth of understanding of business problems and on the acquisition of a working knowledge of important managerial tools and techniques.

In the senior year opportunity is afforded for selection, with the aid and advice of the faculty, of from three to five one-term subjects compatible with the particular interests and aptitudes of the individual student. The range of elective subjects available is such that the student may in this year both broaden his knowledge by the study of new areas and increase his depth of understanding by doing more advanced work in one or more subjects with which he already has some familiarity. An important part of the fourth-year program is the thesis, which affords the dual opportunity of exploring in depth a problem of the student's own choice and of carrying out a limited research program on his own initiative.

The program of business and economic subjects covers the external as well as the internal aspects of management. The aim is to encourage an enlightened attitude toward business problems as they relate to industrial, economic, sociological, and political trends. Although current techniques are discussed and evaluated, there is no attempt to develop specialized vocational skills.

Science and Engineering Programs

Courses XV-A and XV-B are designed to place emphasis on subject matter of a fundamental nature and to discourage concentration in any one professional engineering field. It has been concluded that within the limits of a four-year program, development of a secondary engineering specialty is incompatible with the primary objective of sound professional education for administration; that the proper objective for the science and engineering components of the curricula is the laying of a solid foundation both for effective industrial management and for further progress in professional engineering should such later become desirable. To this end every effort has been made

* See Requirements for Bachelor's Degree, page 51 † See page 48 for list of subjects.
¶Students may not elect any combination nor single distributional subject in the fields of Economics or Labor Relations, nor 14·73 in the field of Psychology

XV-A and XV-B. Business and Engineering Administration Continued

to incorporate in Course XV-A that subject matter basic to all types of engineering rooted in the physical sciences and in Course XV-B similar subject matter appropriate to specialties evolving from the chemical sciences.

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 51)

Second Year

First Term	2·011	Statics & Dynamics	3–5	*Second Term*	2·04	Strength of Materials	3–6
	2·851	Machine Tool Lab.	4–0		8·042	Physics	5–5
	8·032	Physics	5–5		15·02	Indust. Manage. II, Fund.	4–5
	15·01	Indust. Manage. I, Fund	4–5		H22	Hum. & Soc. Sciences, Int.	3–5
	H21	Hum. & Soc. Sciences, Int.	3–5		M22	Differential Equations	3–6
	M21	Calculus	3–6		MS22	Military Science	3–0
	MS21	Military Science	3–0				21–27
			25–26				

Third Year

First Term	*2·40	Heat Engineering	4–5	*Second Term*	*1·601	Fluid Mechanics	3–6
	*3·11	Engineering Metals	6–4		*2·06	Dynamics	3–6
	†14·01	Economic Prin. I — Humanities	3–5		*2·42	Heat Engineering	3–6
	*15·50	Accounting	5–4		*15·30	Personnel Administration	3–6
	*15·81	Marketing	3–6		*15·71	Production Management	3–6
			21–24			§†Humanities	3–5
							18–35

Fourth Year

(In effect 1953–54)

First Term	*6·18	Electrical Eng., Fund.	4–6	*Second Term*	*6·19	Industrial Electronics	4–6
		*Thesis	2			*Thesis	10
		§†Humanities	3–5			§†Humanities	3–5
		Hum. or Prof. or Eng. Elec. Subj.	8			Hum. or Prof. Elective Subj.	8
		Prof. Elective Subjects	18			Prof. Elective Subject	9
			46				45

Fourth Year (1952–53 only)

First Term	3·331	Indust. Phys. Metallurgy	4–2	*Second Term*	15·92	Industrial Problems	3–6
	14·31	Elementary Statistics	3–6			*Thesis	10
	*15·41	Finance	3–6			§†Humanities	3–5
		*Thesis	1			Business or Econ. Elective Subjects	17
		§†Humanities	3–5			Engineering Elective Subject	6
		Business or Econ. Elective Subject	9				50
		Engineering Elective Subject	6				
			48				

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

First Year (See page 51)

Second Year

First Term	5·11	Qualitative Analysis	7–3	*Second Term*	5·12	Quantitative Analysis	7–3
	8·032	Physics	5–5		8·042	Physics	5–5
	15·01	Indust. Manage. I, Fund.	4–5		15·02	Indust. Manage. II, Fund.	4–5
	H21	Hum. & Soc. Sciences, Int.	3–5		H22	Hum. & Soc. Sciences, Int.	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			25–24				25–24

Third Year

First Term	*5·41	Organic Chemistry I	4–4	*Second Term*	*5·42	Organic Chemistry II	4–4
	*5·416	Organic Preparations I	6–0		*5·62	Physical Chemistry II	4–4
	*5·61	Physical Chemistry I	4–4		*6·40	Electrical Eng., Elem.	4–6
	†14·01	Economic Prin. I — Humanities	3–5		*15·30	Personnel Administration	3–6
	*15·50	Accounting	5–4		*15·71	Production Management	3–6
	*15·81	Marketing	3–6			§†Humanities	3–5
			25–23				21–31

*See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.
§ Students may not elect any combination nor single distributional subject in the field of Labor Relations.

XV-A and XV-B. Business and Engineering Administration Continued

FOURTH YEAR
(In effect 1953–54)

First Term	*10·28	Chemical Engineering	4–6	*Second Term*	*10·29	Chemical Engineering	4–6
		*Thesis	2			*Thesis	10
		§†Humanities	3–5			§†Humanities	3–5
		Hum. or Prof. or Eng. Elec. Subj.	8			Hum. or Prof. Elective Subj.	8
		Prof. Elective Subjects	18			Prof. Elective Subject	9
			46				45

FOURTH YEAR (1952–53 only)

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

XVI. AERONAUTICAL ENGINEERING

THE primary objective of the Undergraduate Course in Aeronautical Engineering is to prepare the student to apply the methods of the aeronautical engineer to the design and construction of aircraft and their component systems. To do this he must determine the nature of an engineering problem, select between alternate solutions, and judge the effects of compromises.

As a foundation for professional practice, the course provides general training in science, mathematics, and the humanities followed by study of the professional subjects of aeromechanics, aerodynamics, stability, automatic control, structures, and power plants. Work in the classroom is supplemented by laboratory experiments illustrative of the theory and methods of prediction used in design and culminates in an integrated engineering project.

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

HONORS COURSE

The opportunity will be afforded a limited number of students of superior ability to join an Honors Course group. The selection of members of this group will be made by the Department from students who may wish to avail themselves of the opportunity to pursue a coordinated schedule of studies through the senior and graduate years. A member of the Department will serve as adviser to aid members of the group in selecting the senior and graduate schedules which may be best suited to their individual interests. ††

The Honors Course leads to the 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 51)

SECOND YEAR

First Term	2·00	Statics	3–5	*Second Term*	2·04	Strength of Materials	3–6
	8·03	Physics	5–5		8·04	Physics	5–5
	16·70T	Aircraft Detail Design	9–0		16·00	Aeromechanics	4–5
	16·82	Aeronautical Eng., Int.	3–1		H22	Hum. & Soc. Sciences, Int.	3–5
	H21	Hum. & Soc. Sciences, Int.	3–5		M22	Differential Equations	3–6
	M21	Calculus	3–6		MS22	Military Science	3–0
	MS21	Military Science	3–0				21–27
			29–22				

THIRD YEAR§§

First Term	*2·40	Heat Engineering	4–5	*Second Term*	*6·18	(a) Electrical Eng., Fund.	4–6
	*6·18	(b) Electrical Eng., Fund.	4–6		6·19	(b) Indust. Electronics	4–6
	*16·01T	Aeromechanics	5–5		*16·02T	Aerodynamics	6–6
	*16·10	Aerodynamics, App.	4–8		*16·13	Airplane Stability & Cont.	3–6
	*16·20	(a) Structures	3–6		*16·20	(b) Structures	3–6
		‡†Humanities	3–5		16·21T	(a) Structures	4–6
			(a) 19–29			‡†Humanities	3–5
			(b) 20–29				(a) 20–29
							(b) 19–29

Students registered in the third year, first term, in the Fall term 1952–53: Omit 6·18 and 16·20. Add *2·04 Strength of Materials, 3–6.

Students registered in the third year, second term, in the Spring term 1953: Omit 6·19 and 16·21T. (All must take 6·18 and 16·20.)

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.
‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken.
§§ Students must select either the program of subjects indicated as "(a)" or that indicated as "(b)."
†† The program must include completion of all unit and Humanities requirements for the Bachelor's and Master's degrees, but only a single thesis of not less than 30 units in the graduate year.
§ Students may not elect any combination nor single distributional subject in the field of Labor Relations.

XVI. Aeronautical Engineering Continued

FOURTH YEAR
(In effect 1953–54)

First Term	*16·30	Automatic Control, Prin.	3–9	*Second Term*	*16·53	Aircraft Power Plants, Prin.	3–6
	16·65	Aeronautical Eng. Lab.	6–6		*16·72T	Aeronautical Eng.	12–0
	*16·71T	Aeronautical Eng.	10–0			*Thesis or Project	9
		‡†Humanities	3–5			‡†Humanities	3–5
		**Prof. Elec. Subj. or Hum.	8			**Prof. Elec. Subj. or Hum.	8
			50				46

FOURTH YEAR (1952–53 only)

First Term	6·18	Electrical Eng., Fund.	4–6	*Second Term*	16·53	Aircraft Power Plants, Prin.	3–6
	*16·13	Airplane Stability & Cont.	3–6		*16·72	Airplane Des. Practice	9–0
	*16·21	Structures	3–6			*Thesis	12
	16·62	Aerodynamic Laboratory	4–4			†Humanities	3–5
		†Humanities	3–5			¶Prof. Elec. Subj. or Hum. (see below)	8
		Prof. Elec. Subj. or Hum. (see below)	8				46
			52				

Suggested Professional Elective Subjects for 1952–53§

	1·322	Airport Design	6–0		16·22	Aircraft Structures	6–6
	2·48	Gas Turbines	3–6		16·30	Automatic Control, Prin.	3–9
	2·79	Int. Comb. Eng., Elem.	3–6		16·50	Rotat. Wing Aircraft	3–6
	6·19	Industrial Electronics	4–6		16·91	Aeroelasticity	3–6
	16·025	Aeronautical Mech.	3–6		M351	Adv. Calculus for Eng.	3–6
	16·105	Applied Aerodyn.	3–6		M352	Adv. Calculus for Eng.	3–6
	16·14	Airplane Des. Prob.	8–4		M78	Theory of Elasticity, Int.	3–6

XVI-B. AERONAUTICAL ENGINEERING

COOPERATIVE COURSE (FOUR YEARS)

THE aim of the cooperative program for Aeronautical Engineering undergraduates is to provide an opportunity for about six months experience in an industrial organization before the professional work of the senior year. Continuous contact with industrial problems should enable a student to discover and develop his aptitudes and interests to better advantage than would be possible with shorter periods of employment. The program does not interfere with the student's academic progress nor with his extra-curricular activities in association with his classmates.

The cooperating companies of the aircraft industry will pay the students at prevailing rates during their period of employment. The students will pay their own transportation and living expenses while away from the Institute.

Students who are interested in the program should apply to Department Headquarters for a set of Personnel Record Forms prior to March 1 of their sophomore year. These forms should be filled out completely and returned by March 15. A statement as to the location where the student would prefer to work and the class group to which he would prefer to be assigned should be appended to the forms.

Representatives of the cooperating companies will be invited to interview interested students and to determine, jointly with the Department representative, the distribution of those selected for employment. Students thus selected become regular employees during their period of employment in an aircraft plant, and are subject to the usual regulations of the company. They are expected to carry the course through to completion unless they are prevented by exceptional circumstances.

A list of the companies cooperating in this program will be available at the Headquarters of the Department of Aeronautical Engineering.

Juniors in the Cooperative Course are also eligible for selection to the Honors Course described under Course XVI, Aeronautical Engineering.

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

(Same as Course XVI through Second Year)

GROUP A

THIRD YEAR
Summer

At M. I. T. (First 6 weeks)

*2·40	Heat Engineering	4–5
*16·01T	Aeromechanics	5–5
		9–10

Vacation (Approximately 2 weeks)

At Plants (Remainder of Summer)

*16·851	Industrial Practice	40 h.p.w.

*See Requirements for Bachelor's Degree, page 51. †See page 48 for list of subjects.

‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken by undergraduates.

¶ Students expecting to specialize in graduate research or instrumentation should include 6·19 Industrial Electronics, 4–6 as the Elective Subject in fourth year, second term.

** Students registered in the fourth year, in 1953–54 only, who choose a professional elective in the first or second term must take either 16·21T Structures, 4–6, or 6·19 Industrial Electronics, 4–6.

§ Other electives may be chosen with approval of Registration Officer.

XVI-B. Aeronautical Engineering Continued

THIRD YEAR (*Continued*)

Regular Academic Year

	At Plants			*At M. I. T.*		
First Term	*16·852	Industrial Practice.....40 h.p.w.	*Second Term*	*16·02T	Aerodynamics.....	6–6
				*16·10	Aerodynamics, App.....	4–8
				*16·20	Structures.....	3–6
				‡†Humanities.....		3–5
				‡†Humanities.....		3–5
						19–30

Students registered in the third year, second term, in the Spring term 1953: Omit 16·02T and 16·20. Add *2·40 Heat Engineering, 4–5, and 6·18 Electrical Eng., Fund., 4–6.

FOURTH YEAR

Summer

	At M. I. T. (Second 6 weeks)		
Vacation (First 6 weeks)	*6·18	Electrical Eng., Fund.....	4–6
	*16·13	Airplane Stability & Cont.....	3–6
			7–12

Students registered in the fourth year Summer in the Summer 1953: Omit 6·18. Add *16·20 Structures, 3–6.

Regular Academic Year

Same as Fourth Year in Course XVI§

Students registered in the fourth year, in 1953–54 take regular Course XVI, fourth year schedule for 1953–54 with the following changes. In fourth year first term, in the Fall term 1953–54: Omit 16·71T. Add *16·02T Aerodynamics, 6–6. (Students choosing 16·71T as Professional elective in first term, may take 16·72T in place of 16·72 in second term.) In fourth year, second term, in the Spring term 1954: Omit 16·72T. Add *16·72 Airplane Design Practice, 9–0.

Regular Academic Year (1952–53 only)

Same as Course XVI Fourth Year Schedule for 1952–53

GROUP B (Not offered for Class of 1954)

THIRD YEAR

Summer

At M. I. T. (First 6 weeks)			
*2·40	Heat Engineering.....	4–5	*Vacation* (Remainder of Summer)
*16·01T	Aeromechanics.....	5–5	
		9–10	

Regular Academic Year

(In effect 1953–54)

	At M. I. T.				*At Plants*	
First Term	*16·02T	Aerodynamics.....	6–6	*Second Term*	*16·852	Industrial Practice.....40 h.p.w.
	*16·10	Aerodynamics, App.....	4–8			
	*16·20	Structures.....	3–6			
	‡†Humanities.....		3–5			
	‡†Humanities.....		3–5			
			19–30			

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.
§ Students choosing a professional elective must take either 16·21T Structures, 4–6, or 6·19 Industrial Electronics, 4–6.
‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken.

XVI-B. Aeronautical Engineering Continued

FOURTH YEAR

(In effect Summer 1954)

Summer

At Plants (Approximately 4 weeks)

*16·851 Industrial Practice ..... 40 h.p.w.

Vacation (Approximately 2 weeks)

At M. I. T. (Second 6 weeks)

*6·18	Electrical Eng., Fund.	4–6
*16·13	Airplane Stability & Cont.	3–6
		7–12

Regular Academic Year

(In effect 1954–55)

Same as Fourth Year in Course XVI§

Regular Academic Year (1952–53 only)

Same as Course XVI, Fourth Year schedule for 1952–53.

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.

Approximately two-thirds of the undergraduate curriculum is devoted to fundamental and applied science and to the humanities. The strictly professional work provides a correlated group of progressive sequences in construction, materials, structural design, and the economic aspects of the industry, and covers these sequences in a study of buildings of wood, semi-fireproof and fireproof construction.

The Course leads to the degree of Bachelor of Science in Building Engineering and Construction.

FIRST YEAR (See page 51)

SECOND YEAR

First Term	2·011	Statics & Dynamics	3–5	*Second Term*	2·04	Strength of Materials	3–6
	8·03	Physics	5–5		8·04	Physics	5–5
	17·21	Building Construction	6–6		17·22	Building Construction	4–6
	H21	Hum. & Soc. Sciences, Int.	3–5		H22	Hum. & Soc. Sciences, Int.	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			23–27				21–28

REQUIRED DURING SUMMER AT CAMP TECHNOLOGY

1·00	Surveying	13–0
1·04	Construction Survey. Fieldwork	11–0

THIRD YEAR

First Term	*1·351	Soil Mech. & Found. Eng.	4–4	*Second Term*	*1·40	Structural Analysis	3–6
	*1·611	Fluid Mechanics	2–4		*17·40T	Job Management	2–4
	*2·371	Testing Materials Lab.	2–2		*17·52T	Steel Design	5–7
	*2·41	Heat Engineering	4–5		*17·72	Materials — Masonry	6–4
	*17·31T	Building Construction	4–4		*17·73	Materials — Wood	3–3
	*17·71T	Materials — Metals	2–4			††Humanities	3–5
		††Humanities	3–5				22–29
			21–28				

FOURTH YEAR

(In effect 1953–54)

First Term	*1·41	Structural Analysis	3–6	*Second Term*	*1·42	Structural Analysis	3–6
	*6·18	Electrical Eng., Fund.	4–6		*17·54T	Concrete Design	4–6
	*17·53T	Wood Design	3–4			*Thesis	7
		*Thesis	2			††Humanities	3–5
		††Humanities	3–5			Elective Subjects	13
		Elective Subjects	13				47
			49				

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.

§ Students choosing a professional elective must take either 16·21T Structures, 4–6, or 6·19 Industrial Electronics, 4–6.

‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken.

XVII. Building Engineering and Construction Continued

FOURTH YEAR (1952–53 only)

First Term	1·351	Soil Mech. & Found. Eng.	4–4	*Second Term*	*1·42	Structural Analysis	3–6
	*1·41	Structural Analysis	3–6		15·50	Accounting	5–4
	*17·53	Structural Design	6–6		*17·40	Estim. and Job Manage.	5–4
	*17·71T	Materials — Metals	2–4		*17·54	Structural Design	6–6
		*Thesis	4			*Thesis	5
		†Humanities	3–5			†Humanities	3–5
			47				52

XVIII. MATHEMATICS

THE Institute offers exceptional opportunities for the study of mathematics, in both its theoretical aspects and its applications to scientific and engineering work.

The Course outlined is for students who desire to study more mathematics than is contained in the other professional courses. It is well adapted to serve as a preparation for specializing in pure mathematics, in applied mathematics, in mathematical physics, or in engineering fields requiring proficiency in mathematics. The Course also offers excellent opportunities for students who wish to major in mathematical statistics or applied statistics. For most of the students in Course XVIII the curriculum serves as a preparation for furtner professional training at the graduate level.

Any student who has completed, with a sufficiently high record, the work of the first two years in any of the professional courses in the Institute or their equivalent, may be admitted to the third year in this Course.

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

FIRST YEAR (See page 51)

SECOND YEAR

First Term	2·011	Statics & Dynamics	3–5	*Second Term*	8·041	Physics	5–5
	8·031	Physics	5–5		H22	Hum. & Soc. Sciences, Int.	3–5
	H21	Hum. & Soc. Sciences, Int.	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
			20–26				20–27

THIRD YEAR

First Term	M351	Adv. Calculus for Engineers	3–6	*Second Term*	M352	Adv. Calculus for Engineers	3–6
	*M62	Modern Algebra	3–6			†Humanities	3–5
		†Humanities	3–5			§Elective Subjects	30
		§Elective Subject	21				47
			47				

FOURTH YEAR

First Term	*M831	Analysis	3–9	*Second Term*	*M832	Analysis	3–9
		*Thesis	4			*Thesis	7
		†Humanities	3–5			†Humanities	3–5
		§Elective Subjects	21			§Elective Subjects	21
			45				48

Professional Elective Subjects

Group A	M441	Projective Geometry	3–6	*Group B*	8·71	Int. Theoretical Physics I	4–8
	M442	Diff. Geometry, Elem.	3–6		8·72	Int. Theoretical Physics II	4–8
					M331	Statistical Methods, App.	3–6
					M341	Modern Statistical Th.	3–6
					M342	Modern Statistical Th.	3–6
					M411	Numerical Analysis	3–6
					M42	Hydromechanics, Int.	3–6
					M78	Theory of Elasticity, Int.	3–6
					M84	Comp. Var. & App., Int.	3–6
						Any 12-Unit Math. Subject	

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.

§ Each student must include in his program Professional Elective Subjects, as follows: one of the subjects listed in Group A, and 36 units from Group B, at least 12 of which must be Mathematics subjects.

XIX. METEOROLOGY

THE Course in Meteorology is designed to provide a broad background in theoretical and applied meteorology. The curriculum includes a number of elective subjects which are intended to comprise an integrated program in a related field of study. Some of the fields in which an effective elective program can be arranged are Chemical Engineering, Instrumentation, Mathematics and Physics, Economics, Business Administration and Hydrology. The Course prepares the student for positions in the Weather Bureau, in the meteorological services of airlines, in industries whose operations depend on the weather and in many other organizations in which weather is an important subsidiary factor. The Course also provides a sound background for graduate training for those students who wish to prepare themselves for a career in teaching or research.

Emphasis is placed on the application of basic physical principles to the atmosphere. In the more theoretical subjects, thermodynamics, hydrodynamics and fluid mechanics are developed with special reference to the atmosphere. In synoptic meteorology these theoretical developments are supplemented by empirical and statistical methods and applied to the practical problems of the weather forecaster. In the synoptic laboratory, the student works with current weather data from North America and adjacent areas and puts into practice the theories and methods presented in the other subjects of instruction. In climatology, the average state of the atmosphere is treated on the basis of atmospheric circulation patterns, radiation and micrometeorology. In oceanography, the dynamics of the oceans are discussed with special reference to the interactions of the atmosphere and the oceans. In the meteorological instrument laboratory, instruction is given in the methods and procedures of making weather observations and in the theory and operation of meteorological instruments. In other subjects, the special physical phenomena of the atmosphere are treated, including solar and terrestrial radiation, atmospheric electricity, cloud physics and atmospheric optics.

The facilities of the Department include several teletypewriters for the collection of current weather data and equipment for the reproduction of weather data and weather maps. A comprehensive file of past data and weather maps is maintained. The meteorological instrumentation laboratory contains equipment for the testing and development of instruments as well as examples of many types of weather instruments. Special equipment and facilities are available for research in physical meteorology including several radar sets.

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

FIRST YEAR (See page 51)

SECOND YEAR

First Term	2·00	Statics	3–5	*Second Term*	2·01	Dynamics	3–5
	8·03	Physics	5–5		8·04	Physics	5–5
	19·00	General Meteorology	6–3		19·50	Meteorological Lab., Int.	3–0
	H21	Hum. & Soc. Sciences, Int.	3–5		H22	Hum. & Soc. Sciences, Int.	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		M32	Statistics, Elementary	3–6
			23–24		MS22	Military Science	3–0
							23–27

THIRD YEAR

First Term	*2·40	Heat Engineering	4–5	*Second Term*	19·02	Descriptive Meteorol. II	3–6
		or			19·30	General Climatology	2–4
	*8·07	Thermodyn. & Statist. Mech.	4–5		*19·60	Thermodyn. of Atmos.	3–6
	*19·01	Descriptive Meteorol. I	3–6			†Humanities	3–5
	*19·21	Meteorol. Observations	4–2			Elective Subjects	15
	19·70	Physics of Atmos., Elem.	2–4				47
		†Humanities	3–5				
		Elective Subject	8				
			46				

FOURTH YEAR

First Term	*19·51	Synoptic Lab. I	15–0	*Second Term*	*19·44	Synoptic Meteorol. I	3–6
	*19·61	Dynamic Meteorol. I	3–6			*Thesis	9
	19·83	Oceanography	2–4			†Humanities	3–5
		*Thesis	3			**Elective Subjects	22
		†Humanities	3–5				48
		Elective Subject	8				
			49				

** Elective subjects must include one of the following:

19·52	Synoptic Lab. II	15–0
19·62	Dynamic Meteorol. II	3–6

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.

XX. FOOD TECHNOLOGY

THE marked technological progress taking place in modern food industries has created a demand for men having thorough knowledge of the basic sciences pertaining to foods, combined with the ability to apply that knowledge in the technical processes of food production, manufacture, storage, and distribution. Increasing emphasis on quality control as it concerns food and food products in manufacture has necessitated the development of new chemical, physical, biological, and microscopic techniques, and increased the demand for personnel to interpret the significance of such developments in commercial practice.

The undergraduate work in food technology is planned to provide students with a broad perspective in all the contributory sciences supplemented by the more specific technological aspects which especially concern the food industries, and to fit the men for either the laboratory or production branches of such organizations.

This training is equally valuable for those desiring to enter the fermentation industries producing beverages, glycerine, industrial alcohols, solvents, organic acids, or other commercial products of organic origin, or others which are concerned with the control of biological agents such as enzymes, and micro-organisms.

Substitutions may be made for certain of the outlined subjects at the discretion of the registration officer when students are intending to continue their studies for an advanced degree or have special interests in contiguous fields.

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

FIRST YEAR (See page 51)

SECOND YEAR

First	5·11	Qualitative Analysis	7–3	*Second*	5·12	Quantitative Analysis	7–3
Term	7·01	General Biology I	6–4	*Term*	7·02	General Biology II	6–4
	8·03	Physics	5–5		8·04	Physics	5–5
	H21	Hum. & Soc. Sciences, Int.	3–5		H22	Hum. & Soc. Sciences, Int.	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
*5·412	Organic Preparations I	10–0

THIRD YEAR

First	5·61	Physical Chemistry I	4–4	*Second*	5·62	Physical Chemistry II	4–4
Term	5·611	Physical Chem. Lab. I	4–2	*Term*	5·621	Physical Chem. Lab. II	4–2
	*20·01T	Chem. & Tech. Food Sup. I	7–3		*20·02T	Chem. & Tech. Food Sup. II	7–3
	*20·41	Bacteriology	6–2		*20·42	Industrial Microbiology	6–4
		‡†Humanities	3–5			‡†Humanities	3–5
		Elective Subject	8			Elective Subject	8
			48				50

FOURTH YEAR

First	2·601	Food Engineering	4–2	*Second*	2·602	Food Engineering	4–2
Term	*7·80	Biochemistry	8–4	*Term*	*20·12	Tech. of Food Products	6–4
	*20·11	Tech. of Food Products	6–4		20·14	Chem. Eng. Food App.	4–6
	20·13	Chem. Eng. Food App.	4–6		20·32	Chemistry of Nutrition	2–2
		*Thesis	4			*Thesis	10
		‡†Humanities	3–5			‡†Humanities	3–5
			50				48

XX-A. FOOD TECHNOLOGY

A LIMITED number of outstanding students in the regular four-year curriculum, Course XX, will, upon application, be selected during the third year to enter a slightly modified fourth year course to be followed by a fifth, or graduate, year. A period of six months between the fourth and fifth year in this course will be spent in technical positions in selected food industries to enable each man to have some industrial experience before completing his academic work.

The Course leads to the degrees of Bachelor of Science and Master of Science in Food Technology awarded simultaneously at the end of the graduate year.

(*Same as Course XX through Third Year.*)

FOURTH YEAR

First	2·601	Food Engineering	4–2	*Second*	2·602	Food Engineering	4–2
Term	*7·80	Biochemistry	8–4	*Term*	*20·12	Tech. of Food Products	6–4
	*20·11	Tech. of Food Products	6–4		20·14	Chem. Eng. Food App.	4–6
	20·13	Chem. Eng. Food App.	4–6		20·32	Chemistry of Nutrition	2–2
		‡†Humanities	3–5		20·322	Chem. of Nutrition Lab.	5–0
			25–21			‡†Humanities	3–5
						Elective Subject	8
							51

* See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.
‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken.

XX-A. Food Technology Continued

GRADUATE YEAR

First Term	7·81	Enzymology	2–4	*Second Term*	20·52	Food Technology, Adv.	6–4
	20·51	Food Technology, Adv.	8–4		20·62	Food Technology Seminar	2–2
	20·61	Food Technology Seminar	2–2			Thesis	20
		Thesis	16			Elective Subjects	14
		Elective Subject	10				48
			48				

XX-B. BIOCHEMICAL ENGINEERING

RECENT developments in the production of pharmaceuticals and antibiotics and in the food and fermentation industries indicate a strong need for technical personnel with training in the basic biological sciences and in engineering as represented by chemical engineering. In order to make such training available to students who wish to enter this field, the Department of Food Technology offers a coordinated program in Biochemical Engineering. The Course is basically the undergraduate curriculum in chemical engineering, with modifications to allow the study of biology, bacteriology, microbiology, and biochemistry. As warranted by future enrollment, new subjects will be offered to give the students a more thorough background in microbiology and biochemistry and placing the emphasis in chemical engineering on the biological rather than the chemical industry.

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

(Same as Course XX through Second Year)

THIRD YEAR

First Term	*5·41	Organic Chemistry I	4–4	*Second Term*	*5·42	Organic Chemistry II	4–4
	*5·416	Organic Preparations I	6–0		*5·426	Qual. Organic Analysis	6–0
	*5·61	Physical Chemistry I	4–4		*5·62	Physical Chemistry II	4–4
	*5·612	Physical Chem. Lab. I	2–0		*5·622	Physical Chem. Lab. II	2–0
	*10·17	Industrial Chemistry	3–4		*20·42	Industrial Microbiology	6–4
	*20·41	Bacteriology	6–2		‡†Humanities		3–5
	‡†Humanities		3–5			Elective Subject	8
			28–19				50

FOURTH YEAR

First Term	6·18	Electrical Eng., Fund	4–6	*Second Term*	10·21	Industrial Chemistry	3–6
	*7·80	Biochemistry	8–4		*20·14	Chem. Eng. Food App.	4–6
	*20·13	Chem. Eng. Food App.	4–6		*Thesis		8
	*Thesis		7		‡†Humanities		3–5
	‡†Humanities		3–5			Elective Subject	12
			47				47

RESERVE OFFICERS' TRAINING CORPS
MILITARY SCIENCE AND AIR SCIENCE

THE general object of the Reserve Officers' Training Corps is to qualify students for positions of leadership in time of national emergency, and to provide officers for the various components of the Army and the Air Force. The program consists of two parts, the basic course and the advanced course, each of two academic years, the advanced course including a summer camp. The basic course is required by the Institute; the advanced course is elective.

One Air Force and six Army units have been authorized. The Army units are: Engineers, Signal, Ordnance, Chemical, Army Security Agency, and Quartermaster.

All physically qualified male first-year students who are citizens of the United States and under twenty-three years of age at time of initial enrollment (except certain veterans, who must be under twenty-five years of age) are required to enroll in the two-year basic course, unless exempted therefrom on conscientious grounds as approved by the Faculty; those who enter the Institute as second-year transfer students are required to take the subjects of the second year of the basic course. Similarly qualified students who have received instruction in an approved ROTC unit at another institution will receive credit therefor upon presentation of suitable evidence to the Professor of Military Science and Tactics or the Professor of Air Science and Tactics. Also, those who have been members of any of the armed services will receive credit in accordance with established policies.

BASIC COURSE

The Basic Course includes the Military Science or Air Science subjects required in the first two years. Upon initial enrollment, a student elects either the Air Force or the Army program of instruction. Opportunity is given the student to choose the unit in which he desires to take his training. Those who do not make a choice of a unit will be arbitrarily assigned to a unit.

The first-year program consists of drill and other general military training and the subject numbers are MS11 and MS12.

The sophomore subjects of instruction for the Air Force and the six Army units at the Institute consist of drill and an introduction to the tactics and technique of the respective units. The program of subjects required in the respective units in the sophomore year is given below:

Army Units:

Corps of Engineers: MS212 and MS222.

Signal Corps: MS213 and MS223.

Ordnance Corps: MS214 and MS224.

Chemical Corps: MS216 and MS226.

Army Security Agency: MS217 and MS227.

Quartermaster Corps: MS218 and MS228.

Air Force: MS215 and MS225.

*See Requirements for Bachelor's Degree, page 51. † See page 48 for list of subjects.
‡ 14·01 Economic Principles I, 3–5, is a requirement for graduation and must be one of the Humanities subjects taken.

Reserve Officers' Training Corps Continued

Advanced Course

The object of the Advanced Course is to prepare well qualified students to become reserve or regular officers in the Army or the Air Force. This course is open to students who have satisfactorily completed two years in the basic course or its equivalent. To be accepted, students must have the approval of the registration officer of the course in which they are registered, and of the Professor of Military Science and Tactics or Professor of Air Science and Tactics. They should continue the unit in which they were registered in the Basic Course. Students who complete the Advanced Course are commissioned as Second Lieutenants in the Officers' Reserve Corps of the U. S. Army or the Air Force Reserve on graduation. Each year a number of ROTC graduates may be offered commissions in the Regular Army and the Regular Air Force.

A student enrolled in the advanced course receives commutation of uniform at the approximate rate of one hundred dollars, and commutation of subsistence at the approximate rate of ninety cents per day from date of enrollment until the end of the second Institute year thereafter, including one summer vacation, except for the period of the ROTC camp, when he is subsisted by the Government and currently paid at the rate of seventy-five dollars per month.

To enroll, he must have executed a Deferment Agreement and then must execute a contract to continue the course of instruction for two years, should he remain in school for that length of time. The contract includes the obligation to attend the ROTC camp, normally during June and July following the first year of the advanced course, at which all expenses, including transportation, are paid by the Government. In exceptional cases, attendance at camp may follow the sophomore year or may be postponed until after the senior year.

The program of subjects required in the respective units of the Advanced Course is given below.

Army Units:

Corps of Engineers: MS312, MS322, MS412, MS422.
Signal Corps: MS313, MS323, MS413, MS423.
Ordnance Corps: MS314, MS324, MS414, MS424.
Chemical Corps: MS316, MS326, MS416, MS426.
Army Security Agency: MS317, MS327, MS417, MS427.
Quartermaster Corps: MS318, MS328, MS418, MS428.

Air Force Unit:

MS315, MS325, MS415, MS425.

Army Advanced ROTC students must complete 12 semester hours of subjects selected from the list below, according to the branch in which they are enrolled.

	Subject No. and Name	*Semester Hours*	*CE*	*SC*	*Ord C*	*Cml C*	*ASA*	*QMC*
1·40	Structural Analysis	3	x					
1·601	Fluid Mechanics	3	x			x		
1·771	Sanitation	2	x					
2·002	Applied Mechanics II	3	x	x	x	x		x
or								
2·04	Strength of Mat.	3	x	x	x	x		x
2·081	Strength of Mat.	3	x	x	x	x		x
2·42	Heat Engineering	3	x	x	x	x		x
2·731	Machine Design	3.5	x	x	x	x	x	x
2·791	Int. Combustion Eng.	3	x	x	x	x		x
2·792	Int. Combustion Eng.	3	x	x	x	x		x
2·85	Machine Tools, Int.	2	x	x	x	x		x
or								
2·851	Machine Tool Lab.	2	x	x	x	x		x
3·11	Engineering Metals	5	x	x	x	x		x
3·31	Phys. Metallurgy I	4	x	x	x	x		x
4·62	Site Plan. & Constr.	4.5	x					
5·02	Chemistry, General	5.5					x	
5·41	Organic Chemistry I	4	x		x	x	x	x
5·42	Organic Chemistry II	4	x		x	x	x	x
5·61	Physical Chemistry I	4	x	x	x	x	x	x
5·62	Physical Chemistry II	4	x	x	x	x	x	x
6.02	Elec. Eng., Prin. (Electronic Circuits)	4	x	x	x	x	x	x
6·031	Elec. Eng., Prin. (Electric Machinery)	2.5	x	x	x	x	x	x
6·18	Elec. Eng., Fund.	3.5	x	x	x	x	x	x
6.76	Eng. Electronics Lab.	2	x	x	x	x	x	x
7·01	General Biology I	4.5				x		x
7·02	General Biology II	4.5				x		x
7·80	Biochemistry	5				x		x
7·831	Biochem. of Microorg.	5	x			x		x
8·04	Physics (Modern Phys.)	4.5	x	x	x	x	x	x
8·05	Atomic Physics	4	x	x	x	x		
8·07	Thermo. & Statist. Mech.	4	x	x	x	x		x
8·08	Electronics	4	x	x	x	x	x	x
10·18	Industrial Chemistry	3			x	x		x
10·28	Chemical Engineering	4	x		x	x		x
12·011	Mineralogy	2	x			x		x
12·301	Physical Geology	5						x
12·321	Engineering Geology	3	x					x
12·44	Geology of Oilfields	2						x
14·51	International Rel.	3	x	x	x	x	x	x

Reserve Officers' Training Corps Continued

	Subject No. and Name	*Semester Hours*	*CE*	*SC*	*Ord C*	*Cml C*	*ASA*	*QMC*
14·52	Maj. Prob. in Contemp. World Polit.	3	x	x	x	x	x	x
14·63	Labor Relations	3	x	x	x	x	x	x
14·70	Psychology, Int.	3	x	x	x	x	x	x
14·73	Org. & Com. in Groups	3	x	x	x	x	x	x
14·92	Comp. Polit. & Ec. Systems	3	x	x	x	x	x	x
15·11	Indust. Manage., Int.	3	x	x	x	x		x
15·30	Personnel Admin.	3	x	x	x	x	x	x
15·61	Business Law	3	x	x	x	x	x	x
15·70	Production	3	x	x	x	x		x
15·71	Production Manage.	3	x	x	x	x		x
16·21	Structures	3	x		x			
or								
16·21T	Structures	4	x		x			
16·53	Aircraft Power Plants, Prin.	3			x			
17·22	Building Constr.	3.5	x					
19·02	Descript. Meteor. II	3		x		x		
19·21	Meteor. Observations	2.5		x		x		
M21	Calculus	3					x	
M22	Diff. Equations	3					x	
M32	Statistics, Elem.	3					x	
M831	Analysis	3			x		x	
M832	Analysis	3			x		x	
	All Modern Language subjects except L75 & L76	3 each					x	

Advanced Air Force ROTC students must complete 12 semester hours in subjects which are to be selected from the following list.

	Subject No. and Name	*Semester Hours*
1·08	Navigation	2
1·28	Highways & Airports	3
1·40	Structural Analysis	3
1·41	Structural Analysis	3
1·42	Structural Analysis	3
2·48	Gas Turbines	3
2·79	Int. Combustion Eng., Elem.	3
2·791	Int. Combustion Eng.	3
2·792	Int. Combustion Eng.	3
5·67	Atomic & Molec. Struct., Int.	2
5·68	Kin. of Chemical Reactions	2
6·003	Elec. Eng., Prin.	3
6·01	Elec. Eng. Prin. (Mag. Circ. & Trans.)	3
6·02	Elec. Eng., Prin. (Electronic Circuits)	4
6·031	Elec. Eng., Prin. (Elec. Mach.)	2.5
6·16	Electricity	3
6·18	Elec. Eng., Fund.	3.5
6·20	Electronic Cont. & Meas.	3
6·202	Electronic Cont. & Meas.	3
6·281	Wire Com., Prin.	3
6·291	Radar, Prin.	3
6·292	Radar, Prin.	3
6·30	Com. Network Th.	3
6·311	Elec. Com., Prin.	3
6·312	Elec. Com., Prin.	3
6·321	Elec. Com., Prin.	3
6·322	Elec. Com., Prin.	3
6·35	Eng. Acoustics	3
8·05	Atomic Physics	4
8·06	Nuclear Physics	4
8·08	Electronics	4
8·13	Vibration & Sound	3
14·30	Statistics, Elem.	2
14·31T	Quantitative Method, Int.	3
14·51	International Relations	3
14·52	Maj. Prob. in Contemp. World Politics	3
14·60	Labor Relations	3
14·63	Labor Relations	3
14·70	Psychology, Int.	3
15·11	Indust. Management, Int.	3
15·71	Production Management	3
16·01T	Aeromechanics	4.5
16·02	Aerodynamics	5
16·13	Airplane Stab. & Control	3
16·14	Airplane Design Prob.	5
16·20	Structures	3
16·21	Structures	3
or		
16·21T	Structures	4
16·22	Aircraft Structures	4.5
16·30	Automatic Control, Prin.	3
16·53	Aircraft Power Plants, Prin.	3
19·21	Meteor. Observations	2.5
19·44	Synoptic Meteorology I	3
19·60	Thermodyn. of Atmosphere	3
M351	Adv. Calculus for Eng.	3
M352	Adv. Calculus for Eng.	3

THE GRADUATE SCHOOL

ADMINISTRATION OF THE GRADUATE SCHOOL

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Professor of Physical Chemistry

J. M. AUSTIN, SC.D
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Assistant Professor of Marine Engineering

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R. R. SHROCK, PH.D.
Professor of Geology

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Associate Professor of Physiology

W. E. STANLEY, C.E.
Professor of Sanitary Engineering

G. B. THOMAS, JR., PH.D.
Associate Professor of Mathematics

G.C. WILLIAMS, SC.D.
Associate Professor of Chemical Engineering

CHAIRMEN† OF DEPARTMENT COMMITTEES ON GRADUATE STUDENTS

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Physics	P. M. MORSE
Sanitary Engineering	W. E. STANLEY

* Correspondence regarding admission to the Graduate School and graduate scholarships and fellowships should be addressed to the Dean of the Graduate School.
† Inquiries regarding prerequisites for graduate subjects and programs of graduate work in any field of study should be addressed to the Chairman of the Committee on Graduate Students of the appropriate department.

THE GRADUATE SCHOOL

GENERAL INFORMATION

The Graduate School brings together Faculty members and post-baccalaureate students as a community of scholars having a common interest in advanced professional study and creative work. It seeks to provide in the atmosphere of a professional school the widest possible opportunity for advanced study and investigation of a high order and for intimate association among creative workers whose common objective is to extend the boundaries of their professions.

Graduate students may pursue work leading to any of the following degrees:

Doctor of Philosophy, Ph.D.
Doctor of Science, Sc.D.
Engineering Degrees (see page 96)
Master of Science, S.M.
Master in Architecture, M.Arch.
Master in City Planning, M.C.P.

Fields of Study

The following major fields for graduate study, grouped by Departments or Courses, are presented in subsequent pages, on which are described the programs of graduate instruction offered by the various departments.

Aeronautical Engineering, Course XVI
- Aerodynamics
- Design
- Instrumentation
- Power Plants
- Structures

Architecture, Course IV-A

Biology, Course VII
- Basic Biology
- Biochemistry
- Biophysics
- General Physiology
- Microbiology
- Physical Biology (VII-A)
- Chemical Biology (VII-B)

Building Engineering and Construction, Course XVII
- Building Management
- Materials of Construction
- Structural Design

Chemical Engineering, Course X
- Applied Chemistry
- Engineering Operations
- Fuel Engineering
- Chemical Engineering Practice (X-A)

Chemistry, Course V
- Analytical
- Inorganic
- Nuclear
- Organic
- Physical

City Planning, Course IV-B

Civil Engineering, Course I
- Geodesy and Photogrammetry
- Hydraulics
- Soil Mechanics
- Structural Engineering
- Transportation Engineering

Economics and Social Science
- Economics and Engineering (or Science)
- Industrial Economics
- Industrial Relations

Electrical Engineering, Course VI
- Automatic Computation and Numerical Analysis
- Communications and Electronics
- Electric Power
- Electronics Applications and Automatic Control

Food Technology, Course XX

Geology and Geophysics, Course XII
- Crystallography
- Geochemistry
- Geophysics
- Mineralogy
- Mineral Deposits
- Mineral Industry
- Petrology
- Stratigraphy and Paleontology

Industrial Management, Course XV

Mathematics, Course XVIII

Mechanical Engineering, Course II
- Applied Mechanics
- Heat Engineering
- Materials
- Propulsion
- Textile Technology

Metallurgy, Course III
- Ceramics
- Metallurgy
- Mineral Engineering

Meteorology, Course XIX

Naval Architecture and Marine Engineering, Course XIII
- Marine Engineering
- Naval Architecture
- Naval Construction and Engineering (U. S. N. and U. S. C. G.: XIII-A)

Physics, Course VIII

Sanitary Engineering, Course XI

Each graduate student is enrolled in one course which assumes responsibility for his guidance and approval of his program. The work of a student is not limited, however, to that offered in a single department: his actual studies and research may be chosen from among several departments with the aid and counsel of the staff, subject only to the fundamental requirement that his program be designed to achieve a concentration in a major field of study.

In addition to specialized professional competence, graduate students are expected to have or else to acquire a background in non-professional fields such as the humanities and social studies. The Faculty believes that breadth of information and understanding which tend to promote qualities of leadership, along with specialized competence, should characterize the recipients of advanced degrees. As an aid in accomplishing this dual objective, electives are available to graduate students in English, history, economics, international affairs, the fine arts, etc.

Special Facilities

In addition to unexcelled research laboratories, administered within the several departments, the Institute maintains interdepartmental Centers of Research which co-

ordinate the activities of various departments in fields of overlapping interest. These interdepartmental laboratories unite the staff and student personnel of the various departments for concerted effort with centralized facilities and services.

In certain of these special laboratories projects are being conducted in basic or applied science, sponsored by Government or Industry, which offer to well qualified graduate students an opportunity for participation. Student membership in a research project should be a valuable and timely experience. To insure the success of a joint effort in the solution of a common problem or one of various related problems with a common objective, the student must have an understanding of human relations, as well as a capacity for individual research: exchanges of experience and ideas with fellow participants in group research broaden the perspective in appraising one's own efforts and capacities.

Notable among the interdepartmental centers of research, concerning which further details are set forth under the several department headings, are the following:

THE ACOUSTICS LABORATORY, sponsored and staffed jointly by the Physics, Electrical Engineering and Architecture Departments, offers to graduate students an opportunity to pursue intensive studies in basic problems of sound and vibration, in electro-acoustics and audio communication, and in acoustics of rooms and structures. Specialized facilities are available for broad programs devoted to theory and application.

THE RESEARCH LABORATORY OF ELECTRONICS, serving jointly the Departments of Electrical Engineering and Physics, offers a program which ranges widely from fundamental problems in physics to application of electronic techniques in the field of communications. Current graduate students are participating in studies of the structure of solids, spectroscopy of gases at microwave frequencies, the behavior of superconductors at radio frequencies, a study of klystrons and magnetrons for generation of millimeter waves, the construction of a 30-million volt linear accelerator, noise and inherent limitations to transmission of information by pulsed microwave systems. The equipment is unusually extensive and completely up to date for handling almost any task involving the behavior of electrons.

THE LABORATORY FOR NUCLEAR SCIENCE AND ENGINEERING, serving all departments of science or engineering, offers exceptional opportunities for pre- or post-doctoral studies in all phases of the nuclear field, interactions of elementary particles, nuclear structure, construction and operation of electro-nuclear machines, instrumentation techniques, radioactive tracers, biologic effects of high energy radiations, fission chemistry, or engineering aspects of nuclear power.

Physical equipment includes a cyclotron of 14-million electron volt deuterium capacity, Van de Graaff electrostatic generators of 2, 4 and 5 million volts (a 12-million volt machine is nearing completion), a 300-million volt synchrotron and lesser equipment.

Both theoretical work and applications of nuclear engineering are under way. The Institute is one of nine institutions operating the Brookhaven National Laboratory.

THE SPECTROSCOPY LABORATORY serves the various science and engineering departments, especially Physics, Chemistry and Biology. The entire optical spectrum from the vacuum ultraviolet to the far infrared is covered in the research activities which interest physicists through high-precision wavelength measurements, Zeeman-effect studies, and the classification of atomic spectra; chemists with molecular structure determinations by infrared, ultraviolet and Raman spectra; and biologists with such applications to biophysics as ultraviolet absorption microspectroscopy and low-temperature spectra of complex biochemicals. Microwave spectroscopy and nuclear spin studies are made in cooperation with the Research Laboratories of Electronics and of Nuclear Science.

THE DIVISION OF INDUSTRIAL COOPERATION, being the contracting agency for sponsored research, makes possible a great variety of established programs of research, providing graduate students with an extensive opportunity for research, and granting to a limited number the opportunity to earn while learning.

THE ENGINEERING PRACTICE SCHOOL AT OAK RIDGE, Tennessee, in the Diffusion Plant, the Electromagnetic Plant, and the Oak Ridge National Laboratory of the Atomic Energy Commission, all operated by Carbide and Carbon Chemicals Corporation, is available for qualified graduate students in any department who are United States citizens, subject to Security clearance by the Atomic Energy Commission. Under the direction of Institute Faculty, resident at the site, the work will emphasize the application of engineering principles to the solution of plant problems, and is designed to develop initiative, resourcefulness and cooperative effort in large scale industrial operations. There are two periods per year, (1) from late July to Christmas, and (2) from early February to early July. Each period carries academic credit for 36 units. Application should be made at least four months in advance to allow ample time for clearance. All inquiries should be addressed to Professor J. Edward Vivian of the Chemical Engineering Department.

OTHER LARGE LABORATORIES, well equipped with research facilities, include the Servomechanisms Laboratory, the Aero-Instrumentation Laboratory, the Wright Brothers Wind Tunnel, the Gas Turbine and Sloan Automotive Laboratories, described elsewhere.

SOCIAL AND RECREATIONAL FACILITIES

All athletic facilities are available for the entire student body. Likewise, graduate students are welcome as members of the Nautical Association which maintains an extensive fleet of sailing dinghies. The Graduate House Student Organization in which every resident of the Graduate House is eligible to membership is a self-governing body, which through appropriate subcommittees is empowered to arrange a variety of social functions, primarily for its own membership but actually for the benefit of all graduate students.

ORGANIZATION

The Faculty of the Graduate School is the Faculty of the Institute. Its officers are the President of the Institute, the Dean of the Graduate School and the Committee on Graduate School Policy, comprising a Faculty member of each department which offers graduate subjects of instruction. For each of these departments, there is at least one Graduate Registration Officer to guide the choice of subjects for which its graduate students register.

Details of admission, registration, acceptance of fees and recording of grades are administered by the regular authorities of the Institute as a whole. Student conduct is the concern of the Dean of Students.

The Dean of the Graduate School will welcome any graduate student at his office, 3-108, at any time on any matter.

ADMISSION

ADMISSION TO GRADUATE SCHOOL AS GRADUATE STUDENT

To be admitted as a Graduate Student, an applicant must have received a Bachelor's degree from a college,

university, or technical school of standing acceptable to the Director of Admissions of the Massachusetts Institute of Technology, and his academic record and other credentials must be such as to indicate that he has the ability to accomplish satisfactorily an approved program of graduate study and research.

For acceptance to work toward a Master's degree, the applicant shall, in addition to the above requirement, have been ranked in the upper two-thirds of his class at graduation; for a Doctorate, in the first third of his class, or have satisfactorily completed the equivalent of requirements for a Master of Science degree in an institution acceptable to the Director of Admissions.

Admission to Graduate School as Provisional Graduate Student

Admission as a Provisional Graduate Student may be granted to an applicant who, although unable to meet the above requirements for acceptance as a graduate student, *is judged by a Department Committee on Graduate Students probably to be able to pursue successfully graduate studies*, with or without additional preparation in prerequisite subjects.

Provisional Graduate Student status will be changed to that of Graduate Student upon demonstration of ability necessary to pursue successfully graduate studies by completion of either of the following requirements:

(1) Completion with a satisfactory grade in one academic term of not less than 45 units of regular subjects, of which at least 32 units are of "A" classification,

or

(2) Completion with a satisfactory grade in two academic terms of not less than 36 units of "A" subjects.

Admission to Graduate School as Special Student

A duly qualified applicant who desires to enroll for graduate subjects with a clearly defined objective, but not as an applicant for a degree, may be admitted as a Special Graduate Student by approval of the Dean of the Graduate School and of the chairman of a departmental committee on graduate students. Such a student will be enrolled as of the department which has approved his admission. The subjects for which a Special Graduate student may register are limited to those for which specific written approval has been granted by instructors in charge in advance of enrollment.

Procedure for Making Application for Admission to Graduate School

Before an applicant will be considered for admission to the Graduate School, he must file an "Application for Admission to the Graduate School," which may be secured by writing to the Director of Admissions, Massachusetts Institute of Technology, Cambridge 39, Massachusetts.

Admission, in general, will be restricted to the beginning of an academic year in the Fall. For early consideration, an application for such admission, together with all credentials, should be submitted by March 1. Applications received between March 1 and June 1 will receive consideration until enrollments are filled in the departments specified by the applicants.

Applications from non-citizens of the United States received previous to May 1 will be appraised at that time only for admission in the following Fall term.

Applicants who file requests for admission during their final year of work toward a bachelor's degree will be considered for admission and may be accepted conditional upon subsequent filing of evidence of having been awarded said degree.

Notices of decisions made on regular applications for Fall admissions, together with notification of scholarship awards for an ensuing academic year, will be mailed on or about April 1.

All students admitted to the Graduate School will receive with their notification of admission a copy of the booklet entitled "Information for Graduate Students." They will be held responsible for complete knowledge of its contents. Additional copies of the booklet may be secured from the Information Office or the Admissions Office.

Correspondence concerning admissions should be addressed to the Director of Admissions. Inquiries concerning preparation or subject matter in courses should be addressed to the chairman of the appropriate Departmental Committee on Graduate Students (see page 92).

Graduate Record Examination

As additional evidence in support of an application for admission to the Graduate School, an applicant who has taken the Graduate Record Examination of the Carnegie Foundation for the Advancement of Teaching may offer an official report of this examination. It is entirely optional whether such evidence be offered by the applicant.

For a student desiring to undertake graduate work at the Institute, the results of a Graduate Record Examination are often useful in informing him and the admissions authorities of his competence in cultural subjects, particularly. Correspondence relative to the conditions and places of examination should be addressed to the Educational Testing Service, Princeton, N. J., or Berkeley, Calif.

UNDERGRADUATE PREPARATION FOR ADVANCED DEGREES

General Requirements for Admission

Except as stated below under requirements peculiar to an individual field, evidence of satisfactory preparation will ordinarily be required in the following undergraduate subjects:

Mathematics. Mathematics substantially equivalent to the Institute's subjects of the first and second undergraduate years, namely Calculus, M11, M12, M21 and Differential Equations, M22.

Chemistry. College chemistry substantially equivalent to the Institute's first-year chemistry, 5·01, 5·02.

Physics. College physics substantially equivalent to the Institute's first and second year physics, 8·01, 8·02, 8·03, and 8·04.

Cultural Subjects. At least six semester courses in English, history, economics (or allied subjects) or other cultural subjects equivalent in scope to those included in the undergraduate curricula of the Institute. Deficiencies may be satisfied by presenting satisfactory grades in the Profile Tests of the Graduate Record Examination or by completing appropriate subjects from fourth-year or graduate electives in the humanities and social studies.

Professional Subjects. As specified below, particular professional subjects are required by individual departments.

Deficiencies in Preparation

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

If an applicant for admission to the Graduate School lacks so many undergraduate requirements that the attainment of the advanced degree is likely to be unduly pro-

tracted, he may be advised to postpone his application until his deficiencies have been reduced. Minor deficiencies in his preparation may be removed while he is pursuing graduate study.

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

RESIDENCE

Residence requirements are specified, not in terms of elapsed time, but in terms of amount of registration during which it is anticipated that residence benefits may be acquired.

Residence credit may be achieved by the satisfactory completion of approved subjects of instruction or thesis for which the applicant is registered while in the status of regular student or of Special Student who is also an Institute Staff member, or, in unusual cases, by accepted substitutions therefor, as set forth below.

For the degrees of Master in Architecture, Master in City Planning, or Master of Science, the entire thesis and at least two thirds of the remainder of the 72 "A" units must be completed with residence credit.

For a degree of Engineer, the equivalent of substantially two terms of full-time graduate work, including thesis, must be completed with residence credit.

For a doctorate, the equivalent of at least two years of full-time graduate work must ordinarily be completed with residence credit unless advanced work, completed otherwise, is accepted by a student's major department in lieu of similar work in residence, but in no case may the required amount of work in residence be reduced to less than the equivalent of one full-time academic year.

Transfer of Special Student Credits

Subjects completed by a Special Student, whether or not at the same time a member of the M. I. T. Academic or D. I. C. Staffs, may be subsequently offered in partial fulfillment of requirements for an advanced degree by such a student who has achieved regular graduate student status, and the student's major department will in each case determine to what extent such subjects are acceptable, with or without residence credit.

THE DEGREES, MASTER OF SCIENCE, MASTER IN ARCHITECTURE, AND MASTER IN CITY PLANNING

The degrees Master of Science, Master in Architecture, or Master in City Planning are awarded by the Corporation upon recommendation of the Faculty, based upon approval of the Committee on Graduate School Policy, upon the satisfactory completion of a course of advanced study and research approved by the department in which the student has been enrolled and complying with the regulations as set forth hereunder, during residence of at least one academic year.

Students who complete the requirements for the Bachelor's degree at 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 Master's degree upon completion of the requirements therefor.

A graduate of the Institute in the department in which he enrolls for the Master's degree, or others with equivalent preparation, may attain that degree in one year. Others with less direct and extensive preparation will require a longer time according to the 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 called to the statement of professional prerequisites under the appropriate department in the following pages.

Degree Requirements. The degrees, Master of Science, Master in Architecture, or Master in City Planning are awarded upon the satisfactory completion of an approved program of at least 96 units, of which 72 units, including a thesis of not less than 20 nor more than 40 units, shall be "A" subjects. (See "Subjects of Instruction Tabulated" for "A" subjects.)

The choice of field of specialization must be approved by the Committee on Graduate Students of the department in which the student is enrolled. The choice of subjects is not restricted to those offered in a single department: subjects in more than one department may be selected, provided that the resultant program is approved as being integrated and well-balanced.

Approval of the entire program must be obtained from the student's Registration Officer and the Committee on Graduate Students of the department in which the student is enrolled, or by a Special Interdepartmental Committee appointed by the Dean of the Graduate School to supervise his program if it be in a field which concerns two or more departments.

Credit is rarely granted for thesis work done in absentia: all thesis work must be done under the supervision of a member of the Institute's Academic Staff.

To be recommended for a Master's degree, a student must not only have a clear record in a program of graduate study and research as defined above, but his scholastic standing must be of a distinctly high grade.

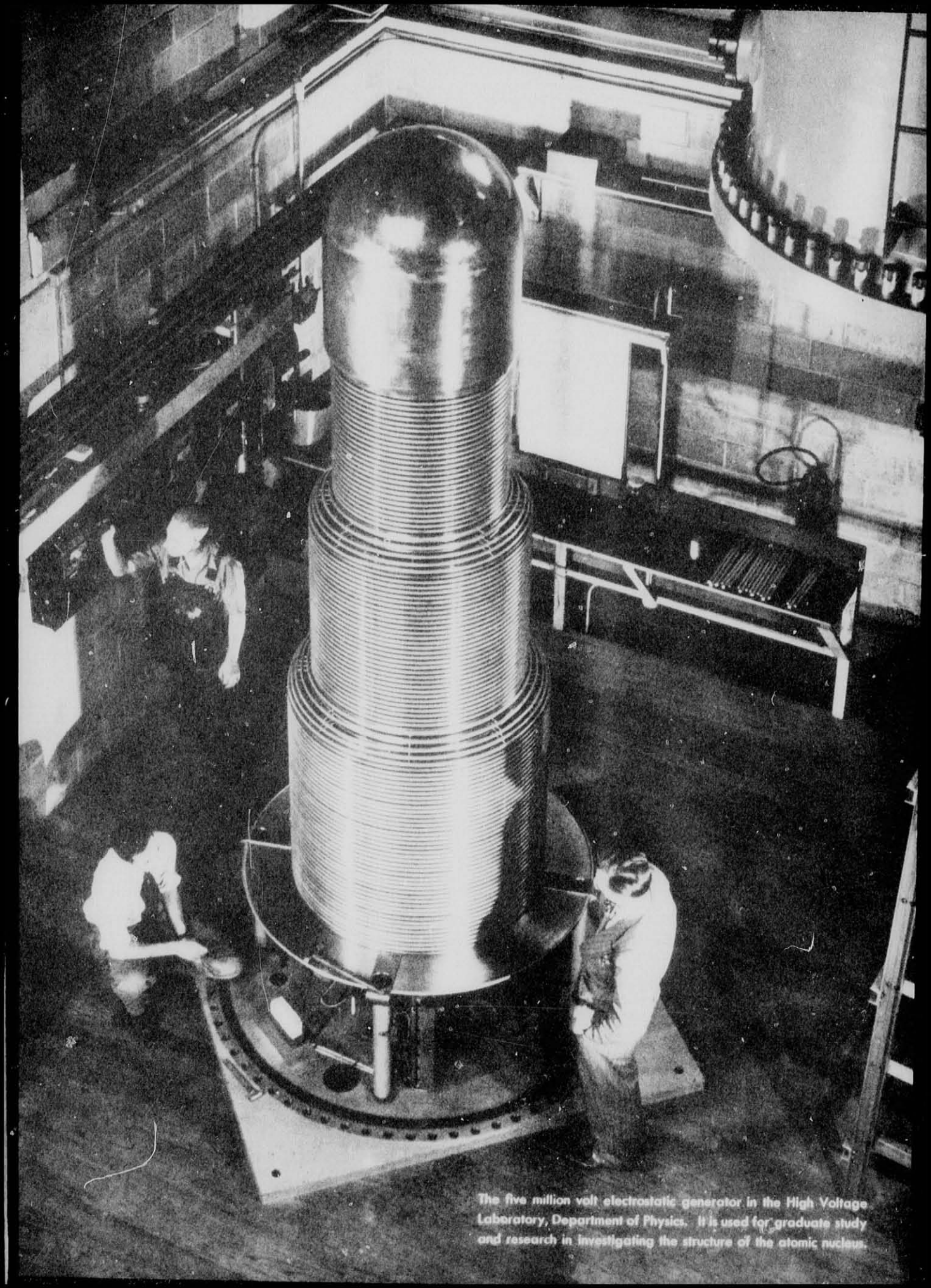
Degrees With and Without Specification

In a program for a Master of Science degree, if 64 units of "A" subjects, including thesis, in an approved program, are in a single field of science or engineering as determined by a departmental Committee on Graduate Students, the degree will be recommended with specification in the field in which the student has thus specialized; otherwise, the degree will be recommended without specification. The same high standard of academic performance is required in either case.

ENGINEERING DEGREES

The following degrees are awarded for the satisfactory completion of a program comprising at least 192 units of advanced study and research, including a thesis of not less than 20 nor more than 50 units, approved by the appropriate department of the School of Engineering: Civil Engineer (C.E.), Mechanical Engineer (Mech.E.), Metallurgical Engineer (Met.E.), Mineral Engineer (Min.E.), Electrical Engineer (E.E.), Chemical Engineer (Chem.E.), Sanitary Engineer (San.E.), Marine Mechanical Engineer (Mar.Mech.E.), Naval Architect (Nav.Arch.), Naval Engineer (Nav.E.), Aeronautical Engineer (Aer.E.), Building Engineer (Bldg.E.), and Meteorologist (Meteor.).

A graduate of the Institute who enrolls for an Engineering Degree in the same department in which he received



The five million volt electrostatic generator in the High Voltage Laboratory, Department of Physics. It is used for graduate study and research in investigating the structure of the atomic nucleus.



In the Gas Turbine Laboratory, graduate students in the fields of Mechanical, Chemical and Aeronautical Engineering conduct studies and researches. Here the mixing of gases is being investigated, under controlled conditions, leading to a better knowledge of combustion processes, jet pump design, and problems of jet propulsion.

his Bachelor's degree, or others with equivalent preparation, may complete the requirements for that degree in four academic terms; students with less direct or less extensive preparation will require a longer time.

The objective of a program leading to one of these degrees is a higher level of professional engineering competence than is required by the program for the Master's degree, without the emphasis on creative research which is characteristic of a doctoral program.

THE DOCTORATES

The degrees Doctor of Philosophy in fields of science and Doctor of Science in fields of applied science or of engineering certify to performance of original research of high grade and to creditable completion of an approved program of advanced study, principally at the Institute.

If at any time a Department Committee on Graduate Students is convinced that one of its applicants for a doctorate has not demonstrated those abilities necessary to meet the requirements for this degree, he may be required to change his registration to that of an applicant for a lower degree or to discontinue his registration in the Graduate School.

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

(1) Completion of a Major program of advanced work, concluding with a General Examination.

(2) Completion of a Minor program of study in an area distinct from that of the Major field.

(3) Demonstration of proficiency in the use of scientific modern languages.

(4) Preparation of a thesis on original research.

The Major Requirement

The Major, consisting of advanced study and research may be selected in any field of science or engineering approved by the department in which the student is enrolled. The Thesis will be in this same field. The program of the Major need not necessarily be confined to subjects offered in a single department.

When the Major field involves a program made up of subjects in several departments, there may be appointed a special committee to supervise the applicant's work.

A general examination upon the field of the Major will be held for each applicant for a doctorate at such time and in such manner as his Department Committee shall approve, except that each examination shall comprise both written and oral parts.

The Minor Requirement

The Minor requirement for the Ph.D. or Sc.D. degree comprises at least three subjects (not less than 24 units of credit) in some field other than that in which the Major lies. All of these subjects shall be more advanced in character than required in the prescribed undergraduate curriculum of the department in which the student majors. Subjects elected to satisfy this requirement will be selected with the primary objective of contributing broadly to the development of professional leadership rather than merely improving technical competence in a particular region of major interest; they will usually be offered by some department other than that in which the student is registered.

The full program of subjects comprising the Minor should be specifically agreed upon before it is begun. The field of the Minor must have the approval of the student's registration officer, and the components must have the approval of the Chairman of the Committee on Graduate Students of that department in which a plurality of the Minor subjects is given. The chairman of the Minor department shall file with the Registrar a record of the anticipated program as soon as it is determined. Any modification of the Minor program shall be reported promptly to the Registrar by the Minor department.

Occasionally, a student may desire to offer as a Minor a program of subjects which, although complying with both the letter and spirit of the first paragraph under this heading, involves components which, for administrative reasons, are offered within the department of which the student's Major field constitutes a portion. Such programs, if approved by the corresponding Departmental Committee and by the Dean of the Graduate School, shall be administered through the student's registration officer.

Subjects required for the completion of the Minor program should be approved in advance of enrollment therein. However, credit for appropriate subjects previously taken at the Institute or elsewhere as a graduate student, may be given to any extent satisfactory to the Minor department.

An examination to be based on the field of the Minor may be required, especially if credit for a part of the Minor requirement is granted for work done elsewhere.

The Language Requirement

Each candidate for a doctorate must demonstrate to the Department of Modern Languages his ability to read in English and two other modern languages the scientific literature of his field of specialization. These languages must be acceptable to the department in which he is enrolled and must be languages in which there is important literature in the field of his specialization. Accordingly, a student from a non-English-speaking nation may expect acceptance of his native tongue as one of the approved languages only if there is in that language a sufficient amount of important and pertinent literature.

Examinations in reading scientific literature in modern languages are held at intervals stated by the Department of Modern Languages.

Thesis

The thesis must be carried out under the direction of a member of the Faculty. Work already accomplished elsewhere not under supervision of a member of our Faculty cannot be accepted in partial fulfilment of thesis requirement, nor can credit be granted for thesis work done in absentia.

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

Award of the Degree

Upon completion of the above requirements, with the approval of the candidate's supervisory committee, and upon recommendation to the Faculty by the Committee on Graduate School Policy, the degree will be awarded by the Corporation of the Institute.

COOPERATIVE ARRANGEMENT WITH HARVARD UNIVERSITY

A student enrolled in the Graduate School at the Massachusetts Institute of Technology who is engaged full-time in study or in a combination of study and academic staff

duties together equivalent to full-time, may by permission enroll for advanced work exclusive of research at Harvard University or Radcliffe College without payment of additional tuition, provided that such exchange enrollment may not exceed one-half of his total registration. In the above category are included Fellows and full-time Special Graduate Students who are carried on the rolls of the Graduate School at M. I. T.

A student desiring to avail himself of this privilege must present to the Dean of the Graduate School at M. I. T. a written request from his Registration Officer, specifying the name and number of the Harvard subject desired, and whether for credit or for auditing without formal grade; the Dean's office will issue to the petitioner certain forms which must first be presented by him to the Instructor in the course desired, and then to the Dean of the appropriate Graduate School at Harvard. Registration must be completed within two weeks of the Registration Day specified by Harvard University for each term.

Permission will be granted for attendance at only such classes as are not so crowded that this additional registration creates an undue load on the instructors.

Requests should be confined to subjects not available in our own institution, and if there be apparent duplication of a requested subject in the two schools, acceptable reasons for the request must be presented.

Procedure for Harvard Students

A student enrolled in a graduate school at Harvard must obtain on appropriate forms the endorsement of the dean of his school and the written consent of the instructor in charge of each M. I. T. subject he plans to take. This approved request must then be presented at the office of the Dean of the Graduate School at M. I. T., Room 3-108. If the request is granted, the student must call for a letter of authorization which he must present at the Office of the Registrar, Room 7-142, in order to obtain registration material.

Such requests on behalf of Harvard students will not be granted after the end of the second week of a term at M. I. T.

COOPERATIVE ARRANGEMENT WITH LOWELL TEXTILE INSTITUTE

Opportunity is afforded by a cooperative arrangement with Lowell Textile Institute for use of facilities in connection with undergraduate and graduate classes, summer programs of instruction, interchange of staff members for lectures, and the use of library facilities.

I. CIVIL ENGINEERING

THE Department of Civil and Sanitary Engineering provides opportunity for study and research to satisfy the requirements for the degrees of Master of Science in Civil Engineering, Civil Engineer, or Doctor of Science in Civil Engineering.

Programs of study may be selected from the following fields:

Structural Engineering: advanced subjects dealing with methods of analysis and design of statically indeterminate and other complex structures

Soil Mechanics: theoretical treatment and experimental technique

Hydraulics: theoretical and experimental work in fluids, and *Water Power Engineering*

Transportation Engineering: design, construction and economics of airports, highways and railways

Geodesy and Photogrammetry: theory and practice of surveying by geodetic and photogrammetric methods

The Structural Analysis Laboratory offers facilities for instruction and research in the static and dynamic behavior of structures. The Soil Mechanics Laboratory is available for instruction in experimental technique and for investigations of soils of various kinds. The Hydraulics Laboratory has facilities for investigation of problems in Hydraulics including studies involving the use of models. Camp Technology in Maine makes it possible to carry on field work in Geodesy during the latter part of the summer.

(For instruction and research in Sanitary Engineering, see Course XI.)

Departmental Requirements for Graduate Work

In addition to the general requirements as set forth on page 95, the applicant must present evidence of training in professional subjects considered essential for all Civil Engineers and corresponding approximately to the following Institute subjects:

1·00, 1·01	Surveying
1·21	Route and Construction Surveys
1·40, 1·41	Structural Analysis
1·44	Elementary Structural Design
1·441T	Structural Design
1·601	Fluid Mechanics
2·04	Strength of Materials

He must also present evidence of having had, in addition to the subjects listed above, sufficient undergraduate training to prepare him for the advanced subjects which he desires to take.

Further specific professional requirements prerequisite for graduate study in the various branches of Civil Engineering are as indicated below:

For *Soil Mechanics, Hydraulics:*
No additional requirements.

For *Structural Engineering:*
1·42 Structural Analysis.

For *Geodesy:*
1·03 Advanced Surveying.

For *Transportation Engineering:*
1·271, 1·272 Transportation Engineering.

For *Water Power Engineering:*
1·70 Hydrology and Flood Control.
1·71 Water Power Engineering.

Deficiencies in prerequisites may be removed by the student while pursuing a program of graduate work but must be removed by him before proceeding with advanced subjects dependent upon them.

The Degree, Master of Science in Civil Engineering

At the discretion of the Department, up to 24 units of the more advanced subjects in the undergraduate curricula may be accepted in partial fulfillment of the requirements for the degree of Master of Science.

The Degree, Civil Engineer

Programs of study leading to the degree of Civil Engineer provide opportunities for students to obtain training broader than that required for the Master's degree and

I. Civil Engineering Continued

better preparation for undertaking professional practice in Civil Engineering. The rigor of the program and the quality of academic performance required are substantially those demanded of students working toward the Master's degree or those preparing for the general examination for the Doctor's degree. It is expected that the normal period of study for this degree should be two full years after the Bachelor's degree has been obtained.

THE DEGREE, DOCTOR OF SCIENCE IN CIVIL ENGINEERING

Only students who have shown promise of outstanding performance in work of a creative nature are encouraged to study for the doctorate. Where the records of students entering on graduate work do not yield evidence of this ability, they are usually advised to qualify first for the Master's degree. The thesis research for the doctorate is expected to make a contribution to professional knowledge in the field of Civil Engineering.

The general requirements for the doctor's degree are as given on page 97.

Each applicant for the doctorate in Civil Engineering is required to demonstrate his ability to read scientific literature in English and in two other modern languages, with German and French usually specified.

II. MECHANICAL ENGINEERING

The Department of Mechanical Engineering is equipped to provide opportunities for graduate work leading to the degrees of Master of Science in Mechanical Engineering, Mechanical Engineer, or Doctor of Science in Mechanical Engineering, or the degree of Master of Science in Textile Technology.

Laboratory facilities for experimental work are available in Photoelasticity and Experimental Stress Analysis, Materials Testing and Plasticity, Metal Cutting and Processing, Lubrication and Wear, Dynamics and Control, Fluid Mechanics, Temperature Measurements, Heat Transfer, Low Temperature, Refrigeration, and Heating and Ventilating. Through the Sloan Automotive Laboratory and the new Gas Turbine Laboratory special facilities are available for design and research activities in Internal Combustion Engines and Gas Turbines with particular emphasis on flow and combustion phenomena.

The Department, in cooperation with other departments of the Institute, operates a Practice School at the Atomic Energy Plant, Oak Ridge, Tennessee, where a number of graduate students take a four months course of work under the supervision of resident M. I. T. staff members, enjoying all of the technical facilities available at Oak Ridge. For further information see page 94.

The Institute also offers opportunity for advanced study and research in the field of textiles.

DEPARTMENTAL REQUIREMENTS FOR GRADUATE WORK

The general admission requirements are those set forth on page 95. A statement concerning transfers from other colleges is given below.

THE DEGREE, MASTER OF SCIENCE IN MECHANICAL ENGINEERING

The principal object of the study program leading to the degree of Master of Science in Mechanical Engineering is to broaden the student's background of engineering science in order to enable him to approach rationally any problem that may arise in the mechanical engineering field.

This object precludes specialization in any one narrow field as well as the development of general practical skills. To reach this objective within the present limit of 96 units, it is necessary to place certain limitations on the freedom of the student to select his program. With this purpose in mind, the subjects available to graduate students in the Mechanical Engineering Department have been grouped under seven major categories, including the Thesis, as shown below. Minimum requirements of units are prescribed for four of these categories. Since the prescribed number of units makes a total of 65, the student may have complete freedom of choice for a maximum of 31 units within the standard program of 96 units.

Subject Group	*Minimum Number of Units*
1. Mathematics	18 (Two Terms)
2. Applied Mechanics and Fluid Mechanics	18 (Two Terms)
3. Thermodynamics and Heat Engineering	9 (One Term)
4. Design	..
5. Materials Testing, Processing, and Metallurgy	..
6. Manufacturing and Production	..
7. Thesis	20
	65

The choice of subjects within any one subject group is intended to be as free as possible but must be made so as to insure a logical program.

The programs for transfer students must necessarily differ from those of graduates of the Mechanical Engineering Department. In general, a transfer student is required to take undergraduate subjects in those fields where this is necessary to bring his background up to the level required for graduates of the Mechanical Engineering Department. However, the student is encouraged to take the most advanced subject which his previous training justifies. Satisfactory grades in a graduate subject will permit the elimination of undergraduate deficiencies in subjects which cover the corresponding field at the undergraduate level. Experience shows that the majority of transfer students without previous graduate training should take 2·081, 2·256, and 2·43, or their equivalents.

Attention is called to the five-year program leading to the S.B. and S.M. degrees described under the Course II undergraduate schedule.

THE DEGREE, MASTER OF SCIENCE IN TEXTILE TECHNOLOGY

Graduates of the Institute, or of other institutions which award the Bachelor's degree on the basis of a course essentially equivalent in breadth and training to that offered by the Institute in the fields of Chemical Engineering, Chemistry, Mechanical Engineering, Business and Engineering Administration, Industrial Physics, or General Science and Engineering may obtain the Master's degree in Textile Technology in from one to two years depending upon preparation. Graduates of high standing, of technical schools or textile schools offering less extensive preparation in science or engineering, will, in general, require a minimum of two years to fulfill the requirements for the degree.

THE DEGREE, MECHANICAL ENGINEER

For students wishing to pursue a program of study more advanced than the Master's degree permits, but without the emphasis on creative research required for the Doctorate, the Department offers the degree of Mechanical Engineer.

The requirements for this degree include those of the Master's degree with, in general, the addition of another year of advanced study for further development of engineering competence. A General Examination, as described under the Doctor's degree, is also required.

II. Mechanical Engineering Continued

THE DEGREE, DOCTOR OF SCIENCE IN MECHANICAL ENGINEERING

The objective to be followed in planning the Major program of study towards the Doctorate is exactly the same as that outlined for the degree of S.M., but after the attainment of the proficiency embodied in the requirements for the degree of S.M., further and more mature specialization is required in at least one subject group selected from 2, 3, 4, or 5. Completion of this Major program is verified by a General Examination. Experience indicates that no rigid rules for the number of units involved in the Major program are desirable, but for the average candidate without previous graduate training, the equivalent of about 200 units is usually required. This also includes the established minimum of 24 units for the Minor requirement.

The General Examination includes all subject matter covered in the requirements for the Master's degree and the additional graduate subjects for which the candidate has registered as a part of his Major program. The Oral part of the General Examination may not be taken until the written part is passed.

The Minor program for Doctor of Science in Mechanical Engineering may be selected from some field of Science or Engineering other than Subject Groups 2, 3, and 4. Mathematics is now the most common field for the Minor, but whenever possible the Minor may be chosen from the fields of Physics, Chemistry, Metallurgy, Chemical Engineering, Civil Engineering, Naval Architecture, and Aeronautical Engineering.

The principal research program, its results embodied in a Thesis and verified by a Final Examination, should be selected within the field previously chosen for the Major program. Depending upon the degree of coordination between the research program and the Major program, this part of the doctorate program usually covers about 100 units.

Unless specifically approved by the Chairman of the committee on Graduate Students of the Mechanical Engineering Department, the General Examination and the Language Requirement must be completed before the program of research is undertaken. Whenever possible, the Language Requirement should be fulfilled in the first or second terms of the graduate program so that scientific literature in at least one important foreign language may be available to the candidate for the Major program of study.

III. METALLURGY

(INCLUDING MINERAL ENGINEERING AND CERAMICS)

The Department of Metallurgy offers graduate work leading to the degrees of Master of Science in Metallurgy or in Ceramics, Metallurgical Engineer, Mineral Engineer, or Doctor of Science in the field of Metallurgy, Mineral Engineering, or Ceramics.

The Physical Metallurgy laboratories provide general facilities for research on the constitution of metals and alloys, diffusion and reactions in the solid state, phase transformations, equilibrium diagrams of alloy systems, and the physical and mechanical properties of metals and alloys. The facilities include complete metallographic equipment, a wide variety of heat treating furnaces, X-ray units for diffraction studies and radiography, and numerous special items such as dilatometers and magnetometers.

The Process Metallurgy laboratories have been completely modernized and provide a wide variety of facilities for advanced study and research in such fields as roasting, extraction, reduction, smelting, distillation, and the many chemical reactions involved in these processes. Equipment for the preparation of experimental steels and other alloys on a scale up to 150 pounds is available. Research is in progress on the refining of liquid metals and in gas-metal reactions and solubilities.

The Mechanical Metallurgy laboratories include forging and rolling equipment, a complete foundry which is being modernized throughout, a welding laboratory, and equipment for powder pressing, metal spraying and other special forming methods.

Specialized laboratories of the Department also provide facilities for research in corrosion and electrochemistry, high-temperature metals, ferromagnetism, surface hardening, powder metallurgy, foundry practice and steelmaking. As a further aid to its research activities, the Department maintains an analytical laboratory and machine and instrument shops.

In the Mineral Engineering laboratories facilities are available for the study of crushing, grinding, screening, classification, thickening, filtration, tabling, jigging, electrostatic and magnetic separation of ores, fuels and minerals. In addition, complete microscopic equipment is available for the 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 separation.

The field of ceramics is a broad one, covering pottery, heavy clay products, refractories, abrasives, glass and enamels. However, common fundamental principles apply to all the branches, and these form a sound basis on which to specialize. The laboratories are well equipped to carry out any phase of advanced research in the field.

DEPARTMENTAL REQUIREMENTS FOR GRADUATE WORK

The general admission requirements are those set forth on page 95.

Professional subjects prerequisite for graduate study in the Department of Metallurgy are given below.

For students in *Metallurgy:*

3·01	Metallurgical Engineering I
3·31	Physical Metallurgy I
3·32	Physical Metallurgy II
5·61	Physical Chemistry I
5·62	Physical Chemistry II
6·18	Electrical Engineering, Fundamentals

For students who are graduates of Course II or have an equivalent background and who wish to specialize in the field of Mechanical Metallurgy, a special program will be arranged in lieu of the above requirements in Chemistry and Metallurgy.

For students in *Mineral Engineering:*

3·01	Metallurgical Engineering I
3·81	Mineral Engineering I
5·61	Physical Chemistry I
5·62	Physical Chemistry II
12·011	Mineralogy
12·20	Elementary Crystallography

For students who are graduates of other courses and wish to specialize in Mineral Engineering, a special program will be arranged as partial substitution for the above requirements.

III. Metallurgy Continued

For students in *Ceramics:*

The graduate program in Ceramics correlates the fundamental instruction in a number of fields. Each student is therefore considered individually on the basis of his background for graduate study and his special interests. A required program will be selected from the subjects listed below, while the remainder may be considered as elective subjects for graduate students in Ceramics.

2·221	Plasticity (A)
2·222T	Seminar in Plasticity (A)
2·43	Heat Engineering
2·50	Heat Measurements
3·81	Mineral Engineering I
5·061	Inorganic Chem., Adv.
5·062	Inorganic Chem., Adv.
5·63	Physical Chemistry I
5·64	Physical Chemistry II
5·66	Surface and Colloid Chemistry
5·71	Chemical Thermodynamics I (A)
6·26	Insulators and Semi-Conductors
6·64	Dielectric Phenomena and Materials (A)
8·27	X-rays and Crystal Physics
8·28	X-ray Diffraction (A)
10·21	Industrial Chemistry
10·33	Analytical Treatment of Chemical Engineering Processes (A)
10·661	Introduction to Colloid Chemistry (A)
10·662	Colloid Chemistry (A)
10·691	Colloid Chemistry of Silicon (A)
12·15T	Petrography
12·20	Elementary Crystallography
12·231	Optical Crystallography
12·24	Theoretical Crystallography
14·60	Labor Relations
14·61	Industrial Relations
15·11	Introduction to Industrial Management
17·72	Materials — Masonry
17·771	Cementitious Materials
17·772	Cement and Concrete (A)
M36	Advanced Calculus (A)
M37	Advanced Calculus (A)

The Degree, Master of Science

The specifications for the degrees of Master of Science in Metallurgy or Master of Science in Ceramics are as set forth on page 96.

The Degree, Metallurgical Engineer

The specifications for the degree of Metallurgical Engineer are as set forth on page 96.

The Degree, Mineral Engineer

The specifications for the degree of Mineral Engineer are as set forth on page 96.

The Degree, Doctor of Science

The specifications for the degree of Doctor of Science in Metallurgy or in Ceramics are as set forth on page 97.

IV-A. ARCHITECTURE

The Department of Architecture offers work leading to the degree of Master in Architecture.

Graduate study in Architecture affords students who have demonstrated professional promise an opportunity for advanced work in the further application to creative design of the contributing fields of study that formed part of their undergraduate curriculum. There is also an opportunity for participation with students of related disciplines in the exploration of important problems whose solution appears to require the contributions of more than one profession. The work is arranged to enable the student to devote large units of time to research and design under the guidance of the School and with the assistance of Institute specialists in the related fields. This activity is enriched by the availability of unusual laboratory and library facilities and by the association with graduate students from other backgrounds.

Departmental Requirements for Graduate Work

Undergraduate preparation in Architecture usually differs from that required for the scientific degrees, and in place of the requirements on page 95, the following are set up as prerequisites for graduate study.

Architecture. Bachelor in Architecture or equivalent degree with high academic standing from a professional undergraduate course in architecture at an institution of recognized standing, or S.B. or A.B. degree with high standing and enough professional work in a school of architecture of recognized standing to indicate promise of competence in the profession.

Evidence of satisfactory preparation in the following undergraduate subjects will be required for all Graduate students in Architecture.

Mathematics and Physics. Two years of college work which includes subjects in one or more of the fields of Mathematics and the Physical and Natural Sciences.

Cultural Subjects. At least six semester courses in English, history, economics (or allied subjects) and other cultural subjects equivalent in scope to those included in the undergraduate curricula of the Institute.

Professional Subjects in Architecture. Two full years of subjects in mechanics and structural design and one full year of subjects in other technical aspects of building; a completed program of work in history of architecture, freehand drawing, and architectural design equivalent to these subjects as required in the Institute's curriculum for the Bachelor in Architecture.

Deficiencies in mathematics and physics may be removed by the enrollment in special sections in subjects offered by the Institute. A student whose deficiencies are of minor extent will be permitted graduate registration while taking the appropriate subjects at the Institute to remove them. Where such subjects are at theprofessional level, they may contribute, up to 24 units if approved by the Department, toward the requirements for the Master's degree.

The Degree, Master in Architecture

The degree of Master in Architecture is awarded upon satisfactory completion of a course with a minimum of 96 units of advanced study, subdivided as set forth on page 96, including a minimum of two terms of architectural design and a thesis of from 20 to 40 units. Completion ordinarily involves twelve months of residence for graduates of five-year professional courses.

IV-B. CITY PLANNING

The Department of City and Regional Planning offers work leading to the degree of Master in City Planning.

The Graduate Course in City Planning is designed to train practitioners or staff men in the fields of city and regional planning. It offers to the advanced student a broad survey of the entire field of planning, and practice work in the library, drafting room, and field. It is intended primarily for students with undergraduate training in city planning, architecture, landscape architecture, civil engineering, or one of the social sciences; but those whose undergraduate preparation has been in other fields may also be admitted provided that they make up certain deficiencies ordinarily required in undergraduate courses. Graduates of the undergraduate Course IV-B or its equivalent if accepted for admission to the Graduate

IV-B. City Planning Continued

School, should be able to complete the requirements for the degree of Master in City Planning in one year. Students with degrees in other professional fields would normally take two years.

Departmental Requirements for Graduate Work

Undergraduate preparation in City Planning usually differs from that required for the scientific degrees, and in place of the requirements on page 95, the following are set up as prerequisites for graduate study.

Planning. The degree, Bachelor in City Planning, from the Institute or other approved college, or the S.B. or A.B. degree together with academic records and background considered satisfactory as preparation for graduate study in the field of city planning.

Evidence of satisfactory preparation in the following undergraduate subjects:

Mathematics and Physics. Two years of college work which includes subjects in one or more of the fields of Mathematics and the Physical and Natural Sciences.

Cultural Subjects. At least six semester courses in English, history, economics (or allied subjects) and other cultural subjects equivalent in scope to those included in the undergraduate curricula of the Institute.

Professional Subjects in City Planning. Acceptable courses of at least one term's credit each in surveying, urban sociology, transportation engineering, architectural design, and city planning principles. At least twelve weeks of practical experience in a planning office are ordinarily required.

Deficiencies in mathematics and physics may be removed by the enrollment in special sections in subjects offered by the Institute. A student whose deficiencies are of minor extent will be permitted graduate registration while taking the appropriate subjects at the Institute to remove them. Where such subjects are at the professional level they may contribute, up to 24 units described on page 96, toward the requirements for the Master's degree.

The Degree, Master in City Planning

The degree of Master in City Planning is awarded upon satisfactory completion of a course with a minimum of 96 units of advanced study, subdivided as set forth on page 96, including at least three terms of city and regional planning design and a thesis of from 20 to 40 units.

V. CHEMISTRY

The Department of Chemistry offers graduate programs leading to the degrees of Master of Science, Doctor of Philosophy, or Doctor of Science in Chemistry. Details of these programs, which differ according to whether the candidate chooses to specialize in Analytical, Inorganic and Nuclear, Organic, or Physical Chemistry are recorded below. Students working toward the Doctorate are expected to choose one of these four fields of specialization; students working toward the Master's degree may make a similar selection, or may take a program in chemistry including study in an approved combination of these fields.

Attainment of the Master's degree is not prerequisite to a program of study leading to a Doctorate. Master's candidates may, by permission, change to the corresponding Doctorate without loss of credit.

There is a demand for chemists to serve as investigators and to direct investigational work in 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.

Teaching Assistants

The Department appoints a limited number of Teaching Assistants who are candidates for the degree of Doctor of Philosophy in Chemistry. Teaching Assistants serve in the laboratories of the Department, and may be assigned to the classroom on a part time regular schedule throughout the academic year. For information in regard to appointments, address correspondence to the Head of the Department.

Physical Chemistry

Graduate courses in physical chemistry cover the fundamentals of thermodynamics, statistical mechanics, kinetic theory and molecular structure. The Minor in mathematics and physics broadens the fundamental basis. The research gives intensive specialization in a narrower field and develops experimental technique and ability to carry on independent investigations.

Research in Physical Chemistry is being carried out in the following fields and the laboratory is especially well, often uniquely, equipped for such research:

Pressure-volume-temperature relations of gases and liquids.
The absolute temperature scale.
Heat capacities and latent heats at low temperatures.
Properties of gases at low pressures.
Diffusion of gases.
Scattering and other properties of molecular beams.
Electromotive force in concentration cells, and oxidation-reduction potentials.
Freezing points of liquid solutions.
Vapor pressures of liquid solutions.
Infra-red, ultra-violet and Raman spectroscopy.
Precision photometry.
Kinetics of thermal and photochemical reactions.
Properties of high polymers.
Properties of protein solutions.
Optical and electrical properties of thin metal deposits.
Study of crystal structure by X-ray diffraction.

Organic Chemistry

In the graduate program, subjects are offered which aim to develop in the student a sound knowledge of fundamentals and familiarity with current progress in the most active and important branches of Organic Chemistry. Each student undertakes a research problem which forms the nucleus of his graduate work, and through the experience of conducting an experimental investigation leading to the Ph.D. or S.M. thesis, acquires the research attitude and method of approach, and training in the specialized techniques of organic research. Basic graduate subjects in Organic Chemistry cover broadly organic reactions and their application to synthetic and structural problems, and theoretical organic chemistry.

Fields of research in Organic Chemistry which are being investigated in the department include carbohydrates; heterocyclic compounds; organic peroxides; organometallic compounds; amino acids; synthetic alkaloids; polymerization; reactions of active methylene compounds; reaction mechanisms; synthetic methods; small-ring compounds; tracer studies; relation of structure to reactivity; vitamins; terpenes; sterols; other natural products and physiologically active compounds.

V. Chemistry Continued

Inorganic and Nuclear Chemistry

Inorganic Chemistry. The remarkable advances which have been reported in recent years in the utilization of the less familiar elements, such as titanium, niobium and tantalum, the rare earth metals, uranium and the "artificially" prepared heavier elements; the isolation of small quantities of the compounds of other hitherto unknown elements, such as technetium (element No. 43) and promethium (element No. 61), as well as progress in the utilization of certain non-metallic elements such as selenium and fluorine, have called attention to the fact that the opportunities for research in inorganic chemistry, nuclear chemistry, and allied fields of interest were never more appealing.

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.

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 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.

Nuclear Chemistry. Special facilities are available for studies in the field of nuclear chemistry: the preparation and identification of radioelements; the fundamental chemistry of general and specific methods for the separation of radioactive materials throughout the periodic system; the reactions of substances at very low concentration; and the applications of radioactive techniques to general chemical problems.

Analytical Chemistry

The graduate curriculum in Analytical Chemistry is designed to prepare men for leadership both in industrial and in academic laboratories. The program provides a broad background in inorganic, physical and organic chemistry and places emphasis upon both organic and inorganic aspects of analytical chemistry. The subjects stress principles and methods; the thesis aims at providing a varied research experience, as well as specialization in a field of limited scope.

The laboratory is unusually well equipped for studies involving modern instrumental methods. The student is able to employ a wide variety of methods, as well as to compare the performances of a number of different instruments designed to carry out the same general technique. Among the newer types of instruments being used are those for polarography, graded potential electrolysis, spectrophotometry, flame photometry, and radiochemical measurements.

Many of the research problems now under investigation in this laboratory are concerned with the analytical chemistry of the fission and spallation elements, and the determination of organic functional groups. The program of the division is by no means limited to these fields, however, and the initiation of work on other subjects is encouraged.

Departmental Requirements for Graduate Work

The general admission requirements are those set forth on page 95, with the following exceptions and additions:

Mathematics. Doctoral candidates with their Major in Analytical, Inorganic or Organic Chemistry need not present M22.

Professional Subjects. All candidates for admission to graduate work in this department must present equivalents of the following subjects:

Analytical Chemistry: 5·10, 5·13
Organic Chemistry: 5·41, 5·414, 5·42, 5·424
Physical Chemistry: 5·63, 5·631, 5·64, 5·641

The Degree, Master of Science

For the degree, Master of Science in Chemistry, in addition to the subjects listed above, two elementary foreign languages are required equivalent to L11, L12 (German) and L51, L52 (French).

The Doctorates

For the degree of Doctor of Philosophy or Doctor of Science in a field of chemistry, each candidate must fulfill the requirements listed below.

Candidates for the Doctorate in any field of chemistry are required to take a written Qualifying Examination. This will be offered twice each year; once in the week preceding the opening of the Fall Term, and once in the week immediately following the Spring Recess. Any student admitted for September to a graduate program in the Department of Chemistry may, at his option, take the September examination; but otherwise, doctoral candidates beginning their programs in June or September must take the next following Spring Examination, and those entering in February must take the next following Fall examination.

Each Qualifying Examination comprises three three-hour parts covering the following fields:

Part I. *Inorganic and Analytical Chemistry.* (General Chemistry 5·01 and 5·02; Qualitative Analysis 5·10; Quantitative Analysis 5·13; Advanced Inorganic Chemistry 5·061.)

Part II. *Organic Chemistry.* (General Organic Chemistry 5·41 and 5·42; Theoretical Organic Chemistry 5·43.)

Part III. *Physical Chemistry.* (General Physical Chemistry 5·63 and 5·64 and a choice of one of the four subjects: Atomic Structure and Spectra 5·67 or 5·75; Reaction Kinetics 5·68; Surface and Colloid Chemistry 5·66; or Chemical Thermodynamics I 5·71.)

The Qualifying Examination will not be based solely on M. I. T. subject content, but the corresponding subject numbers are listed above as an indication of the professional level of the fields involved.

Satisfactory completion of the qualifying examination automatically certifies the candidate in all the undergraduate deficiencies in subjects in Chemistry and a passing grade is prerequisite for the subsequent Major Examination in the candidate's field of specialization.

In order to complete the Language Requirement, the student must pass written examinations in scientific French and German before taking his Major Examination.

To fulfill the Minor requirement the student must take at least 24 units of subjects outside of his field of specialization. Candidates majoring in Physical Chemistry must take the Minor in Mathematics or Physics.

V. Chemistry Continued

Each candidate must complete or be certified in the following subjects in the Course V curriculum: viz., 5·01, 5·02, 5·061, 5·10, 5·13, 5·41, 5·42, 5·43, 5·414, 5·424, 5·63, 5·64, 5·631, 5·641.

In addition to the general requirements indicated above, candidates for the Doctor's degree pursue a program of graduate subjects. The specific content of these programs varies according to the major field in which the candidate is registered, but ordinarily will include selections from the following subjects:

Analytical Chemistry: 5·062, 5·15, 5·192, 5·193, 5·194, 5·417, 5·426, 5·67, 5·71, and during each year of residence 5·915, 5·916, 5·951 and 5·952.

Inorganic Chemistry: 5·062, 5·08, 5·68, 5·71, together with at least 14 units in approved subjects, such as X-rays and Crystal Physics, Nuclear Physics, Radiochemistry, X-ray Metallography, or Crystallography, and during each year of residence 5·071, 5·912, 5·941, and 5·942.

Organic Chemistry: 5·44, 5·51, 5·52, 5·54, 5·67, and during each year of residence after the first year 5·913 and 5·914.

Physical Chemistry: 5·68, 5·71, 5·72, 5·73, 5·74, 5·75, 5·76, 5·77, and during each year of residence 5·931, and 5·932.

In the interpretation of these requirements, the Department will consider the candidate's previous academic record and professional experience together with his particular aims and objectives, and will take a liberal attitude toward substitution of other subjects of equivalent educational and scientific value. Graduate students are urged to select a research supervisor during the first or second academic term of residence and to plan their program of study in consultation with him and with the chairman of the departmental graduate committee.

Inquiries should be addressed to the Chairman, 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 in Electrical Engineering, Electrical Engineer, or Doctor of Science in Electrical Engineering.

There are no fixed programs of study toward these degrees. Particular effort is made with each student to develop his program of graduate study along the lines of his individual special interest. Such a program provides him with a strong incentive to a high level of accomplishment and gives him a specialized ability that is immediately useful. This specialized ability, however, is deemed a less significant result of graduate study than is the clearer insight into and better integration of fundamental principles so generally gained by the graduate student. Soundly conceived advanced work rarely fails to send the student back to deepen his understanding of elementary but basic principles. These ideas influence both the methods of approach used in graduate engineering subjects and the counsel given to students to include in their programs further formal study of mathematics and physics.

At the graduate level the Department offers a wide choice among a number of areas of activity. Several of these are interdepartmental in scope, representing a trend emphasized by the war and regarded most desirable. The Department regards active research projects as a dominant influence in its graduate program provided each is so conceived and administered that the graduate student can and does have full opportunity to associate himself with it while retaining his scientific individuality and initiative. This educational principle is vigorously enforced.

Graduate work tends to center about a number of especially active areas in the broad field associated with electrical engineering. Each of these areas is characterized by an active research program, and in general by graduate class and laboratory programs. Some of these are mentioned in the following paragraphs.

In servomechanisms and automatic control a large research and development program is closely coupled with extended graduate study covering numerous and varied phases of this subject. Close integration of electronic and electric circuits, electromechanical, hydraulic, and mechanical elements in single dynamical systems provides excellent educational breadth in a currently active field.

In the Research Laboratory of Electronics sponsored jointly by the Departments of Electrical Engineering and Physics particular attention is currently given to microwave techniques and their applications in such fields as communications, television, acoustics, generation of high-energy radiation, electronic computation, gaseous conduction, and atomic structure.

Advanced network theory is an important area in its own right and contributes to several other areas, for example, servo theory, communications, and power transmission.

A group is concerned with advanced topics in the electric power field and uses the Network Analyzer in power system studies ranging from those of large public utility systems to those of multimotored airplanes.

Digital and analogue computation are taught through subjects developed from machine research in the Center of Analysis and in the Digital Computer Division of the Servomechanisms Laboratory. Specific subjects are available in machine logic, numerical analysis, and electronic circuits. Subjects related to machine computing applications are taught also in other departments of the Institute.

The Departments of Architecture, Physics and Electrical Engineering are engaged in an extensive program of research and development in the field of acoustics, both fundamental and applied.

Fundamental research and development work on dielectrics are concentrated in the Laboratory for Insulation Research. Insulators, semiconductors, and conductors are studied in all states of aggregation by means of the techniques of electrical engineers, physicists, and chemists. The work aims at a deeper understanding of the properties of dielectric materials and at the development of new fields of application.

The development of generators in the several-megavolt-range and their use in the generation of high-energy particles and radiation are subjects both of research and development and of graduate study. High-precision measurements of the properties and effects of such radiations, the problems of very-high-voltage insulation, and therapeutic applications in cooperation with medical research groups are emphasized.

Certain aspects of nuclear energy and machines for producing extremely high-energy particles constitute another focus of activity as a part of the Laboratory of Nuclear Science and Engineering. This laboratory is another project in which several departments cooperate.

A facility differing in kind from the centers of new development but equally essential in the Department's educational program is the Vail Library. This Library is one of three great electrical libraries of the world. The original Vail Collection (30,000 volumes), presented to the Department in 1912 through the interest of the late Theodore N. Vail, was combined with other electrical literature in the Institute Library to form the Vail Library which now comprises approximately 50,000 volumes. It

VI. Electrical Engineering Continued

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, maintains unusual files of current industrial catalogues and other current material in addition to providing the usual library services.

From the emphasis given to the graduate student's association with active projects it is evident that his graduate study is considered to include much more than class exercises and assignments pursued in a routine manner. He is expected to conceive of his program as a coordinated whole, having as its objective the advancement of his professional preparation and providing for a substantial amount of independent and correlative study in current literature and independent investigation in the laboratories. Such study and investigation are essential parts of thesis research, affording the student an opportunity to develop his ability to do sound constructive reasoning, and to contribute to the advancement of engineering.

ASSISTANTSHIPS. Each year a limited number of appointments to assistantships are available to men especially qualified by training and natural endowment for teaching or research. Every effort is made to arrange the assigned work of an assistant so that he may 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 a graduate thesis, a research assistant is permitted to make use of it.

DEPARTMENTAL REQUIREMENTS FOR ADMISSION TO GRADUATE WORK

The general requirements are as set forth on page 95, without exceptions.

In addition to the general requirements for all graduate students, a candidate for the degree of Master of Science in Electrical Engineering, Electrical Engineer, or Doctor of Science in Electrical Engineering must present evidence of training in certain professional subjects considered essential for all Electrical Engineers, and which correspond approximately to the following Institute subjects:

2·001, 2·002	Applied Mechanics
2·04	Strength of Materials
6·00T, 6·01T, 6·02, 6·031, 6·032	Electrical Engineering, Principles
6·75	Electrical Measurements Laboratory
6·76	Engineering Electronics Laboratory
M31	Differential Equations

He must also present evidence of having had sufficient undergraduate training to prepare him for the advanced subjects he wishes to take, and to give him a certain professional breadth. For each of the following fields, the amount of such training should be approximately equivalent to that included in the Institute subjects indicated:

Electric Power

2·07	Dynamics
2·40	Heat Engineering
6·04	Electrical Engineering, Principles
6·78, 6·79	Electrical Machinery Laboratory

Communications and Electronics

6·30, 6·311, 6·321	Elec. Communications Principles
6·331, 6·332	Elec. Communications Laboratory
6·781	Electrical Machinery Laboratory
8·071, 8·08	Thermo. & Statist. Mech.; Electronics

Electronics Applications and Automatic Control

Automatic Computation and Numerical Analysis

2·07	Dynamics
6·20	Electronic Control and Measurement
6·781	Electrical Machinery Laboratory
6·83	Electronic Eng. Laboratory

When the student's interest in graduate work does not fall in one of these distinct fields, he must present comparable evidence both of adequate preparation for advanced work in his chosen field and of reasonable competence in collateral fields.

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. Selected subjects considered to be prerequisites for graduate studies may be counted up to a total of 24 units for credit toward the Master's degree.

THE DEGREE, MASTER OF SCIENCE

The general requirements for the Master's degree are given on page 96.

Students working for the Master's degree are expected to devote themselves to a few subjects, not more than four each term, in addition to their research. The subjects of study are wholly elective and not restricted to those given by the Department of Electrical Engineering; however, the program of study must be well balanced, emphasizing one or more of the mathematical, economic, and experimental aspects of electrical engineering.

Course VI-A, listed under the undergraduate course schedules, leads to the degrees of Bachelor of Science and Master of Science.

THE DEGREE, ELECTRICAL ENGINEER

Able students who are desirous of preparing for creative application of engineering and scientific principles in engineering practice, who desire more extensive training than is possible within the 96 units required for the Master's degree, yet are not interested in acquiring the training in research afforded by doctoral study, are encouraged to study for the Electrical Engineer degree. Programs for this degree are elective except for Thesis, and will ordinarily require at least four terms of graduate study beyond the Bachelor's degree level.

The general requirements for the Electrical Engineer degree are given on page 96.

The student is required to demonstrate his professional engineering competence in an oral examination in the field of his specialty. The examination is to be taken not later than the first month of the term in which the student is a candidate for graduation.

THE DEGREE, DOCTOR OF SCIENCE

Only students who have shown promise of outstanding performance in work of a creative nature are encouraged to study for the doctorate. Students entering on graduate work who do not have records that show evidence of this outstanding ability are usually advised to qualify first for the Master's degree. The thesis research for the doctorate is expected to make a substantial and noteworthy contribution in Electrical Engineering or a related field.

The general requirements for the Doctor's degree are given on page 97.

The General Examination is divided into a first and second part. The first part is both written and oral. It should be taken within one year after entering graduate work. It is normally offered each fall and spring, and its purpose is to determine whether, in terms of command of the basic sciences and practices of Electrical Engineering,

VI. Electrical Engineering Continued

the candidate is qualified to take advanced study and research of doctoral caliber. The second part is wholly oral and is to be taken after a student has taken his specialized graduate study.

Each applicant for the doctorate in Electrical Engineering is required to demonstrate his ability to read scientific literature in English and in two other modern languages selected from German, Russian, and French. Ordinarily this requirement in one of the modern languages should be satisfied by the time the first part of the General Examination is taken, and in both modern languages before undertaking the thesis research. Special one-term subjects are offered in these languages to assist graduate students in obtaining the required reading knowledge for their field (see description of subjects L17, L57, and L97). However, more extensive study of these foreign languages is preferred. When a choice can be made, German is preferred, since German literature in the field of Electrical Engineering is at present the most extensive of the three, with Russian as a second choice.

The field of the Minor is not prescribed by the Department, but usually Mathematics, Physics, or Economics is chosen.

VII. BIOLOGY

Graduate study and research in this Department may be selected in one of the following fields: Basic Biological Sciences, Biochemistry, Biophysics, General Physiology, Microbiology. Advanced work in these fields leads to the degrees of Master of Science in Biology, or Doctor of Philosophy or Doctor of Science in the field of specialization. Course VII-A leads to the degrees of Bachelor of Science in Quantitative Biology and Master of Science in Physical Biology.

Course VII-B leads to the degrees of Bachelor of Science in Quantitative Biology and Master of Science in Chemical Biology, awarded simultaneously. Both of these special curricula are listed under the undergraduate course schedules.

The Biological Research Laboratories

The Biological Laboratories offer facilities for advanced work in biochemistry, biophysics, cytology, enzymology, general physiology, and microbiology. 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:

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, electron microscopes, and polarization optical equipment. These techniques are being applied at the present time especially to collagen, insulin and the proteins of muscle. 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 poly-molecular films. Electrical instrumentation is provided for a study of the biological action of high-frequency electric fields, and ultrasonic radiation. Equipment and laboratories are available for the study of the instruments used in physical medicine.

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. Studies are also in progress to determine the active groups of enzymes, their distribution in cells and tissues, and the relationship of enzyme concentration to the nutrition of living organisms.

Departmental Requirements for Graduate Work

Only students with a bachelor's degree and 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.

For admission to graduate work in this department, the general requirements as set forth on page 95 are modified by the following exceptions:

Mathematics. Through calculus equivalent to M11 and M12.

Physics. One year of satisfactory college physics.

Chemistry. Equivalents of 5·01, 5·02, 5·12, 5·41, 5·412, 5·61, 5·62.

Professional Subjects. Two years of college biological subjects, and the equivalent of 7·19, 7·20, and 7·80. Other prerequisites may be required depending upon field of specialization.

Deficiencies in subjects listed above may be removed, if not too extensive, while pursuing a graduate program but before entering upon advanced work which is dependent upon them.

The Degree, Master of Science

The degree of Master of Science in Physical Biology is awarded only upon completion of the special curriculum designated as VII-A. The degree of Master of Science in Chemical Biology is awarded upon completion of the special curriculum VII-B. Other candidates may attain the degree of Master of Science in Biology, or Master of Science (without specification).

The Doctorate

A doctorate in this Department requires a reading knowledge of scientific literature in two modern languages other than English, selected from French, German, and Russian.

Preliminary examinations for a doctorate in this department consist of both written and oral parts. The preliminary examinations include fundamentals of general biology, general physiology, and biochemistry as well as other undergraduate and graduate courses in biology for which the student has received credit.

VIII. PHYSICS

The Department of Physics offers work leading to the degrees of Master of Science, Doctor of Philosophy, or

VIII. Physics Continued

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 matter in bulk, of electronics and gas discharges, of atomic spectra and the nature of light. The discovery of radioactivity, of induced radioactivity, of nuclear fission and of cosmic rays, has led to an understanding of the nature of the atomic nucleus, and of high energy particles, which is far from complete, but which is bound to lead to further far-reaching discoveries. The fundamental laws governing the nature of matter and energy are partly understood as a result of recent work, almost certainly within reach in the near future.

Along with this remarkable advance in basic knowledge has come very widespread application of new principles and methods to practical problems. The methods of electronics have revolutionized communications and instrumentation. Relatively old fields like acoustics have become revitalized. Physical tools 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. Four interdepartmental research laboratories, the Laboratory for Nuclear Science and Engineering, the Research Laboratory of Electronics, the Spectroscopy Laboratory, and the Acoustics Laboratory, serve to correlate the research of the various departments in these fields, and their facilities are available to graduate students in physics. In nuclear physics, equipment includes a large cyclotron, and high voltage electrostatic generators. Further electronuclear machines of very high voltage are available in connection with the Laboratory for Nuclear Science and Engineering. There are active research programs in nuclear structure, applied radioactivity, and in cosmic rays and high energy particles. The Research Laboratory of Electronics provides unequalled facilities for research in microwave electronics, and related branches of physics. The laboratory has equipment for the production of very high magnetic fields, and of very low temperatures. The Acoustics Laboratory works both in low frequency acoustics, including architectural acoustics, and in ultrasonics. The Spectroscopy Laboratory is unique in the field of spectroscopic measurement and analysis. Research in the field of color measurements, in X-ray diffraction and crystal structure, electron microscopy, and the structure of dielectrics, is actively carried on.

Subjects of study include work in almost all of these experimental fields, and in the various branches of theoretical physics as well. It is expected that the graduate student will gain real familiarity with several of the branches of physics, not merely with one specialty. Whether he plans to go into academic work, or into industrial research, the training includes a broad and thorough understanding of the fundamentals of physics, as well as of its more advanced applications.

Departmental Requirements for Graduate Work

General requirements are those set forth on page 95 with the following additions:

Professional Subjects. The equivalents of the following subjects, which are not credited in fulfillment of degree requirements:

8·05	Atomic Physics
8·06	Nuclear Physics
8·07	Thermodyn. & Statis. Mech.
8·08	Electronics

The following advanced undergraduate subjects may be credited (to the extent of 24 units) toward and are required for advanced degrees:

8·11	Experimental Physics
8·71, 8·72	Introduction to Theoretical Physics

Deficiencies in subjects required for admission or for advanced degrees may be removed while engaged in graduate work before undertaking advanced subjects dependent upon them.

The Degree, Master of Science

In addition to general requirements set forth on page 96 a reading examination in either scientific French or German is required.

The Doctorates

The degrees of Doctor of Philosophy in a field of pure physics or Doctor of Science in a field of applied physics require examination for reading knowledge of scientific literature in either German and French or German and Russian.

The student is expected to take graduate subjects to prepare himself for the general examination but there are no stated required subjects.

X. CHEMICAL ENGINEERING

Graduate study in this Department leads to the degrees of Master of Science in Chemical Engineering or in Chemical Engineering Practice, Chemical Engineer, or Doctor of Science in Chemical Engineering.

Because of the breadth of the field of Chemical Engineering the undergraduate Course must be devoted primarily to training in fundamentals, and strictly professional subjects are necessarily elementary in character. Postgraduate work is therefore of particular importance and value to the chemical engineer.

The program for the S.M. degree, particularly in Chemical Engineering Practice, is usually arranged as a continuation of the broad professional training on a more mature basis. Work for the Sc.D. degree is more specific in character and the Department offers coordinated programs in three fields: Engineering Operations of Chemical Engineering, Applied Chemistry, and Fuel Engineering. Special programs are developed for individual cases.

X. Chemical Engineering Continued

SCHOOL OF CHEMICAL ENGINEERING PRACTICE

Integrated programs which include Engineering Practice are offered for the degrees of Master of Science, Chemical Engineer, and Doctor of Science. The Course leading to the degree of Master of Science in Chemical Engineering Practice (designated as X-A) requires completion of the three field stations described below.

In the School of Chemical Engineering Practice a selected group of graduate students who have completed at least four years of undergraduate study at the Institute or elsewhere spend five 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 cooperative effort under industrial conditions.

The quantitative aspects of Chemical Engineering are intensively studied in the Practice School. In addition to tests on industrial equipment, plant investigations are carried out by the students on some special phase of one of the unit operations, or on some problem of industrial chemistry which is particularly important at the station in question.

Finally, the School of Chemical Engineering Practice offers exceptional opportunity for graduate engineering research: first, by affording an opportunity for comparing laboratory data, formulae, and conclusions with observations on plant apparatus operating under practical working conditions; and second, by extending, from laboratory scale at the Institute to commercial scale in the various plants, the range of investigations possible.

The following program will be taken by men graduating in Chemical Engineering from the Institute. For twenty-two weeks, starting in July following graduation, students are at the field stations (10·81, 10·82, and 10·83), spending seven weeks at each station. They then return to the Institute for intensive work in Chemical Engineering Plant Design (10·53) during January. The program for the Master's degree is completed by graduate professional subjects and thesis at the Institute during the spring term.

A similar Practice School program starts early in February and extends to mid-summer.

The Engineering Practice School at Oak Ridge, described on page 94, is similar in educational philosophy and technique to the School of Chemical Engineering Practice. Although it does not lead to the Practice School degree, it operates on the same schedule and for chemical engineering students may be regarded as an alternative experience to that of the School of Chemical Engineering Practice.

For graduates in Chemical Engineering from other institutions the usual program of study for the Master's degree in Chemical Engineering Practice involves one or two terms at the Institute followed by the field station work in the Practice School and the Design Course (10·53). Graduates in chemistry from other institutions normally require an additional term. Students are usually not admitted to the Practice School until they have spent at least one term at the Institute.

FIELDS OF STUDY

Engineering Operations. Graduate subjects in the several important unit operations such as heat transmission, distillation, and absorption are offered, emphasizing the engineering phases of the students' professional training.

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 of the Practice School can be utilized for advanced investigations in fuel engineering practice.

Since the program in any of these fields will depend on undergraduate training and industrial experience, any one interested is requested to furnish information permitting individual consideration.

DEPARTMENTAL REQUIREMENTS FOR GRADUATE WORK

The requirements for graduate study are dependent on the degree to which the student wishes to specialize. The broadest training is required in Chemical Engineering and in Chemical Engineering Practice as it is assumed that the student is preparing himself for any phase of chemical engineering. Students who plan definitely to major in Applied Chemistry 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 general requirements are as set forth on page 95, with the following additions:

CHEMISTRY: the substantial equivalent of the undergraduate subjects in Course X.

ENGINEERING: (*a*) a one-year problem course in heat engineering or chemical engineering thermodynamics, and (*b*) preparation in applied mechanics or elements of electrical engineering.

CHEMICAL ENGINEERING: problem courses in industrial chemistry and in unit operations.

THE DEGREE, MASTER OF SCIENCE

The requirements for the degree of Master of Science are as specified on page 96.

THE DEGREE, CHEMICAL ENGINEER

For the degree of Chemical Engineer, see the general statement on Engineering Degrees on page 96.

THE DEGREE, DOCTOR OF SCIENCE

The degree of Doctor of Science in Chemical Engineering requires examinations for reading knowledge of scientific literature either in German and Russian or in German and French.

The student is expected to take graduate subjects, which may include the School of Chemical Engineering Practice or the Engineering Practice School at Oak Ridge, in preparation for the general examination, but no specific subjects are prescribed.

XI. SANITARY ENGINEERING

Graduate study and research are offered by the Department of Civil and Sanitary Engineering, as Course XI —

XI. Sanitary Engineering Continued

Sanitary Engineering, to satisfy the requirements for the degrees of Master of Science in Sanitary Engineering, Sanitary Engineer, or Doctor of Science in Sanitary Engineering.

Special Sanitary Engineering subjects are offered dealing with: water supply and treatment; sewerage, sewage and industrial waste treatment and disposal; sanitary chemistry and chemical examination of water, sewage and industrial wastes; sanitary biology, bacteriological examination of water and sewage, and other applications of sanitary bacteriology; environmental sanitation; and public health.

There are also available Civil Engineering subjects, such as advanced hydraulics, soil mechanics and foundations, structural theory and design, and others, of value to Sanitary Engineers, and a number of closely related subjects in other departments, that may be pursued to complete a particular plan of study.

Programs of study may be arranged to provide the fundamental training required for professional careers in the special fields of Sanitary Engineering, including: engineering design and construction of sanitary facilities, and consulting engineering practice; process or functional design for water, sewage, and industrial waste treatment, and stream sanitation; operation and management of waterworks, sewage treatment plants and other sanitary facilities and services; and environmental sanitation with private corporations or in public health agencies.

Sanitary Engineering Laboratories

The William Thompson Sedgwick Laboratories of Sanitary Science provide well equipped facilities for instruction and research in sanitary chemistry, sanitary biology, sanitary bacteriology, environmental sanitation in relation to health and comfort, and engineering problems relating to water, sewage and industrial waste treatment.

Departmental Requirements for Graduate Work

In general, graduates from approved courses in Civil Engineering will have the necessary undergraduate preparation to undertake graduate study in preparation for any of the special fields of Sanitary Engineering. Graduates in Chemical Engineering approved courses will be well prepared to take up Sanitary Engineering in the fields of operation and environmental sanitation, but if they desire to prepare for Sanitary Engineering design and construction, they should take the summer program of surveying at Camp Technology, preferably before starting their graduate programs, and should include additional studies in hydraulics and structural theory as part of their graduate programs. A graduate from any other course in engineering, or in chemical or biological science, will need additional undergraduate preparation depending upon his previous training and the program of study proposed or may qualify for study leading to a degree without specification.

The general requirements are those given on page 95, except that the requirement for Differential Equations M22 may be omitted.

In addition to the foregoing general requirements the applicant for a degree in Sanitary Engineering must present evidence of undergraduate training considered essential for all Sanitary Engineers, corresponding approximately to the following Institute subjects:

1·601	Fluid Mechanics
1·75	Water Supply and Purification
1·76	Sewerage and Sewage Treatment
2·04	Strength of Materials

In addition to the above, students with undergraduate training in Civil Engineering shall present evidence of preparation substantially equivalent to the following subjects as given at the Institute:

1·00, 1·01	Surveying
1·40	Structural Analysis
1·44	Elementary Structural Design
1·602	Fluid Mechanics

A student whose undergraduate training has been in some other field, such as Chemical Engineering, may substitute for the above subjects required for Civil Engineering, other subjects well adapted to the training of a Sanitary Engineer engaged in process work in such fields as the treatment of industrial wastes.

The Degree, Master of Science in Sanitary Engineering

In meeting the requirements for the degree of Master of Science in Sanitary Engineering, certain of the subjects listed above may be accepted, at the discretion of the Department, up to 24 units, in partial fulfillment of degree requirements.

In general, students with proper preparation may expect to complete the requirements for the degree of Master of Science in Sanitary Engineering in two terms.

The Degree, Sanitary Engineer

Programs of study leading to the degree of Sanitary Engineer provide opportunities for students to obtain training broader than that required for the Master's degree and better preparation for undertaking professional practice in Sanitary Engineering. The rigor of the program and the quality of academic performance required are substantially those demanded of students working toward the Master's degree or those preparing for the general examination for the Doctor's degree. It is expected that the normal period of study for this degree should be two full years after the Bachelor's degree has been obtained.

The Degree, Doctor of Science in Sanitary Engineering

Only students who have shown promise of outstanding performance in work of a creative nature are encouraged to study for the doctorate. Where the records of students entering on graduate work do not yield evidence of this ability, they are usually advised to qualify first for the Master's degree. The thesis research for the doctorate is expected to make a contribution to professional knowledge in the field of Sanitary Engineering.

The general requirements for the doctor's degree are as given on page 97.

Each applicant for the doctorate in Sanitary Engineering is required to demonstrate his ability to read scientific literature in English and in two other modern languages, with German and French usually specified.

XII. GEOLOGY AND GEOPHYSICS

The Department of Geology and Geophysics offers a wide choice of graduate study and research for specialization in the following fields: basic geology; crystallography; engineering geology; geochemistry; mineralogy; mineral industry; mineral deposits; mineral fuels; petrology, sedimentation, stratigraphy, and paleontology; structural geology; and geophysics. In the borderland between geology and geophysics and another science, the student may arrange a program of study and research under supervision of a special interdepartmental committee. Advanced work in the fields mentioned leads to one of the following degrees: Master of Science in Geology, or Doctor of Philosophy or Doctor of Science in the field of specialization.

XII. Geology and Geophysics Continued

The Department is equipped to offer the graduate student an unusual opportunity to pursue study and research in both theoretical and applied geology, X-ray crystallography, and geochemistry, and in geophysics. Modern laboratory facilities, research instruments, and extensive collections of specimens and materials are available to qualified graduate students. Field studies are included as an essential part of the graduate curriculum in both geology and geophysics, and special arrangements may be made for summer employment and field research with industrial organizations and governmental agencies.

Departmental Requirements for Graduate Work

The general admission requirements are those given on page 95, with the following exception: Mathematics, M22, may not be required as a prerequisite in Course XII-A, Geology.

In addition, the Department requires of students in geology preparation in geology essentially equivalent to the program of subjects leading to the degree of Bachelor of Science in Geology at the Massachusetts Institute of Technology and of students in geophysics preparation in geophysics essentially equivalent to the program of subjects leading to the degree of Bachelor of Science in Geophysics at the Massachusetts Institute of Technology. If the student is not fully prepared in certain of the required subjects, he usually will be asked to extend his preparation in these, along with his advanced work. The subjects to be taken for this purpose will be designated by the Committee on Graduate Students of the Department after the student's preparation and proposed program of study have been considered. The actual program of advanced subjects and research leading to a graduate degree is arranged by the Registration Officer and the student, with the advice of the professor who will direct the major part of the student's program.

The Degree, Master of Science

In addition to the general and departmental requirements stated in the preceding paragraphs, the candidate for the degree of Master of Science in Geology is required to pursue a program of advanced study and research in some area of geology approved by the Committee on Graduate Students of the Department. Possible fields of specialization are listed above.

The Doctorates

The general requirements for the degrees of Doctor of Philosophy or Doctor of Science are given on page 97. Departmental requirements for graduate work leading to these degrees are given in a preceding section. In addition, candidates for doctorates may be asked to meet certain other requirements in study or research. Possible fields of specialization are indicated in the introductory paragraph.

The preparation and research ability of any candidate for the doctorate must be such as to satisfy the Committee on Graduate Students of the Department that he is qualified to undertake advanced study and research. The thesis is expected to be a contribution to knowledge in the field of the candidate's specialization.

Soon after the student registers in the Department as a doctoral candidate, he will be given an informal examination, which may be partly oral and partly written, to survey his training and attainments and to serve as a basis for arranging his graduate program.

The program of graduate work may, with the approval of the Committee on Graduate Students of the Department, include subjects in other departments for which the student has adequate preparation. Also open to M. I. T. graduate students are certain advanced subjects in geology, mineralogy, and geophysics given at Harvard University.

Each candidate for the doctorate must demonstrate to the Department of Modern Languages that he can read scientific literature in his field of specialization in English, and in two of the following languages: French, German, Russian, or such other languages as are appropriate. Ordinarily this requirement should be satisfied by the time the general examination is taken, and before undertaking thesis research.

The Minor requirement is generally satisfied by taking n another department at least 24 units of approved study.

XIII. NAVAL ARCHITECTURE AND MARINE ENGINEERING

The Department of Naval Architecture and Marine Engineering offers courses leading to the following advanced degrees: Master of Science in Naval Architecture, Master of Science in Marine Engineering, Master of Science (without specification), Naval Architect, Marine Mechanical Engineer, Naval Engineer (restricted generally to commissioned officers of the United States Navy and United States Coast Guard) and Doctor of Science.

The Degrees, Master of Science in Naval Architecture and Naval Architect

The undergraduate preparation in mathematics, chemistry, physics and the humanities should be that given on page 95. Undergraduate preparation in professional subjects should in general be equal in quality and quantity to that contained in the Institute's undergraduate curriculum in Naval Architecture and Marine Engineering. Professional subjects prerequisite for graduate study in this field include the following or their equivalents:

2·01, 2·04, 2·081	Dynamics and Strength of Materials
2·251	Fluid Mechanics
2·40, 2·42	Heat Engineering
2·681	Engineering Laboratory
6·18	Electrical Engineering, Fundamentals
13·01, 13·02	Naval Architecture I, II
13·40	Naval Arch. & Marine Eng. I
13·41	Ship & Eng. Drawing
13·42T	Hull Form Design
13·43	Ship Structural Drawing
13·45	Ship Structures, Design
13·46	Ship Design
13·52T, 13·54	Marine Engineering and Dynamics

The candidate for the degree of Master of Science in Naval Architecture may pursue any program of study which is approved by his registration officer. To be accorded such approval, his program should include one or more subjects taken from the following group: 13·03, 13·031, 13·04, 13·05 and may include one or more subjects taken from the following group: 13·73, 13·74, 13·78, 13·79. The major part of the program of study including the thesis must be in the field of naval architecture, but this program may include advanced mathematics, physics, applied mechanics, structures, fluid mechanics and related subjects which have applications to hull design and construction but are taught in other departments of the Institute. A candidate for this degree who has a Bachelor of Science degree in Naval Architecture can normally complete this program in one year.

XIII. Naval Architecture and Marine Engineering Continued

The program of study of the candidate for the degree of Naval Architect must include a comprehensive design problem (at least 20 units of 13·031 and/or 13·032) and the following subjects: 1·40, 1·42, 13·03, 13·04, 13·73, 14·60, 15·501, and either M351 and M352 or M36 and M37. The thesis must be in the field of naval architecture. The program of study should also include one or more subjects from the following group: 13·05, 13·74, 13·78, 13·79. The balance of the program may consist of work in structures, applied mechanics, hydrodynamics, business or economics which have some application to the design and construction of ships or the business of shipbuilding or ship operation. A candidate for this degree who has a Bachelor of Science degree in Naval Architecture can normally complete this program in two years.

The Degrees, Master of Science in Marine Engineering and Marine Mechanical Engineer

The undergraduate preparation should, in general, be the equivalent of the Institute's course in Naval Architecture and Marine Engineering. Professional subjects prerequisite for graduate study in this field include the following or their equivalents:

2·01, 2·04	Dynamics and Strength of Materials
2·251	Fluid Mechanics
2·40, 2·42	Heat Engineering
2·681	Engineering Laboratory
2·851	Machine Tool Laboratory
6·18	Electrical Engineering,Fundamentals
13·01, 13·02	Naval Architecture I, II
13·52T, 13·54, 13·55	Marine Engineering
13·61, 13·62	Marine Engineering Design

A candidate for the degree of Master of Science in Marine Engineering may pursue any program approved by his registration officer. His program should ordinarily include one or more of the following subjects: 13·71, 13·711, 13·72, 13·721, 13·73, 13·74, 13·79. It may include one or more subjects of the following group: 13·03, 13·04, 13·05, 13·78. The major part of the program of study, including thesis, must be in the field of marine engineering, including subjects taught in other departments, such as mathematics, physics, applied mechanics, fluid mechanics, thermodynamics and related subjects having applications in marine engineering. A candidate who has a Bachelor of Science degree in Marine Engineering can normally complete this program in one year.

The program of study leading to the degree of Marine Mechanical Engineer should be more extensive than that stated above for the degree of Master of Science in Marine Engineering. It should include the following subjects or equivalents: 2·256, 2·43, 13·73, 14·60, 15·501, M36, M37. The balance of the program may consist of subjects having application in marine engineering or the marine industry offered in the Department of Naval Architecture and Marine Engineering or in other departments. A candidate for this degree who has a Bachelor of Science degree in Marine Engineering can normally complete this program in two years.

The Degree, Master of Science (Without Specification)

The undergraduate preparation should, in general, be the equivalent of the Institute's course in Naval Architecture and Marine Engineering. Professional subjects prerequisite for graduate study and research in this Department include the following or their equivalents:

2·01, 2·04	Dynamics and Strength of Materials
2·251	Fluid Mechanics
2·40, 2·42	Heat Engineering
2·681	Engineering Laboratory
13·01, 13·02	Naval Architecture I, II
13·52T	Marine Engineering

Work in the Graduate School should include some of the graduate subjects given in the Department but the major part of the program may consist of subjects given in other Departments which have applications in the fields of Naval Architecture, Marine Engineering or the business of shipbuilding.

The Degree, Naval Engineer

The course of study leading to this degree, designated Course XIII-A Naval Construction and Engineering, is restricted generally to commissioned officers of the United States Navy and United States Coast Guard. They must have completed the prescribed course of studies at the United States Naval Academy, United States Coast Guard Academy or their equivalent.

Course XIII-A includes four different curricula leading to specialization in four different fields of engineering involved in naval construction and engineering. The four curricula are fully prescribed, each requiring three years for completion. Approximately three-quarters of the term subjects are common to all of the curricula. The remaining quarter is in the specially designated field. Student officers are assigned to the field of specialization of their choice insofar as practicable and within limits to meet quotas established by the Navy Department and the United States Coast Guard.

The subjects which are common to all four curricula and which must be completed are given below:

2·046	Strength of Materials and Dynamics	6–8
2·081	Strength of Materials	3–6
2·402	Heat Engineering	6–7
3·391	Properties of Metals	3–3
3·392	Properties of Metals	3–3
8·03	Physics (Electromagnetism)	5–5
10·311	Heat Transfer	3–3
13·01	Naval Architecture I	4–5
13·02	Naval Architecture II	4–5
13·12	Warship General Arrangements	2–4
13·13	Warship Structure, Theory I	3–6
13·15	Warship Basic Design I	3–6
13·16	Warship Basic Design II	3–6
13·17	History of Warships	3–4
13·20	Elementary Ship Design	5–0
13·21	Warship Form Design	5–0
13·22	Warship General Design	5–0
13·26	Preliminary Design of Warships	9–0
13·75	Warship Propulsion I	5–6
13·76	Warship Propulsion II	6–4
14·113	Economics and Labor Relations, Prin.	4–8
M351	Adv. Calculus for Engineers	3–6
M352	Adv. Calculus for Engineers	3–6
M73	Review of Mathematics	20–0
	Thesis	20

In addition to the above subjects, the following subjects are required of students who do not take them or their equivalent in their field of specialization:

1·612	Fluid Mechanics	3–6
6·181	Electrical Engineering	4–6
6·191	Electrical Engineering	4–6
13·54	Marine Engineering Dynamics	2–4

The remainder of the program is devoted to subjects determined by the student's registration in one of the following specialized curricula:

XIII. Naval Architecture and Marine Engineering Continued

Hull Design and Construction
Marine Electrical Engineering
Electronics Engineering
Ship Propulsion Engineering

The Degree, Doctor of Science

Ordinarily a period of residence of three years is the minimum in which a student holding the degree of Bachelor of Science in Naval Architecture and Marine Engineering can expect to complete the requirements for the degree of Doctor of Science in this Department. A student having a baccalaureate in some other field will probably require a longer period of residence. The program of study for the major requirement should be similar to those for the degrees of Naval Architect and Marine Mechanical Engineer but involve additional theoretical work in one of the following fields: structural design, engineering mechanics, thermodynamics, or fluid dynamics. The minor should be in some non-engineering field.

XIV. ECONOMICS AND SOCIAL SCIENCE

The Department of Economics and Social Science offers work leading to the degrees of Doctor of Philosophy in Industrial Economics, Master of Science in Economics and Engineering or Master of Science in Economics and Science.

The Degree, Master of Science in Economics and Engineering (or Economics and Science)

The undergraduate preparation for this degree should include the substantial equivalent of the Economics subjects required for the Institute's bachelor degree in this field. The other admission requirements are those set forth on page 95, with the following exceptions:

Mathematics. M22 Differential Equations is not a prerequisite.

Physics. A complete college course in Physics of at least one year is required.

Science and Engineering Subjects. A substantial number of science or engineering units is required, comparable to the number required in the undergraduate Course in Economics and Engineering. These units need not necessarily be in Mechanical, Electrical, or Chemical Engineering, as in the undergraduate Course XIV, but may include work in such fields as physics, chemistry, geology, etc.

Deficiencies in prerequisites for admission or for the receipt of the Master's degree may be taken along with graduate work.

Graduates of Courses XIV-A, XIV-B, or XIV-C or of a similar undergraduate course of study elsewhere may ordinarily expect to complete the requirements for the Master's degree in one year. Graduates of other Institute Courses, or of their equivalent elsewhere, will undertake a two-year program. The first year of study is devoted to the satisfying of Economics prerequisites. The second year is given wholly to graduate work, in accordance with the general requirements for the Master's degree.

The Doctorate in Industrial Economics

In place of the general requirements for admission set forth on page 95, the following requirements have been established as prerequisites for graduate study leading to the degree of Doctor of Philosophy in Industrial Economics.

Mathematics. One full year of college mathematics, including at least one term of calculus.

Physics. One full year of college work in physics.

Cultural Subjects. At least six semester courses in English, history, economics (or allied subjects) and other cultural subjects equivalent in scope to those included in the undergraduate curricula of the Institute.

Professional Subjects. Three full-year subjects in social science chosen from the following: economics, psychology, sociology, and history. One of these subjects must have been economics; and history subjects to be acceptable must have stressed economic and technological developments.

Deficiencies in mathematics and physics may be removed by enrollment in special one-semester subjects offered by the Institute, Calculus M10 and Physics 8·001. A student whose deficiencies are of minor extent will be permitted graduate registration while taking the appropriate subjects at the Institute to remove them.

In studying for the Ph.D. in Industrial Economics, the candidate must prepare himself for a general examination covering five fields. Unless Statistics and Economic History are among these fields, he must, in addition, demonstrate an elementary knowledge in Statistics and have taken one graduate subject in Economic History. Possible fields include Economic Theory, Labor Economics and Labor Relations, Industrial Organization and Price Policy, the Economics of Innovation, Human Relations in Industry, Methods in Human Relations, Statistical Method and Theory, Fiscal Policy and Economic Fluctuations, International Economics and Relations, Economic and Industrial History, and others. Two or three of the candidate's five fields, designated as *primary*, require more intensive preparation than the other two or three, which are designated as *secondary*.

There are no formal requirements for a stated number of graduate subjects in the Economics Department; but ordinarily the candidate will need two full academic years of course work to prepare himself adequately for his general examinations and to meet the other pre-thesis requirements for the doctorate.

Following the Institute rules, the candidate for the Ph.D. degree will be required to take a Minor in a field other than economics. Possibilities include: Business Administration, Mathematics, Biology, or any of the other scientific or engineering fields.

The candidate will be required to demonstrate his ability to read professional literature in two modern foreign languages. Ordinarily these languages will be German and French, but substitutions may be permitted in appropriate cases.

XV. INDUSTRIAL MANAGEMENT

The course leading to the degree of Master of Science in Industrial Management is designed to prepare the science or engineering graduate for ultimate executive responsibilities. Its objective is the adequate development of men whose intelligence, motivation, and character promise executive ability and whose training and experience combine the fundamentals of science and engineering with an understanding and appreciation of the social, political, and economic implications of industry and a familiarity with managerial policies, programs, problems, fundamentals, and philosophies. Its aim is not that of training functional specialists. Instead, the course stresses the professional aspects of administration and seeks to develop an ability in planning, organizing, directing, and controlling, and the qualities requisite to effective working with others, of communicating, and of leading.

XV. Industrial Management Continued

The curriculum is closely correlated with the graduate subjects in the Department of Economics and Social Science. The resources of all departments of the Institute may be drawn upon. Every effort is made to provide opportunity for mature and realistic study at the advanced level through a variety of educational means including executive conferences, group field work, individual field investigation, and special seminars as well as regular classes. Research activities undertaken in fields of active interest are available to graduate students in Industrial Management. Men active in management participate as members of the faculty and as visiting lecturers. Students go to industry where they study the problems of day-to-day industrial management and observe and consult with industrial leaders. Thus, every effort is made to give the student a sense of the realities of industrial management so that when he has completed his basic theoretical preparation he will have a more mature comprehension of the practical necessities which that theory is designed to serve.

Graduate work in Industrial Management ordinarily requires two years of study at M. I. T. Students who have combined substantially one year of study of fundamental business subjects with their science or engineering programs may secure the Master's degree in one year. The first year of the two-year program is used to give the students a fundamental understanding of the problems and contribution of important functional divisions of the typical industrial enterprise and its orientation in the broader industrial structure. It includes study in the areas of economics, accounting, finance, statistics, marketing, industrial relations, psychology, production, and administration. The second year is given wholly to advanced work, in accordance with the general requirements for the Master's degree. Each program is worked out individually in consultation with members of the staff, in order to maintain flexibility and to permit each student to make the most of his individual skills and interests.

Sloan Fellowships

In addition to the regular graduate program outlined above, the School of Industrial Management, under grant from the Alfred P. Sloan Foundation, offers a special Executive Development program for men on leave from present business employment. These men typically have engineering and science backgrounds, with ten to fifteen years of business experience, and are nominated by the top managements of their companies. They are selected for this twelve months' program through a nationwide competition. A part of this program is taken in conjunction with the regular graduate program, and it may lead to the degree of Master of Science in Industrial Management. Specific inquiries concerning this program should be addressed to the Director, Sloan Fellowship Program for Executive Development, School of Industrial Management, M. I. T.

Requirements for Graduate Work

The general admission requirements are those set forth on page 95, with the following additions and exceptions:

Science or Engineering. Applicants for graduate study in the School of Industrial Management must have a college degree in some recognized field of science or engineering. This program must have included regular college courses in Physics, Chemistry, and Calculus of not less than one year each.

XVI. AERONAUTICAL ENGINEERING

Advanced study in this Department leads to the degrees of Master of Science in Aeronautical Engineering, Aeronautical Engineer, or Doctor of Science in Aeronautical Engineering.

Emphasis is laid on individual study and research. Each student must follow a consistent program of work directed toward some particular part of the aeronautical field, such as aerodynamics, design, instrumentation, structures or power plants. Since most phases of the graduate work in Aeronautical Engineering rest heavily upon mathematics and mechanics, aptitude in these subjects is required.

Students may also elect subjects given in other departments, but bearing a useful relation to their program of aeronautical studies. The selection of such subjects must be approved by the registration officer.

The facilities for research in aeronautical engineering are listed below. All are available for student theses provided obligations for departmental and sponsored research projects permit the use of these facilities.

Wind Tunnels: Naval Supersonic Tunnel, 10,000 horse power, rectangular throat 18 by 24 inches, operating pressures ¼ to 4 atmospheres, velocities up to four times sonic speed; Wright Brothers Tunnel, 2,000 horse power, elliptical throat 7½ by 10 feet, operating pressures ¼ to 4 atmospheres, velocities up to 350 miles per hour; Flutter Tunnel, rectangular throat 5 by 7½ feet, atmospheric, velocity 130 miles per hour, fitted with special oscillograph equipment for the study of oscillating models; Student Tunnel, rectangular throat 4½ by 6 feet, atmospheric, fitted with six component balance, velocity 120 miles per hour; Turbine Component Tunnel, 1,500 horse power, rectangular throat 8 by 8 inches, velocities up to three times sonic speed, provided with pressure and humidity controls, schlieren and interferometer apparatus for mapping flow fields.

Aeroelastic Laboratory: Model construction and test equipment for study of the interrelation between aerodynamic and elastic forces. Experimental work is performed largely on models constructed to be dynamically, elastically and aerodynamically similar to full-sized structures. Extensive instrumentation permits analysis of the response of such structures to excitation in still air or in a wind stream.

Structures Laboratory: Equipment 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 for studies of strain distribution under static loadings on structures of types commonly employed in aircraft. By using equipment from the Aeroelastic and Instrumentation Laboratories, the behavior of helicopter blades and other structures can be investigated under dynamic loadings.

Instrumentation Laboratories: Equipment for the study of the performance of measuring and control systems. One of these laboratories provides instruction in the fundamentals of such systems. It has special equipment for studying aircraft instruments, including an electronic simulator, harmonic synthesizer, and apparatus by which flight conditions can be reproduced. A second laboratory is equipped for the measurement of vibratory displacement, acceleration and strain. It is provided with calibration apparatus and vibration-testing machines. A third laboratory is devoted to fire control apparatus and systems.

Gas Turbine Laboratory: 8 by 8 inch turbine component tunnel, as well as equipment for the study of phenomena of fluid mechanics involved in turbines, compressors and combustion chambers, boundary layer flow and mixing of jets.

Sloan Automotive Laboratory: Equipment for research of

XVI. Aeronautical Engineering Continued

all kinds on reciprocating engines and their components, as well as equipment for investigating combustion, for measuring rapidly fluctuating pressures, air flow, and temperature, for taking high-speed photographs, etc.

Departmental Requirements for Graduate Work

The general requirements for admission and degrees are those set forth on pages 95 through 97 with the following additions:

Professional Subjects. Applicants for a degree with specification in Aeronautical Engineering must have preparation substantially equivalent to the following Institute subjects:

2·40	Heat Engineering
6·18	Electrical Engineering, Fund.
16·02T	Aerodynamics
16·10	Aerodynamics, Applied
16·21	Structures

For advanced work in various fields professional preparation is required as follows for 1952–53 only:

For *Aerodynamics:* 16·13, 16·62, 16·72
For *Aeronautical Design:* 16·13, 16·14, 16·22, 16·62, 16·72
For *Aeronautical Structures:* 16·13, 16·22, 16·72
For *Instrumentation and Control:* 6·19, 16·13
For *Aeronautical Power Plants:* 2·48, or 2·792 and 2·7942; 16·53

If applicants have not had the specified undergraduate preparation before entrance, they may remove deficiencies while engaged in graduate work, provided that advanced work may not be undertaken until prerequisites therefor have been satisfied.

The Degree, Master of Science

For the degree of Master of Science in Aeronautical Engineering at least one year of an approved program is required, including thesis. Two terms of advanced mathematics (beyond M22) must be included.

The five-year program in Aeronautical Engineering, leading to the degrees of Bachelor of Science and Master of Science simultaneously, is described under the Course XVI undergraduate schedules.

The Degree, Aeronautical Engineer

For the degree of Aeronautical Engineer the student must complete at least two years of an approved program, including thesis, planned to provide a broad foundation in both aeronautical science and its engineering applications.

The Degree, Doctor of Science

For the degree of Doctor of Science the student is required to complete an approved program, including thesis, more extensive than that for the degree of Aeronautical Engineer. The general examination includes both written and oral parts. The Doctor's thesis must demonstrate the ability of the student to do original research of high grade on a problem of aeronautical science or engineering.

XVII. BUILDING ENGINEERING AND CONSTRUCTION

The Department of Building Engineering and Construction offers opportunities for advanced study and research in the fields of Structural Design, Materials and Building Management leading to the degree of Master of Science in Building Engineering and Construction or to the engineering degree of Building Engineer.

Graduate work is divided into the following major fields of study:

Structural Design:
Reinforced Concrete and Structural Steel
Materials of Construction:
Plastics, Engineering Laminates, Masonry Materials
Management:
Job Management — Building Maintenance

The Department encourages graduate work which combines two or all of the above fields. Students will be expected to include in their programs approved graduate subjects such as mathematics, theory of elasticity, theory of structures, photoelasticity, structural laboratory, chemistry, physics, and business administration.

Departmental Requirements for Graduate Work

In addition to the general requirements for all graduate students, as set forth on page 95, a candidate must present evidence of training in professional courses which are equivalent to those included in the undergraduate courses in Building Engineering and Construction and which correspond approximately to the following Institute subjects:

1·00, 1·04	Surveying
1·40, (1·41) (1·42)	Structural Analysis
2·04	Strength of Materials
2·371	Testing Materials Laboratory
17·21, 17·22, 17·31T	Building Construction
17·40T	Job Management
17·52T	Steel Design
(17·53T), (17·54T)	Wood and Concrete Design
17·71T, 17·72, 17·73	Materials

If the student has not completed, before entering upon his graduate work in this Department, all of the subjects in the above list, or any others listed as prerequisites for graduate courses in this Department, deficiencies may be made up during his attendance at the Institute; the subjects, shown in parentheses in the above list, up to a total of 24 units, will count for credit toward either degree, if not already accepted for credit toward the Bachelor's degree.

To meet the requirements for the engineering degree of Building Engineer a candidate must include, in addition to the general requirements given above, a program of graduate studies which will provide an extended basis for professional competence in structural design, materials and management.

XVIII. MATHEMATICS

This Department offers courses leading to the degrees of Master of Science, Doctor of Philosophy, or Doctor of Science in Mathematics.

A wide range of graduate subjects in various branches of mathematics is offered. Graduate seminars are conducted regularly by members of the staff, and colloquia and lecture series on topics of current mathematical interest are held at frequent intervals throughout the academic year. Candidates for the doctorate are encouraged to obtain a broad general knowledge of mathematics together with sufficient depth in a field of specialization to enable them to pursue research effectively. The seminars, colloquia, general lectures and informal conferences with members of the staff, along with formal graduate subjects, offer excellent means of achieving these ends.

Candidates for advanced degrees who work in the field of pure mathematics, aside from the minor program, will ordinarily take most of their courses in the mathematics department. In addition to their advanced specialization, they will be encouraged to acquire breadth by taking basic courses in analysis, algebra, geometry and topology.

XVIII. Mathematics Continued

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 problems in applied mathematics being investigated by members of the staff may constitute part of graduate programs.

Departmental Requirements for Graduate Work

General requirements are those set forth on page 95, with the following additions:

Professional Subjects. Candidates are expected to have completed, before admission, the equivalents of the following subjects:

M441	Projective Geometry
or	
M442	Differential Geometry, Elem.
M62	Modern Algebra
M831, M832	Analysis

If a candidate is admitted with any of these prerequisites lacking, he may be required to include them in his program without credit toward the degree.

The Degree, Master of Science

For the Master's degree, in addition to the subjects listed above, M381 and M382 (Theory of Functions) are required. At least two additional 12-unit mathematics subjects offered by the Department must be included. The remaining part of the program should consist of thesis (usually not over 24 units) and approved electives in mathematics or other fields.

The Doctorate

Graduate students in Mathematics at the Institute will normally first register as candidates for the Master's degree. However, a student who demonstrates the necessary professional promise, by his performance in graduate subjects and by passing a written qualifying examination, may, upon recommendation by the Departmental Graduate Committee, become a candidate for the doctorate either with or without first fulfilling all of the requirements for the Master's degree.

The requirements for the degree of Doctor of Philosophy or Doctor of Science are those set forth on page 97.

XIX. METEOROLOGY

The purpose of this course is to prepare students for practical work and for research in the field of meteorology. Instruction is offered leading to the degrees of Master of Science in Meteorology, Meteorologist, or Doctor of Science in Meteorology. Emphasis is placed on the application of physical principles and mathematical techniques to atmospheric processes as well as on observational, empirical, and statistical methods. Students may be admitted for graduate study without previous training or experience in the field of meteorology provided that they satisfy the general requirements and have a good background in the physical sciences. Students with no previous training in meteorology in general will have to spend four semesters in residence to qualify for the Master's degree.

Weather data are collected by means of teletypes so that all students may have access to the latest weather reports from North America and the neighboring oceans. This extensive coverage of current information together with a file of past data provides an excellent opportunity for research on problems of weather forecasting. 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. The application of statistical methods to meteorology is undertaken in cooperation with the staff of the Department of Mathematics. Staff and facilities are available for the study of advanced dynamics of atmospheric motion.

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 at regular intervals 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 cooperation 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 Air Force.

Departmental Requirements for Graduate Work

The general requirements for admission to graduate work in Meteorology are those set forth on page 95.

Candidates for advanced degrees in Meteorology must present evidence that they have had the equivalent of the following undergraduate professional subjects:

19·01, 19·02	Descriptive Meteorology
19·60	Thermodynamics of the Atmosphere

Deficiencies in the above subjects may be removed while pursuing a program of graduate study.

The Degree, Master of Science

For the degree of Master of Science in Meteorology, "A" subjects may be chosen from those offered in synoptic laboratory, synoptic meteorology, dynamic meteorology, long-range weather forecasting, physical meteorology, and instrumentation. All candidates will be expected to take the meteorological seminar. There are no foreign language requirements for the Master's degree.

The Degree, Meteorologist

The general requirements for the degree of Meteorologist are as set forth on page 96.

The Doctorate

Students are accepted as candidates for the degree of Doctor of Science provided that they can satisfy the Department Committee on Graduate Students that they are qualified to undertake an extensive course of advanced study and to complete a thesis of high caliber.

Candidates for the Doctorate in Meteorology shall be required to demonstrate their ability to read scientific literature in English and in two other modern languages, at least one of which shall be German or Russian. Wide latitude is permitted in the choice of the second modern language, but the following are considered to be particularly suitable: German or Russian (if not chosen as the first language), French, Norwegian, Spanish, and Portuguese.

XX. FOOD TECHNOLOGY

The Department of Food Technology offers advanced courses leading to the degrees of Master of Science or Doctor of Philosophy or Doctor of Science in Food Technology.

Graduate work in food technology for the doctorate offers opportunity for advanced study and experimental work in the chemical, biological, engineering, or economic aspects of food production, and development or control of new processes relating to product improvement or conservation of nutritive quality. Such work may be combined with subjects in chemical engineering, chemistry, mechanical engineering, physics, business administration, or others.

The 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 cooperation 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.

Departmental Requirements for Graduate Work

The general requirements for admission are those set forth on page 95.

Applicants for admission to graduate work in food technology are required to meet as prerequisites the general equivalent of the undergraduate program in food technology. Graduates from accredited institutions presenting evidence of scholarship of high order in contiguous professional fields may be permitted equivalent substitutions for such prerequisites, or the privilege of advanced standing examinations in the case of deficiencies.

The Degree, Master of Science

The requirements for the degree of Master of Science in Food Technology are as set forth on page 96. A five-year course leading to the degrees of Bachelor of Science and Master of Science in Food Technology is outlined under the Undergraduate Course Schedules. This course, 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.

The Doctorates

For students working toward the degree of Doctor of Science or Doctor of Philosophy in Food Technology, graduate subjects should be taken in preparation for the general examinations, but no specific subjects are prescribed. The choice of subjects is determined by the preparation and field of interest of the individual in consultation with his graduate registration officer.

Requirements for the doctorate include the satisfactory completion of oral and written examinations prescribed by the Department which demonstrate the competence and thorough understanding of the basic scientific phases of food technology and their application in certain specified fields.

DESCRIPTION OF SUBJECTS

The list below is subject to change. The prerequisites, units of exercise and preparation, and instructors in charge of each subject will be found under "Subjects of Instruction Tabulated."

CIVIL AND SANITARY ENGINEERING

SUBJECTS 1·00 TO 1·99

1·00. SURVEYING. 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. ADVANCED SURVEYING FIELDWORK. At Camp Technology. Continuation of 1·00. 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 latitude, 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*.

1·06. PHOTOGRAMMETRY. 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.

1·071. GEODETIC SURVEYING. 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 coordinates; correction to altitudes; use of Greenwich Hour Angle for time data; latitude sights; line of position sights; navigator's day's work at sea.

1·141, 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.

1·20. ROUTE SURVEYING FIELDWORK. At Camp Technology. Location survey for a railway or highway project; laying out curves, setting grade and slope stakes for earthwork and staking out masonry structures. A limited amount of class work and drafting to supplement the fieldwork.

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 for construction projects, lines and grades, and quantity surveys of earthwork and masonry for civil engineering construction.

1·24. TRANSPORTATION PLANNING. Planning, layout, design and construction of highways and streets; highway traffic surveys and traffic control; public transportation and railroad problems in regional and city planning; and a consideration of airport location, design and operation.

1·271, 1·272. TRANSPORTATION ENGINEERING. Transportation by railway, highway, and air with some attention to inland waterways and pipe lines. 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, finance, regulation and taxation. Railway 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. Coordination of the different forms of inland transport. Design problems in highway, railway and airport location.

1·28. HIGHWAYS AND AIRPORTS. Principles and practice in the location, design, construction and maintenance of highways, streets and airports.

1·30. ADVANCED RAILWAY TRANSPORTATION (A). A continuation of 1·271 and 1·272. Design and operation of locomotive, freight and passenger terminals; railway organization and economics; public relations and regulation; individual investigations and reports.

1·311, 1·312. ADVANCED HIGHWAY TRANSPORTATION (A). Advanced study of methods of design, construction, maintenance, operation and economics of highways with particular reference to current developments and research results.

1·321. AIRPORT PLANNING AND ADMINISTRATION (A). Study of air traffic potentials, development of future aircraft, air traffic control and landing systems, airport management, airport finance, airport revenue potentials, establishment of airport user charges, airport ground operations, terminal functions, passenger and cargo circulation, utilities, apron activities, cargo handling, highway traffic potentials, highway circulation, parking facilities, and airport maintenance.

1·322. AIRPORT DESIGN (A). Development of a layout for an airport on a given site including the location of runways and taxiways, zoning of runway approaches, design of airport paving, drainage, lighting systems, and site planning for terminal area buildings, access roads and parking lots.

1·35. SOIL MECHANICS AND FOUNDATION ENGINEERING. Physical and mechanical properties affecting soil action in engineering problems; coefficients of permeability, capillarity and compressibility and their application in practical problems relative to seepage, uplift, liquefaction and the settlement of

Civil and Sanitary Engineering Continued

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; pressure distribution on retaining walls and footings; and case studies of foundation problems. Reading assignments on soil sampling, excavation, cofferdams, caissons, types of piles and types of foundations. Laboratory work covering the important soil tests.

1·351. Soil Mechanics and Foundation Engineering. Same material in general as covered in 1·35 but considerably abbreviated.

1·354. Soil Engineering. Theoretical and practical aspects of various soil engineering subjects. Possible subjects, determined in part by special interests of class members: subsurface exploration, stability of earth embankments, seepage and drainage investigations, frost action, soil stabilization, bearing capacity, considerations of footings, piles and other foundation types. Terzaghi and Peck, *Soil Mechanics in Engineering Practice.*

1·361. Soil Mechanics (A). Physical and mechanical properties of soil governing its behavior as an engineering material. Basic soil classifications; laws of permeability, capillarity and seepage; compressibility and consolidation theory 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.

1·362. Soil Mechanics (A). Stability of slopes and retaining walls; analyses of earthdams and masonry on earth, with reference to stability, seepage, and piping effect; bearing capacity and settlement of foundations; piles and pile groups; frost action; and consideration of special soil engineering problems.

1·37. Soil Mechanics Laboratory (A). Technique of soil testing, starting with tests for measurement of specific gravity, water content, limits of consistency, grain size and permeability; followed by the more important soil tests for consolidation, compaction and shearing strength; consideration also given to special tests including those for chemical properties and mineral content.

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. Structural Analysis. Introductory theory of stress analysis for civil engineering structures, such as buildings and bridges. Loadings, reactions, shears, bending moments, analysis of simple trusses, graphic methods, influence lines for stress in girders and trusses with applications to computation of maximum stresses caused by systems of live loads, and introduction to the use of the moment distribution procedure.

1·401. Structural Analysis. Same as 1·40 with addition of drafting exercises to discuss methods for computing deflections of structures. (Primarily for selected officers of the U. S. Navy and Coast Guard.)

1·41. Structural Analysis. Continuation of 1·40. Stress analysis for statically determinate trusses of various forms including three hinged arches, cantilevers and space frames; statically indeterminate structures of certain types such as building frames, trusses with multiple web systems and portal frames by approximate methods. Cables and elementary suspension systems are considered and also gravity type dams and retaining walls. Determination of deflections of trusses and beams by methods of Virtual Work, Moment Area and Williot-Mohr.

1·42. Structural Analysis. Continuation of 1·41. Elementary treatment of analysis of statically indeterminate structures by Superposition Equations, Castigliano's Theorem, Slope-Deflection Method, and Moment Distribution. Continuous structures, rigid frames, and arches among those considered.

1·44. Elementary Structural Design. Introduction to design of structural elements in steel, reinforced concrete, and wood. Study of steel elements including beams, riveted and welded connections, riveted and welded girders, and members in direct tension and compression. Development of principles of reinforced concrete with application to the design of beams, columns, and slabs. Discussion of wood beams, columns, and connectors. One or more comprehensive problems involving all three structural materials.

1·441T. Structural Design. Application of the principles of structural design presented in 1·44 to the design of a riveted plate girder railway bridge, a welded girder bridge and a steel truss highway bridge. Development of careful systematic and practical habits of computation encouraged.

1·442T. Reinforced Concrete Design. Extension of the elementary concepts introduced in 1·44 and their application to the design of specific reinforced concrete structures such as retaining wall, footing, beam bridge, one-way slab, two-way slab, flat slab, arch or rigid frame. Introduction to elementary concepts of plastic theory and prestressed concrete.

1·521. Structural Laboratory (A). Lectures, conferences, assigned reading and laboratory work, covering the theory and practice of structural analysis by the use of models. Fundamentals of the entire field.

1·522. Structural Laboratory (A). Continuation of 1·521 with work in fields of special interest to individual students. Time arranged to suit these individual requirements

1·541. Advanced Reinforced Concrete Design (A). Advanced treatment of the theory underlying the design of reinforced concrete structures in general, starting with a brief review of elementary theory, and proceeding to consideration of deflections, torsion, shrinkage, plastic flow, ultimate strength theories, and pre-stressed structures.

1·542. Advanced Reinforced Concrete Design (A). Continuation of 1·541, with application of theory to the design of civil engineering structures such as precast decking, slabs, rigid frames, arches, tanks, hipped-plate roofs, etc.

1·551. Advanced Structural Design (A). Important problems of a general nature encountered by structural designers, such as choice of type, general proportions, economics, methods of preliminary design, organization of design procedure, influence of erection methods, etc., with special reference to statically indeterminate structures.

1·552. Advanced Structural Design (A). Continuation of 1·551, with applications to structures of complicated types such as suspension bridges, arch dams, building frames, etc. Theory to supplement design procedures given as required. The exact content adaptable to the interests of the class.

1·561, 1·562. Advanced Structural Mechanics (A). Introduction to problems in advanced mechanics with applications to structural analysis. Among the subjects considered are Theory of Elasticity, Theory of Elastic Stability, Thin Plates and Shells, and Vibrations of Structures.

1·571, 1·572. Statically Indeterminate Structures (A). Rigorous treatment of the analysis of Statically Indeterminate Structures, starting with a brief review of elementary theory and proceeding to the analysis of internally indeterminate trusses, continuous trusses, arches, building frames, etc. Effect of variable stiffness and the subject of secondary stresses included. Methods of Virtual Work, Castigliano, Slope Deflection and Moment Distribution considered.

1·58. Elastic Stability of Flat Plates (A). Discussion of question of stability of a flat plate subjected to loading in its own plane and having various conditions of support at the edges. (Primarily for students in Course XIII-A.)

1·601. Fluid Mechanics. Elementary mechanics of incompressible and compressible fluids. Properties of fluids. Fluids at rest, geometry of fluid motion, general equations of motion. Dynamic similarity for inertia, gravity and viscous forces, laminar and turbulent flow, skin friction, lift and form-drag. Basic principles applied to steady flow through orifices, nozzles and other flow meters. Fluid flow in pipes and open channels. Flow through pipe systems.

Civil and Sanitary Engineering Continued

1·602. Fluid Mechanics. Continuation of 1·601. Dynamic similarity for elastic and surface tension forces, dynamics of immersed bodies, circulation and lift, cavitation, theory and operation of hydraulic machinery. Non-uniform flow in open channels, hydraulic jump and backwater curves. Unsteady flow in open and closed conduits, water-hammer problems.

1·611. Fluid Mechanics. Abbreviated course covering hydraulic problems in statics, kinematics and dynamics. The energy equation, basic concepts of fluid friction, flow through pipes and fluid metering devices, theory and operation of hydraulic machinery.

1·612. Fluid Mechanics. Introduction to theoretical fluid mechanics with emphasis on problems in naval architecture; properties of fluids, equations of motion, dynamic similarity, laminar and turbulent flow, skin friction, flow resistance in conduits, forces on floating and submerged bodies, cavitation and propulsion.

1·613. Fluid Mechanics. Elementary course for electrical engineers. Properties of fluids, general equations of motion, potential flow, dynamic similarity, laminar and turbulent flow, skin-friction, lift and form-drag, cavitation. Basic principles applied to practical flow problems in conduits, fluid meters and hydraulic machinery.

1·621. Fluid Mechanics Lab. Experiments concerned with basic flow phenomena including surface resistance, lift and drag forces, turbulent diffusion, waves and surges, as well as with engineering applications such as pressure conduits, open channel flow, fluid meters, pumps, and turbines.

1·63. Applied Hydromechanics (A). General equations of motion, potential flow, conformal mapping applied to hydraulic structures, laminar and turbulent motion in conduits, boundary layer phenomena, surface and form resistance, theories of turbulence, turbulent mixing and transfer of matter in fluid streams.

1·64. Hydraulic Machinery (A). Treatment of various turbomachinery types of hydraulic machines, including centrifugal and axial flow pumps, blowers and fans, and impulse, reaction, and propeller turbines. Basic theory of turbomachinery and its application, performance analyses of the several types, design criteria, and design procedures, field requirements and selection of machinery.

1·65. Free Surface Flow (A). Steady and unsteady flow in open channels and reservoirs, backwater curves in natural and artificial channels, hydraulic jump, surges and waves, standing waves in supercritical flow, transportation of sediments.

1·66. Design of Hydraulic Structures (A). Preparation of integrated designs of selected hydraulic structures, such as penstocks, siphons, tunnels, spillways, stilling pools, movable weirs and gates, shore protection works, canals, locks, and river improvements.

1·67. Seminar in Hydromechanics (A). Study of recent advances in all fields of Hydromechanics. Application of developments in related branches of fluid mechanics to hydraulics. Lectures and reports.

1·681. Experimental Hydromechanics (A). Theory of similitude, dimensional analysis, practical methods of establishing dynamic similarity, models of streams with sediment load, model studies of typical hydraulic structures.

1·682. Experimental Hydromechanics (A). Experimental techniques and laboratory practice, experimental studies of fundamental phenomena such as: turbulence, boundary-layers, surface and form resistance, cavitation, wave motion, bed-load movement, density currents. Use of models in hydraulic design exemplified by studies on: spillways, bridge piers, river channels, harbor-basins, hydraulic machinery.

1·683. Experimental Hydromechanics (A). Abridgment of 1·682 with emphasis on experimental problems related to Naval Architecture.

1·69. Rivers and Harbors (A). Hydraulics of river flow, improvements with respect to flood control and navigation, studies of tides and tidal currents, wave action, beach erosion, methods of shore protection, layout of channels and harbor basins.

1·70. Hydrology and Flood Control. 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. Abridgment of 1·70 including the theory, but omitting the practical application in the drafting room. Barrows, *Water Power Engineering*.

1·71. Water Power Engineering. 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. An abridgment 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. 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). Amplification of 1·71 with particular emphasis on details of turbine selection and powerhouse design. Includes a study of gates and gatehouses, accessories at dams, speed and pressure regulation of turbines, transmission lines and a thorough study of the economics of hydroelectric plants. Supplemented by 1·741, 1·742.

1·741, 1·742. Advanced Water Power Design (A). Design of various portions of a water power project at a site where actual data are available from surveys and reports.

1·75. Water Supply and Purification. Principles of water supply engineering including rainfall and runoff, water consumption, surface and ground water supplies, dams and impounding reservoirs, supply and distribution works, principles of water treatment and design; investigations, computations, and an engineering report on the preliminary design of a gravity water supply for a small community; also group inspections of nearby water works construction and water treatment works operation.

1·76. Sewerage and Sewage Treatment. Principles of design of sanitary and storm water sewers, methods of estimating sewage quantities and storm water runoff, procedures for the design and construction of sewerage systems, principles of sewage and industrial waste treatment and design and construction of sewage treatment works. Design of sanitary sewers for new areas, relief sewers and an intercepting sewer for a small community followed by the design of storm water sewers for a small area; also group inspections of nearby sewage works.

1·77. Water Supply and Sewerage. Water consumption, water sources and their development, including wells, dams, reservoirs, supply and distribution mains; procedures for estimating sewage quantities, principles of sewerage design and construction; principles of water and sewage treatment and the design and construction of water and sewage treatment works.

1·771. 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.

1·79. Sanitary Engineering Design. Elements of engineering investigation and report covering the design of a water supply system for a small city, including pumping station, long force main, elevated storage and distribution

Civil and Sanitary Engineering Continued

network; and the design of an outfall sewer, sewage pumping station and treatment works for a small community.

1·811. Advanced Sanitary Engineering (A). Principles of modern water treatment and engineering practices, including coagulation, sedimentation, filtration, sterilization, softening, corrosion control, and removal of tastes and odors. Also group inspection of nearby water treatment works.

1·812. Advanced Sanitary Engineering (A). Principles of modern sewage treatment and engineering practices, including screening, grit removal, sedimentation, removal of colloids and stabilization by contact surfaces and by aeration with activated sludge, chlorination of sewage, digestion, treatment and disposal of sludge, and collection and utilization of gas. Also group inspection of nearby sewage treatment works.

1·821. Sanitary Engineering Laboratory (A). Lectures and laboratory studies concerned with the following phases of water supply and purification: rapid sand filtration, sedimentation, chemical coagulation, water softening, demineralization, chlorination, corrosion control, and microbiology. Lectures on special topics.

1·822. Sanitary Engineering Laboratory (A). Lectures and laboratory studies concerned with the following phases of sewage treatment and purification: sludge digestion, sludge gas analysis, chemical treatment, biology, biochemical oxygen demand, sludge conditioning for filtration, nitrogen analyses, grease analysis, activated sludge plant operation, and plant efficiency studies. Lectures on special topics.

1·831. Sanitary Chemistry. Lectures, demonstration and laboratory exercises dealing with chemical principles, analyses and control tests involved in purification of water and treatment of sewage and industrial wastes. Discussion of the applications, limitations and interpretation of the tests as used in practice.

1·832. Chemistry and Industrial Waste Treatment (A). Lectures on chemistry for Sanitary Engineers followed by lectures on industrial waste treatment practice. Laboratory work on methods of analysis applied to industrial wastes followed by analysis and treatment of typical industrial wastes.

1·84. Sanitary Bacteriology I. Principles of bacteriology and their application in the field of sanitary and public health engineering. Laboratory procedures, including the cultural, microscopical and biochemical methods employed in studying and identifying bacteria with particular reference to the sanitary quality of water supplies.

1·85. Sanitary Bacteriology II (A). Bacteriology in relation to sanitation. Indices of pollution in water supplies other than the coliform group. Bacteriological examination of sewage and sewage effluents, the atmosphere, shellfish, swimming pools, bathing beaches, eating and drinking utensils, milk and dairy products, and interpretation of resulting data.

1·86. Public Health Engineering (A). Lectures and discussions dealing with sources of infection, modes of transmission, principles of immunity, antibiotic agents, and application of engineering principles to the control of environmental sanitation. Some sanitary problems studied: refuse and garbage collection and disposal, rural water supply and sanitation, swimming pools and bathing beaches, food and milk control, housing, entomology and parasitology with relation to mosquito and malaria control, and control of atmospheric pollution.

1·861. Industrial Health Engineering (A). Lectures, demonstrations, and discussions on causes, effects, and engineering principles for the control of factors of the industrial environment affecting the health and welfare of workers. Basic concepts of pathological physiology and biological reactions; occupational diseases of the blood, lungs, skin, and other vital parts of the body resulting from toxic dusts, gases, and liquids within industry and in the industrial environment; air pollution and control; air analysis; radiation and radiological analysis; industrial ventilation and air sanitation.

1·87. Public Health Statistics (A). Vital statistics including population estimates and forecasts, census, index numbers, sources of vital data, construction of life tables and their applications to public health studies. Application of theory of probability and mathematical statistics to the collection, analysis, and interpretation of data obtained in studies of water and sewage treatment processes, stream pollution, epidemiology, and other phases of sanitary engineering and public health.

1·871. Public Health Administration (A). Lectures, discussions and problems pertaining to public health administration, epidemiology and vital statistics including organization and proper functioning of municipal, county, state and federal health agencies; functions of interstate agencies for water pollution control in relation to state health departments and Federal Water Pollution Control Act; case histories of specific epidemics of particular significance to the sanitary engineer; application of vital statistics to problems of epidemiology and control of environmental sanitation by public health agencies.

1·872. Public Health Engineering Fieldwork (A). Field trips under professional guidance and for purposes of study and report of public health engineering activities that are included in the program of municipal, state and federal health agencies. Field trips covering the items enumerated under 1·86.

1·881. Advanced Sanitary Design (A). Functional design of a modern water treatment plant effecting the proper treatment of a given water for domestic and industrial consumption. Conducted in parallel with 1·811.

1·882. Advanced Sanitary Design (A). Functional design of a modern sewage treatment plant effecting the proper treatment of a given raw sewage. Conducted in parallel with 1·812.

1·883, 1·884. Special Studies in Sanitary Engineering (A). Advanced studies aimed at coordinating certain theoretical, experimental and practical phases of sanitary engineering and sanitary science. Some choice in selection of problems with approval of instructor.

1·891, 1·892. Sanitary Engineering Seminar (A). Designed to give graduate students experience in the preparation and presentation of technical papers and to afford to the students and members of the staff an opportunity to discuss and exchange ideas on matters of current interest to Sanitary Engineers.

1·90. Principles of Conservation. Fundamental study of the management of natural resources both renewable and non-renewable, with particular attention devoted to the relation between the principles of conservation and the planning of engineering works. Introduction of the fundamentals of ecology as principles basic to a sustained yield from renewable resources. Comprehensive treatment of problems attendant upon the management of water, soil and land, forests, animals, fish, and wildlife. Discussion of the conservation of mineral and petroleum products.

1·91. Engineering Construction. Construction of civil engineering works, such as railways, highways, water power, water supply and similar projects, including estimates and reports, contracts and specifications, methods of economic comparison, financing of engineering projects, engineering organization and duties, and construction methods illustrated by typical projects. Quantity surveys for construction.

1·92. Construction Equipment and Methods. Analysis of construction procedure and selection of equipment for carrying out civil engineering projects. Includes organization and management for construction operations, cost estimating, job planning, production capacity and operating costs for different types of construction plant and equipment, scheduling of materials, safety, and methods applicable to specific kinds of construction.

1·94. Professional Problems. Methods of setting up engineering problems; interrelation of various phases of an engineering project; written and oral presentation of professional ideas; placement problems; non-professional qualifications; professional ethics and professional societies. Lectures by several members of the faculty and by practicing engineers.

MECHANICAL ENGINEERING

SUBJECTS 2·00 TO 2·99

2·00. STATICS. Review of fundamentals, principle of virtual work. Forces and simple stresses in simple two- and three-dimensional frames and trusses in machines and structures. Cables and chains. Friction. Distributed force systems and centers of gravity. Stress and strain in tension and compression. Properties of ductile and brittle metals as determined in tension test. Elementary statically indeterminate problems.

2·001. APPLIED MECHANICS I. Fundamental engineering applications of the analysis of static equilibrium including simple elastic stress systems. Distributed forces. Cables. Hydrostatics. Friction. Trusses, frames and machines. Introduction to elasticity. Thermal, hoop and statically indeterminate stresses. Bending and twisting stresses. Virtual work and potential energy.

2·002. APPLIED MECHANICS II. Fundamental engineering applications of the analysis of plane dynamics of particles and rigid bodies and of plane stress and strain in elastic systems. Kinematics of particles and rigid bodies; dynamics of particles and rigid bodies in translation, rotation and plane motion; moments and products of inertia. Review of simple stress systems; plane stress and strain; Mohr's circle; combined stresses and strength theories; deflection of beams; statically indeterminate beams.

2·003. APPLIED MECHANICS III. Plane dynamics. Work and energy. Impulse and momentum. Angular momentum. Gyroscope. Free and forced vibrations of systems with 1, 2 and 3 degrees of freedom. Vibrations of distributed mass systems. Elastic stability and buckling. Energy methods in elasticity. Energy methods in vibrations. (Not offered 1952–53.)

2·01. DYNAMICS. Kinematics of particles and mechanisms. Inertia forces, momentum and energy of systems in translation and rotation. Balancing of rigid rotors. Moments and products of inertia of areas and plane masses. Elementary problems in vibration and critical speeds. Elementary problems in plane motion of rigid bodies.

2·011. STATICS AND DYNAMICS. Abridgment of 2·00 and 2·01.

2·04. STRENGTH OF MATERIALS. Elementary analysis of stress and strain in two dimensions; shear stresses and torsion of circular bars; 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 beams. Differential equation of the elastic curve, methods for the determination of slopes and deflections. Statically indeterminate problems in bending. Combined loading. Column theory. Theories of strength. Applications to important engineering problems.

2·046. STRENGTH OF MATERIALS AND DYNAMICS. Elementary analysis of stress and strain in two dimensions; torsion of circular bars; bending of beams; statically indeterminate problems; theories of strength; strain energy; kinematics of a particle; dynamics of a rigid body constrained to plane motion; including free and forced vibrations of simple systems; gyroscope with applications. (Primarily for selected officers of the U. S. Navy and Coast Guard.)

2·06. DYNAMICS. Vibrations of mechanical systems. Vibration isolation and seismic instruments. Critical speeds. Forced vibrations of systems of many degrees of freedom. Distributed mass systems. Rayleigh's, Stodola's, and Holzer's methods. Den Hartog, *Mechanical Vibrations*.

2·07. DYNAMICS. Principles of dynamics applied to the study of the performance of single and multiple degree of freedom systems subjected to disturbances in the presence of damping. Vibration measuring instruments. Simple servomechanisms. Electromechanical analogies and systems.

2·081. STRENGTH OF MATERIALS. Review of stress and strain at a point in two dimensions, the torsion problem with description of membrane analogy, review of bending, beams on elastic foundations, plates and sheets, curved beams and thick cylinders, strain energy methods, failures 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. MECHANICAL ENGINEERING PROBLEMS. Survey of a series of important problems in mechanical engineering with emphasis on topics which have figured in recent industrial developments and which impose limitations on further progress. Problems selected from as wide a field as possible covering developments in engineering practice as well as theoretical problems in engineering sciences. Emphasis placed on the historical development of each subject and its position in the history of engineering. Considerable portion of the presentation given by senior members of the staff and by experts and industrial leaders from the outside.

2·11. INDUSTRIAL PLANT ENGINEERING. Fundamentals of the construction of buildings, including foundations, superstructure, materials, heating, ventilation, air conditioning, and mechanical equipment. Particular emphasis on principles of safety and fire protection. Presentation of subject matter by authorities in each major field.

2·121. PHOTOELASTICITY. Use of commercial photoelastic apparatus with applications in the analysis of common engineering problems in two and three dimensions, with lectures on modern photoelastic theory, materials, and methods.

2·122. INDUSTRIAL PHOTOELASTICITY. Introductory subject on the applications of the Photoelastic method to problems commonly encountered in industry. Lectures supplemented by laboratory exercises dealing with modern theory, techniques, methods and laboratory equipment. For those wishing to set up a photoelastic laboratory or for supervisors wishing to become acquainted with the uses and limitations of the method.

2·125. RESEARCH IN EXPERIMENTAL STRESS ANALYSIS (A). Opportunity for graduate students to apply experimental methods to the solution of special problems, or to take part in current development of theory and technique.

2·126. EXPERIMENTAL STRESS ANALYSIS. Introduction to some of the more common experimental methods of analyzing stress distributions. Photoelasticity, brittle lacquers, strain gage techniques and instrumentation, and analogies, as applied to problems involving static, dynamic, and residual stress distributions.

2·128. EXPERIMENTAL STRESS ANALYSIS. Similar in content to 2·126, with more time assigned for greater detail in the laboratory exercises.

2·211. ADVANCED MECHANICS (A). Stress and strain at a point in three dimensions. Introduction to the theory of elasticity with examples of solutions in two dimensions. Development of the strain energy method with applications to beams, curved bars and plates. Survey of the problem of failure of materials under stress, failure theories, fatigue and creep. Applications to important problems in power and marine engineering, aeronautics, railroads, etc. Problems selected with particular emphasis on those aspects which impose limitations on further progress.

2·212. ADVANCED MECHANICS (A). Review of the variational method applied to mechanics. Development of the foundations of dynamics leading to Hamilton's principle and Lagrange's equations. Vibrations and stability of systems with many degrees of freedom, normal modes and frequencies; approximate methods. Systems with variable coefficients and non-linear systems. Gyroscopic effects in mechanical systems. Selected topics of applications to important problems in engineering, such as rotating and reciprocating machinery, turbine and compressor blades, aircraft propellers, helicopters, gyroscopes, etc. Problems selected with particular emphasis on those aspects which impose limitations on further progress.

2·213. GAS TURBINES (A). Application of engineering science to the design and development of gas turbines. Review of thermodynamics and fluid mechanics for flow phenomena in turbines and compressors. Review of problems of mechanical strength and vibrations encountered in rotating machinery and blading of turbines, compressors, heat exchangers and combustion chambers. Fundamentals of design of turbines, compressors, heat exchangers and combustion chambers.

Mechanical Engineering Continued

Operating characteristics of gas turbine power plants. Special problems encountered in aircraft applications.

2·214. Gas Turbines (A). Discussion of selected topics of mechanical engineering science related to gas turbines particularly those which now impose limitations on further progress. Review of problems encountered in power plants, marine engineering, locomotives and aircraft, with examples of construction. Design projects undertaken by students as part of the problem material. (Not offered 1952–53.)

2·215. Numerical Analysis (A). Survey of problem types encountered in engineering analysis with discussion of practical solution techniques in current use in order to reduce complex physical problems to computation programs for hand or machine calculation. Particular applications to structures, hydraulics, electric networks, vibrations, heat transfer, elasticity, plasticity, acoustics, electro-magnetism, compressible fluid flow, etc. Study of iteration, relaxation, perturbation, finite difference and variational methods. Brief description of computing equipment with inspection tours of large-scale computing machines.

2·221. Plasticity (A). Mechanics of the plastic state of materials with particular emphasis on engineering applications. True stress-strain relations for metals as affected by strain rate, temperature, etc. Comparison of equations for plastic deformation. Application to bars, beams, trusses, rotating disks, cold-worked tubes, etc. Problems in plane strain. Residual stresses and relaxation.

2·222T. Seminar in Plasticity (A). An opportunity for further study in branches of plasticity of special interest to the student. Discussion by students of their problems, progress, and results with the class at frequent meetings. (Not offered 1952–53.)

2·225. Physics of Strength and Plasticity (A). Cohesive forces in solids; elasticity. Fracture of brittle materials; Griffith theory of fracture. Ductile types of fracture. Notch brittleness. Cyclic and static fatigue phenomena. Permanent deformations in amorphous materials; viscosity. Grain boundary viscosity in metals.

2·226. Physics of Strength and Plasticity (A). Mechanism of plastic deformation in crystals. Plasticity of polycrystalline metals. Dynamics of slip; dislocation theory. Strain hardening; anelastic effects. Creep and creep testing. Theory of transient creep; dependence of the stress-strain curve upon strain rate and temperature. Mechanical behavior of polymers. Recrystallization and recovery. Martensitic transformations.

2·231, 2·232. Theory of Elasticity (A). Theory of elasticity presented from the point of view of the needs of mechanical engineering, with emphasis on strain energy methods.

2·25. Fluid Mechanics. Hydrostatics. Kinematics. Concept of the control volume. Continuity equation. Momentum theorem. Theorem of momentum of momentum. Dynamics of inviscid fluid. Bernoulli equation. Dimensional analysis. Energy equation. Viscous and turbulent flow. Head losses. Fluid meters. Subsonic and supersonic flow. Shock waves. Fluid machinery. Lift. Drag. Boundary layer. (Not offered 1952–53.)

2·251. Fluid Mechanics. Hydrostatics. Kinematics of fluids. Continuity relations. Euler and Bernoulli equations. Momentum theorem. Dimensional analysis. Energy equation. Viscous and turbulent flow. Head losses. Fluid meters. Subsonic and supersonic flow, and shock waves.

2·252. Fluid Mechanics Continuation of 2·251. Potential flow, circulation theory of lift, boundary layers, drag, effects of compressibility; hydraulic turbines, pumps, fans, fluid couplings and torque converters.

2·252T. Fluid Mechanics. One-dimensional compressible flow, with applications to problems associated with the design of turbojets, ramjets, rockets, combustion chambers, supersonic inlets, supersonic wind tunnels, gas turbines, and steam turbines. Unsteady fluid motions, with applications to problems of water hammer, detonation, and the inlet and exhaust ducts of reciprocating machinery. Design and performance of radial and axial flow pumps, compressors, and turbines. Design and performance of jet pumps. (Not offered 1952–53.)

2·256. Fluid Mechanics. 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, hydraulic machinery, lubrication.

2·261. Lubrication and Friction. Presented in two parts: (a) Hydrodynamic lubrication covering the Petroff and Sommerfeld equations; criteria for load capacity of bearings; factors for side leakage; and heat balance in a bearing; (b) Boundary lubrication covering the effects of lubricant composition, surface finish and bearing materials on bearing performance.

2·262. Research in Lubrication (A). Opportunity for the student to select a research problem which may be independent of or closely related to the program in progress in the Lubrication Laboratory; the field including lubrication proper, bearing design, surface finish, and fundamental studies of mechanism of friction from both the experimental and theoretical standpoints.

2·263. Lubrication and Friction (A). Derivation of a generalized Reynolds' equation and its application to analysis of sliders, tilting pad bearings, journal bearings, partial bearings, thrust bearings, externally pressurized bearings, dynamic loading; heat balance in bearings; effect of constitution of lubricant, including molecular structure, surface geometry and nature of the bearing surfaces on boundary lubrication; current theories and critical experiments on dry and boundary friction and their relation to wear.

2·264. Lubrication Engineering. Hydrodynamic lubrication theory, bearing design, fundamentals of dry and boundary friction, bearing materials, lubricants, both fluid and non-fluid, including properties and tests, lubricating systems, maintenance of hydraulic systems, lubrication of ball, roller and needle bearings and plant maintenance including organization of a lubrication section, establishing of schedules and selection of lubricants.

2·28. Fluid Machinery (A). Unified treatment from a fundamental point of view of different types of fluid-handling machinery. Displacement-type pumps, compressors, and motors. Centrifugal and axial pumps. Radial, axial, and mixed-flow water turbines. Steam and gas turbines. Axial and centrifugal fans, blowers, and compressors. Supersonic turbines and compressors. Air and water propellers. Fluid couplings and torque converters. Jet pumps, injectors, and ejectors.

2·31, 2·32. Mechanical Properties of Materials. Structure and interaction of atoms and molecules. Cohesive forces in various types of matter; elasticity. Strength and fracture of metallic and non-metallic materials under various conditions of loading. Mechanical properties of high polymers; rubber elasticity, plasticity, creep, recrystallization, and related phenomena in metals and other crystalline materials. Meaning of the mechanical tests. Points of view for the selection of materials for engineering purposes. Production, chemical and physical properties, testing, and engineering uses of glass, ceramics, cement, plastics, rubber, and textiles.

2·34. Mechanical Properties of Metals. 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.

2·351, 2·352. Dynamic Strength of Metals (A). Dynamic properties of metals and their interpretation and use in design. Failure of metals by creep, impact and fatigue. Influence of size, speed, stress concentration, corrosion, surface finish, surface treatment, etc. Effect of mean stress and residual stress. Application to design problems in automotive, aircraft, railroad, and marine engineering.

2·37. Mechanical Behavior of Materials. Lecture and laboratory. Review of certain fundamentals of elastic behavior. Methods of stress and strain measurement, and of mechanical testing. Yield criteria; plastic tension, torsion and bending; hardness. Elementary physics of plasticity and strength; creep, fatigue, notch brittleness. Discussion of ceramics, glass, textiles and high polymers.

Mechanical Engineering Continued

2·371. Testing Materials Laboratory. Laboratory methods of making physical tests to determine the properties of the more common engineering materials and a study of their behavior under static and dynamic conditions of stress. Use of true and engineering stress-strain diagrams in tension and torsion. Creep, impact and temperature effects, effect of heat treat. ent, fatigue, torsion, and elastic stability.

2·40. Heat Engineering. First Law of Thermodynamics and internal energy. Properties of liquids, vapors, gases, gas mixtures, and mixtures of air and water vapor. Second Law of Thermodynamics, the temperature scale and entropy. Applications to closed systems and to fluids in steady flow. Keenan, *Thermodynamics;* Keenan and Keyes, *Steam Tables;* Keenan and Kaye, *Gas Tables.*

2·401. Heat Engineering. For students who have taken heat engineering but whose preparation is not sufficient to cover 2·40 and 2·42.

2·402. Heat Engineering. Same as 2·40 with, in addition, applications to engines and turbines and laboratory exercises in heat engineering. Keenan, *Thermodynamics;* Keenan and Keyes, *Steam Tables;* Keenan and Kaye, *Gas Tables.* (Primarily for selected Officers of the U. S. Navy and Coast Guard.)

2·403. Heat Engineering. Introduction to heat transfer. First law of thermodynamics. Energy. Properties of liquids, vapors, gases, gas mixtures, and mixtures of air and water vapor. Second law of thermodynamics. The temperature scale and entropy. Availability. Introduction to the thermodynamics of chemistry. Applications to flow of fluids. Keenan, *Thermodynamics;* Keenan and Keyes, *Steam Tables;* Keenan and Kaye, *Gas Tables.* (Not offered 1952–53.)

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. Steady-state heat transfer through resistances in series and between flowing streams. Reciprocating steam engines and turbines, power-plant cycles, the air standard cycle of the internal combustion engine, an introduction to the thermodynamics of chemistry, heat and power from combustion, gas turbine processes, and a brief discussion of the principles of refrigeration. Keenan, *Thermodynamics;* Keenan and Keyes, *Steam Tables;* Keenan and Kaye, *Gas Tables.*

2·422. Heat Engineering. Power-plant cycles, introduction to the thermodynamics of chemistry, refrigeration, heat and power from combustion, gas-turbine processes. Keenan, *Thermodynamics;* Keenan and Keyes, *Steam Tables;* Keenan and Kaye, *Gas Tables.* (Primarily for selected Officers of the U. S. Navy and Coast Guard.)

2·43. Heat Engineering. Heat transfer comprising steady-state and unsteady-state conduction, analogies between heat transfer and momentum transfer, convection, correlations of experimental data, radiation, and applications. Mass transfer comprising molecular diffusion in gases, liquids, and solids, eddy diffusion, analogies, correlations of experimental data, and applications. McAdams, *Heat Transmission.*

2·44T. Design Problems in Heat Engineering. Applications of principles of thermodynamics, fluid mechanics, heat transfer, and mass transfer to designs of equipment used in heat engineering. Emphasis on creative work.

2·451. Advanced Engineering Thermodynamics (A). First and second laws of thermodynamics, their applications to simple systems and to flow processes; partial differential relations for the pure substance; the relation between pressure, volume, and temperature and its development; thermodynamics of chemical reactions; the equilibrium constant.

2·452. Advanced Engineering Thermodynamics (A). Continuation of 2·451. Availability; the criteria of equilibrium; equilibrium of a pure substance; supersaturated vapor and super-heated liquid; chemical equilibrium; mixtures and rectification; solutions

2·47. Jet Propulsion. Analysis and design of rockets, ram jets and turbojets. Consideration of limitations on performance imposed by thermodynamics, fluid mechanics, and strength.

2·48. Gas Turbines. Principles of thermodynamics, fluid mechanics and dynamics applied to the analysis and design of gas turbines.

2·49. Advanced Fluid Mechanics (A). Statics. Continuity and momentum relations for continuous fluids. Kinematics of fluid motion. Governing equations for motion of non-viscous fluid. Vorticity and circulation. Kelvin's theorem. Helmholtz' theorem. Stream function. Potential flow. Conformal transformation. Theory of lift. Navier-Stokes equation for motion of real fluids and applications. Boundary layer theory. Turbulence. Drag. Introduction to flow of compressible fluids. Applications to fluid machinery and propulsion systems.

2·491. Compressible Fluid Mechanics (A). One-dimensional compressible flow, with effects of area change, friction, heat transfer, combustion, gas injection. Supersonic diffusers and wind tunnels. Compression shocks. Method of small perturbations for subsonic and supersonic flow. Method of characteristics for supersonic flow. Hodograph methods. Unsteady wave motion in gases. Experimental methods.

2·492. Advanced Topics in Fluid Mechanics (A). Selected subjects of current interest in subsonic, transonic, supersonic and hypersonic flow. Friction and heat transfer in the compressible boundary layer. No formal lectures; assigned reading and special problems arranged on an individual basis in consultation with instructor.

2·50. Heat Measurements. Laboratory exercises in the practice of heat measurements, including various types of temperature measuring instruments and heat transfer. Lectures on the theory of temperature measurement, heat transfer and heat insulating materials.

2·51. Advanced Heat Measurements. Expansion of 2·50 designed for graduate students. (Primarily for Course XIII-A.)

2·521. Advanced Heat Transfer (A). Steady state and transient state conduction problems are solved for various constant and fluctuating boundary conditions. Problems in rectangular, cylindrical and spherical coordinates are considered. Study of thermal stresses resulting from non-uniform temperature distribution. Solution of the differential equations are accomplished by formal mathematics, relaxation method, potential field mapping, method of images, and methods of analogy.

2·522. Advanced Heat Transfer (A). Radiation from luminous and non-luminous gases. Review of analogies among heat transfer and friction and mass transfer. Free and forced convection from theoretical and experimental viewpoint. Heat transfer coefficients at high velocities. Heat transfer-friction relationship in heat exchangers. Film and dropwise condensation. Boiling with forced and natural convection.

2·53. Heat Measurements. Selected experiments with laboratory investigation of problems connected with the industrial application of heat such as thermal conductivity, thermal expansion, specific heat, ceramics, etc.

2·56. Power Plant Engineering. Discussion of the Steam Power Plant for the generation of electric power together with the production of steam for industrial processes. Emphasis placed on the thermodynamic, economic, and operating problems involved in selecting the prime movers and auxiliary equipment. Lectures supplemented by laboratory work and a trip to a neighboring power station.

Mechanical Engineering Continued

2·57. Advanced Power Plants (A). Modern power plants, including a study of the design and installation of high pressure boiler, economizers, air preheaters, modern fuel burning furnaces and automatic combustion controls. Study of the various steam cycles and types of auxiliary drive to show their effect on station heat balance. Discussion of deaërators, evaporators, condensers, heater, etc., including turbine and machinery foundations and layouts. Lectures and problems supplemented by trips.

2·601, 2·602. Food Engineering. Brief survey of the fundamental principles of thermodynamics with specific application to problems in heat transfer, refrigeration, and air conditioning as they are related to food processing. Discussion of methods, materials, and equipment used in the preparation and handling of foodstuffs including canning, packaging, and bottling equipment Laboratory work as a supplement to lectures.

2·621. Refrigeration. Discussion of refrigerating cycles. Refrigeration at more than one level. Operation and ratings of various types of compressors, evaporators, condensers, and automatic controls used in commercial refrigerating systems. Heat flow problems in condensers, evaporators, and cooling towers.

2·641. Refrigeration Engineering (A). Study of thermal, physical, and toxic properties of the chief refrigerants. Discussion of the time required to freeze ice and frost formation. Refrigeration at low temperatures. Application of refrigeration to skating rinks, shaft sinking, petroleum, breweries, the manufacture of ice cream, the manufacture of dry ice, and plant design.

2·642. Low Temperature Refrigeration (A). Thermodynamic processes for producing low temperature refrigeration. Problems of heat exchangers, insulation and rectification. Applications of low-level refrigeration to the purification of industrial gases such as oxygen, nitrogen, hydrogen, methane, etc.

2·661. Heating and Ventilation. Thermal balance in the human body in relation to the thermal balance in a surrounding building enclosure. Thermal relationships of the building to climate and weather. Insulation of the building to provide a suitable enclosure. Techniques of heating, heat generation and their control.

2·662. Heating and Ventilation. Continuation of 2·661. Ventilation and its techniques together with discussion of the fundamental problem and techniques of cooling for comfort.

2·663. Air Conditioning. Study and calculation of load, direct and indirect heating systems, heating boilers and water heaters, ventilation and the fundamentals of air conditioning.

2·664. Applied Refrigeration. Application of refrigeration to air conditioning and the storage and transportation of food. Cold storage construction and insulation, load estimates, commercial refrigeration, quick freezing and transportation refrigeration.

2·665. Applied Refrigeration. Theoretical and actual refrigeration cycles including refrigerants and their fields of application. Applications of refrigeration in the storage and transportation of food. Stationary and marine cold storage construction and insulation. Load estimates for storage and quick freezing applications. Laboratory work to supplement lectures. (Not offered 1952–53.)

2·671. Advanced Air Conditioning (A). Psychrometric and comfort data with application to air conditioning problems. Typical air conditioning equipment and controls will be studied with their application to various types of problems.

2·68. Engineering Laboratory. The general mechanical engineering laboratory for Course II seniors. Focus on principles of engineering measurement: determination of properties; dynamometry; flow metering; similarity; research methods; applications of The First Law. Exercises embodying these elements, providing contacts with representative mechanical engineering apparatus and an introduction to the elements of report writing. Project investigations of some depth pursued by small student groups during the final period of several weeks.

2·681. Engineering Laboratory. Survey of representative mechanical engineering apparatus for students who do not take 2·68. Basic units of study on steam power, fluid dynamic machinery, and positive displacement machinery with supplementary exercises on heat transfer, refrigeration, and miscellaneous equipment.

2·693. Refrigeration and Air Conditioning Laboratory. Experimental work involving application and research problems in air conditioning and refrigeration; with equipment including standard condensing units, air washer, heating and cooling coils, constant temperature rooms, and equipment of special design. Facilities available for the use of more than one refrigerant.

2·701. Machine Drawing. Engineering drafting room procedure and technique in the production of working drawings of machinery.

2·73. Machine Design. Lectures and drafting-room exercises covering the kinematic design of the basic mechanisms. An introductory course in machine design by application of the fundamentals of kinematics to geometric design. Sloane, *Engineering Kinematics*.

2·731. Machine Design. Design of machine elements including spur and helical gearing, shafting, bearings, frames, fastenings, general principles. Applications to the design of a simple high performance machine. An original design of a machine undertaken by each student to encourage creative thinking.

2·732. Machine Design. Study of the basic factors involved in machine design including discussion of cams, linkages and indexing devices. Appraisal of some electrical, hydraulic, pneumatic, and mechanical methods of actuation and control. The stress on creative thinking carried through from 2·731.

2·733. Machine Design. Open to a selected group of students interested in design as a possible career. Completion of a layout of a comprehensive machine and a report describing the manufacture and operation of the machine, including all necessary design calculations, the choice of the machine being left to the student. Weekly seminars.

2·734. Product Design. Introductory subject in product design. Correlation of the student's past experience in design and related fields, introducing him to new concepts of design as demanded by the fields of art, marketing, and psychology and guiding his future thinking in the direction of comprehensive design. Execution of a series of small design projects in conjunction with the lecture work.

2·735. Product Design. Group effort applied to a fairly complicated problem, and a comprehensive study of the design, production, and marketing aspects carried out. A complete production design and report submitted by each group.

2·742. Dynamics of Machinery (A). A complete study of various machine elements, carried out with emphasis on their dynamic characteristics. Analysis of the effects of inertia, damping, and elasticity in conjunction with cam follower systems, intermittent motion devices, linkages, power transmission, energy storage, etc. Subject matter not limited to mechanical elements, but including hydraulic, pneumatic, and electrical components as well.

2·751. Systems Design (A). Consideration of the static and dynamic characteristics of various systems; proper matching of such systems in a larger integrated system. Systems covered: prime movers, reduction units, various types of converters (transducers). Discussion of a wide variety of load conditions.

2·78. Design of Industrial Hydraulic Machinery. Theory and design of oil hydraulic machinery and its applications in industry. Discussion of problems in the control of speed, position, torque, and power. Consideration of the matching of load to prime power source.

Mechanical Engineering Continued

2·781. Fundamentals of Hydraulic Power Control. Review of laws of fluid flow with emphasis on those parts of the theory pertaining to such applications as hydraulic servo-mechanisms, machine-tool and process controls. Discussion of hydraulic system components such as pumps and motors, line components (fittings, filters, accumulators, relief valves, etc.), flow-control valves. System synthesis and design with emphasis upon high-performance closed-loop applications such as servo-mechanisms, governors, and precision machine-tool control systems. Electrical and mechanical analogies used freely and associated non-hydraulic components discussed briefly. Emphasis on the hydraulic elements.

2·783. Control Problems in Mechanical Engineering (A). General theory of automatic regulation. Application to advanced problems in temperature, pressure, flow, speed and position control. Speed and power regulation of prime movers. Studies of the dynamics of industrial processes and mechanical systems. Use of simulative methods in dynamic analysis. Consideration of the elements used in industrial control systems.

2·79. Elementary Internal Combustion Engines. Fundamentals of the internal combustion engine, including spark-ignition and compression-ignition cycles. Discussion of combustion, friction, cooling, carburetion, and other factors affecting power, efficiency, and general performance. Selection of the most suitable type of engine for various specific applications.

2·791. Internal Combustion Engines. Fundamentals of spark ignition and compression ignition engines, including thermodynamic cycles, combustion, efficiency, capacity and friction. Taylor and Taylor, *The Internal Combustion Engine*

2·792. Internal Combustion Engines. Introduction to engine design, featuring the application of engine theory to design procedure. Includes work in performance estimation, engine dynamics, stresses and materials, and the decisions leading to rational design. Taylor and Taylor, *The Internal Combustion Engine*.

2·7941. Internal Combustion Engine Laboratory. Laboratory exercises supplementing the classroom work of 2·791. Effects of operating and design variables on engine performance and use of instruments with special emphasis on precision of measurements.

2·7942. Internal Combustion Engine Laboratory. Continuation of 2·7941. Laboratory work of a more advanced nature leading to a final experimental project.

2·797T. Internal Combustion Engines, Advanced (A). Analytical approach to problems of the Diesel engine, gasoline engine, and other types. Consideration of fluid flow, thermodynamics, combustion and performance included. Preliminary design computations made on particular engine type chosen by student. Taylor and Taylor, *The Internal Combustion Engine*, revised edition, 1948.

2·798T. Internal Combustion Engines, Advanced (A). Continuation of first-term subject. Analysis of problems connected with friction, lubrication, fuel injection, supercharging, balance, torsional vibration, detail design of parts. Continuation of design computations begun in first term.

2·80. Automotive Vehicles. Analytical approach to vehicle performance, spring suspension transmission, brakes, etc. Preliminary design study for a complete vehicle prepared by each student.

2·801, 2·802. Special Problems in Internal Combustion Engines (A). Selection of a particular problem by student on which he works independently but under guidance of instructor. Problem may be in field of gas turbines or reciprocating engines. Work summarized in written report.

2·85. Introduction to Machine Tools. General discussion of the uses, capabilities, and characteristics of the basic machine tools of industry. Practical laboratory exercises in key machining operations of turning, milling, shaping, drilling and tapping, reaming and boring, and cylindrical and surface grinding. Use of automatic and special purpose equipment. Introduction to quality control and the use of inspection and precision measuring apparatus. Smith, *Advanced Machine Work*.

2·851. Machine Tool Laboratory. Use of basic machine tools, including straight and taper turning, chucking, boring, screw cutting, cylindrical and surface grinding, lay-out work, drilling, reaming, counterboring and tapping, shaping, milling and gear cutting. Use of inspection and precision measuring equipment. Smith, *Advanced Machine Work*.

2·853. Principles of Metal Cutting. Basic mechanics of the cutting process. Influence of physical properties of work and tool materials upon their cutting characteristics. Thermodynamic conditions at the point of a cutting tool. Importance of friction in the cutting process; role of cutting fluids in facilitating the removal of metal. Nature of the surface produced: surface finish, residual stresses and surface damage. Application of principles to special problems in turning, milling, drilling, grinding and polishing. Survey of current technical literature and special topic assignments. Demonstrations of selected current laboratory techniques.

2·854. Metal Cutting. Basic mechanics of the cutting process. Applications of materials test data to the deformation process in cutting; plasticity considerations in cutting. The nature of friction and its importance in the machining of metals; the role of the cutting fluid. Metallurgical considerations in cutting. The causes of tool wear and means for its evaluation and reduction. Residual stresses in finished surfaces and means for describing and measuring their geometry.

2·855. Theory of Metal Cutting (A). Application of the principles of solid state physics, plasticity and strength of materials to the cutting process. Theory of friction and of cutting points and the chemical and thermal aspects of cutting fluid action. Residual stress, surface damage and the structure of machined surfaces.

2·856. Applied Plasticity (A). Metallurgical aspects relative to the properties of metals. Static properties of metals. Fundamental concepts in the plastic flow of metals. The ideal plastic theory of large deformations. Analysis of hot working of metals, including extruding, piercing, forging, and rolling. Analysis of cold forming of metals including rod and wire drawing, deep drawing, and rubber dieforming, metal cutting and the importance of friction in problems involving large plastic deformations.

2·857. Metal Cutting. Fundamental concepts of scientific and engineering subjects applied to the cutting process to show how these principles may be applied to predict actual performance characteristics of cutting tools. Discussion of atomic structure and physical properties of metals; the mechanics of cutting; the plastic flow of metals during cutting; the role of cutting; fluids in reducing tool friction and wear; machinability and tool life; the thermal aspects of cutting; the metallurgical aspects of machining; grinding, honing and polishing; three dimensional cutting processes (drilling, turning, and milling).

2·86. Machine Tool Fundamentals. Mechanism of chip formation and importance of such items as: tool geometry, physical properties of metal cut, and friction between chip and tool, with regard to tool design and performance. Metallurgical aspects of machining, cutting demonstrations and exercises involving metal cutting dynamometers and thermoelectric apparatus. Surface roughness and nature of finished surfaces. Designing for manufacture; relationship between tolerance and cost. The use of operation sheets and the principles of estimating. (Not offered 1952–53.)

2·871. Manufacturing Engineering. 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 Manu-*

Mechanical Engineering Continued

facturing; Roe and Lytle, *Factory Equipment;* Dowd and Curtis, *Tool Engineering.*

2·872. Preparation for Manufacturing. Study of many engineering problems which must be solved before a product can be manufactured in large quantities after the design has been completed; such as engineering organization, estimating costs, design of tools and equipment, quality control, process and product development. Application of measurement to dimensional engineering standards, shop measurements and analysis of measurement. Buckingham, *Production Engineering.*

2·901, 2·902. Principles of Fabric Structure. Discussion of the properties of fibers as related to the properties of yarns and fabrics; properties of yarns as related to fabrics; construction and finishing of fabrics to produce certain desirable characteristics in these materials. Material dealing with principles of woven fabric structure together with the formation of knitted, braided, twisted, and felted materials. 2·901, I.C.S. *Staff, Weave Construction and Cloth Analysis;* 2·902, I.C.S. *Staff, Weave Construction and Color Effects.*

2·903. Elements of Textile Manufacturing Production and properties of textile raw materials and operations basic to the manufacture of cotton, wool, silk, flax, jute and rayon.

2·904. Principles of Textile Manufacturing. Continuation of 2·903 covering the combination of operations such as blending, carding, combing, drafting, twisting, etc., into processes as for cotton, woolen, worsted, spun and thrown filament, and bast fiber materials; involving mill organization studies and plant inspections.

2·905. Textile Technical Analysis (A). Determination of the physical properties of fibers, yarns, and fabrics, and discussion of the limitations imposed by variable factors, such as the rate of testing, environmental conditions, and the nature of the testing equipment. Development of the principles of viscoelastic behavior and of instrumentation for testing and research.

2·906. Textile Technical Analysis (A). Continuation of 2·905 with emphasis on the internal and geometric structure and the viscoelastic behavior of textile materials in relationship to their physical behavior. Discussion of current research problems and modern techniques in the measurement of loads and deformations by physical and electronic methods.

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 2·905. Emphasis on the planning of experiments, critical analysis of the methods of test and of the results obtained, and on the written and oral presentation of the results of experiments.

2·912. Textile Research Laboratory (A). Application of the research group method to the solution of textile behavior problems in connection with 2·906. Continuation of experiment planning, analysis, and presentation initiated in 2·911. Visits to consulting and industrial research laboratories.

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.

2·92. Principles of Textile Research. Lectures, demonstrations, and seminar sessions covering fiber, yarn and fabric structure, properties and utilization. Techniques for obtaining, presenting and interpreting data through the use of physical and optical equipment discussed. Planning of experiments, statistical methods (including analysis of variance) and the application of electronic, sound velocity, impact and creep test methods.

2·93. Experiment Planning and Analysis (A). Designed to acquaint the technologist with the philosophy and methods underlying the design and interpretation of experiments and the presentation of results. Choice of variables, selection of specimens, size and type of experiment, presentation of data in the form of tables, charts, graphs, and equations, statistical analysis of variable data, comparisons of two or more things subject to interactions, correlation, and the interpretation of quality indices.

2·951, 2·952. Industrial Practice. Approximately six months of practical work carried out by the cooperative students in manufacturing, engineering, research, and developments at the plants of the organizations participating in the cooperative program.

2·991, 2·992. Mechanical Engineering Seminar (A). Presentation of special topics in mechanical engineering and related fields intended to develop the student's ability to summarize a topic orally and take an active part in the discussion and criticism of such presentation.

METALLURGY

Subjects 3·00 to 3·99

3·01. Metallurgical Engineering I. Principles underlying the unit processes by which metals are extracted from ores and other raw materials. Emphasis on those principles common to all metallurgical processes involving chemical reactions or changes in state. Metallurgical stoichiometry, thermochemistry and thermophysics, heat balances, fuels and combustion, fluid flow, heat transfer, refractories, physical and chemical attributes of the solid and liquid phases in metallurgical systems, mass action, reaction rates. Quantitative application to metallurgical engineering problems.

3·02. Metallurgical Engineering II. The unit processes used in extracting metals from ores and other raw materials. Gas-solid processes (roasting, calcining, and drying), sintering, reduction of metal oxides, smelting, converting, distillation, and refining processes studied from the standpoint of the principles introduced in 3·01. Apparatus, design and operating variables, and engineering calculations for the important unit processes. Hydrometallurgical and electrometallurgical processes considered briefly.

3·021. Metallurgical Engineering Laboratory. Laboratory exercises designed to measure important variables in typical metallurgical processes and to illustrate process equipment on a small scale. To be taken simultaneously with 3·02.

3·03. Metallurgical Engineering III. Integrated metallurgical engineering processes. Synthesis of the principles, unit operations, and unit processes studied in preceding courses in mineral and metallurgical engineering, with emphasis on the development of complete flowsheets for producing metals from ores. Economic and other considerations involved in choice of process. Production metallurgy of iron and steel and of the important non-ferrous metals.

3·10. Metallurgical Plant Visits. One week spent in visiting metallurgical plants in New Jersey and Eastern

Metallurgy Continued

Pennsylvania. Production of iron and steel, zinc, copper, lead and non-ferrous alloys. Students meet instructor about one week before opening of fall term. (Restricted to students who have completed the third year of Course III.)

3·11. Engineering Metals. Study of metals and alloys emphasizing the effect of composition and mode of fabrication on their structure, properties and engineering uses, embracing heat treatment and the fundamentals of constitutional diagrams. Brief treatment of the properties and processing of plastics as compared to metals.

3·12. Metal Processing. Theory and practice of metal fabricating processes embracing recent developments in casting, hot and cold forming and joining.

3·13. Foundry Engineering I: Iron and Steel. Theory and modern development of ferrous foundry processes. Sizing, grading and handling of mold materials, flow and solidification of molten metal, heat flow in mold and metal, and gases in metals as related to the production of sound castings. Standard and new methods of molding, melting, alloying, gating, risering, cleaning, cutting, testing and inspection. Comprehensive treatment of casting design.

3·15. Welding Engineering. Detailed treatment of the joining of metals by brazing, and by gas, atomic hydrogen, helioarc, resistance and thermit welding; studies of stress concentration and stress relief, inspection and testing, engineering design and metallurgical aspects of the subject.

3·16. Powder Metallurgy. 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, defusion, recrystallization and grain growth as they apply to this field. Present industrial applications of powder products.

3·18. Plastic Working of Metals. Principles of plastic deformation introduced both from the viewpoint of the physical metallurgist and the materials engineer. Principles applied to study of industrial metal forming processes, such as: wire, rod, and tube drawing; deep drawing; extrusion, rolling, and forging; die-less tension forming; shearing and metal cutting; bending. Relation of friction, wear, corrosion, and their control to the fabrication and use of metals.

3·20. Metallurgical Thermodynamics. Thermodynamics emphasizing topics useful in metallurgical operation. Free energies of substances at elevated temperatures and activities of metals in solid and liquid alloys, used in interpreting metallurgical phenomena and in determining the feasibility and limitations of metallurgical processes.

3·21. Principles of Steelmaking (A). Reactions in the manufacture of steel, studied from the viewpoint of physical chemistry. Reduction of ore, reactions of liquid iron and steel with slags and gases and the chemical effects of alloys and deoxidizing agents. Influence of melting and refining methods upon the properties of the finished product.

3·22. Thermodynamics of Metallic Solutions (A). Study of the current literature covering the entropy and energy functions in solid and liquid metallic solutions and their application to phase diagrams.

3·25. Experimental Methods in Metallurgy (A). Intended to acquaint the student with special experimental techniques and methods used in metallurgical research, such as: vacuum melting and casting; attainment of extremely high temperatures; special casting methods such as precision casting; vacuum fusion and special chemical analytical techniques; ceramic and refractory evaluation and application; optical and thermocouple temperature reading; temperature control; etc (Suggested for all new graduate students in the Department of Metallurgy.)

3·30. Elements of Physical Metallurgy. General methods in the study of metals and alloys. Interpretation of equilibrium diagrams, relations between constitution and physical properties; deformation, recrystallization and grain growth; phase transformations in the solid state. Properties and application of industrial non-ferrous metals and alloys; heat treatment, structures and applications of steels and cast iron. Laboratory exercises with microscopic examination of typical specimens.

3·31. Physical Metallurgy I. Principles of physical metallurgy, covering such basic subjects as the characteristic properties of metals, solid solutions, intermetallic compounds and aggregates thereof; construction and metallographic interpretation of equilibrium diagrams; plastic deformation and rupture of metals; phenomena of recovery, recrystallization and grain growth; kinetics and mechanism of phase changes in the solid state. Commercial non-ferrous alloys used as a basis of discussion wherever possible.

3·32. Physical Metallurgy II. 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. Physical Metallurgy III. Lectures and laboratory conferences on applications of metallography to industrial problems. Examination of microstructures of normal and defective commercial alloys. Critical résumé of the fundamentals of modern physical metallurgy essential to the proper interpretation of the microstructures.

3·331. Industrial Physical Metallurgy. Laboratory exercises to supplement the lectures given in 3·11 followed by lectures and laboratory exercises dealing with the industrial applications of physical metallurgy. Major consideration is given to the examination of the microstructures of normal and defective industrial alloys.

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. (Primarily for selected officers of the U. S. Navy.)

3·391, 3·392. Properties of Metals. Metallurgical properties of metals and alloys with reference to materials used in ship construction. The making, microstructure, processing, heat treatment, joining and corrosion resistance of non-ferrous and ferrous alloys. (Primarily for selected officers of the U. S. Navy and Coast Guard.)

3·396. Technology of Nuclear Reactor Materials (R). Description of physical and nuclear requirements of materials which may be used in reactors. Discussion of metallurgical processes and techniques required to handle these materials, followed by detailed study of uranium, beryllium, graphite, etc. Examination, from a materials viewpoint, of general problems such as heat removal, radiation damage, power generation, and breeding. (Intended for selected U. S. Naval officers, but other properly cleared persons will be accepted.)

3·41. Light Alloys. Detailed study of the properties, heat treatment and uses of alloys of aluminum, magnesium, and beryllium. (Not offered 1952-53.)

3·42. Electrochemistry. Emphasis on fundamental principles of electrochemical theory, with illustrations of their applications in practice. Discussion of electroanalysis, electroplating, electrowinning of metals, primary and secondary cells, electrophoresis, alkalichlorine production, and related processes.

3·43. Corrosion (A). Theories of corrosion; general principles of corrosion control; selection of metals for use at low and high temperatures. Corrosion testing.

3·44. The Behavior of Metals at Elevated Temperatures (A). Study of metal and alloy behavior at temperatures at or above the recrystallization temperature (or equi-cohesive temperature). Correlation of alloy preparation variables with the structure and properties of the alloy. Study of the pertinent binary systems prominent in heat resistant alloys. Quantitative evaluation of the present heat resistant alloy field.

3·50. X-ray Metallurgy. Use of X-rays in the study of metals. Radiographic examination of metal parts, X-ray diffraction study of the structure and texture of metals.

Metallurgy Continued

3·51. Physics of Metals. Modern theories of the metallic state and their relations to the physical properties of metals.

3·52. Advanced Physics of Metals (A). Various problems of the crystalline metallic state and the dependence of physical properties upon structure. Laboratory work in the form of short research problems. A continuation of 3·51.

3·53. Advanced X-ray Metallurgy (A). Conferences and laboratory work covering all of the important X-ray diffraction techniques used in the study of metallic structures.

3·61. Magnetic Properties of Metals and Alloys (A). Detailed discussion of the magnetic behavior of metals and alloys. Ferromagnetic properties covered from a theoretical and experimental standpoint with considerable emphasis on technological applications.

3·62, 3·63. Special Problems in Metallurgy (A). Minor investigation in one of the special branches of metallurgy. Open only to graduate students properly qualified in the special field.

3·70. Ceramics. Introduction to the more advanced ceramic subjects. Selection of ceramic materials, molding, drying and burning, as well as the physical properties of finished products. Commercial processes carried out on a small scale in the laboratory.

3·71, 3·72. Ceramics Seminar (A). Selected topics in Ceramics, varying from year to year, presented by the students and staff, each topic being of group interest and followed by group discussion.

3·73. Fundamentals of Ceramic Processes I (A). Principles concerned with raw materials, forming, drying, melting, firing and decorating in the ceramic industry.

3·74. Fundamentals of Ceramic Processes II (A). Application of ceramic principles to the manufacture and testing in the fields of glass, whitewares, refractories, abrasives, heavy clay products, and enamels.

3·75, 3·76. Special Problems in Ceramics (A). Advanced work in this field. Time devoted to lectures, conferences, assigned readings, or laboratory work.

3·77, 3·78. Advanced Ceramics Laboratory (A). To accompany 3·73 and 3·74. The fundamentals underlying ceramic processes demonstrated by illustrative experiments.

3·81. Mineral Engineering I. Introduction to the preparation for further metallurgical treatment or direct use of mineral substances from the unit-process and unit-operation points of view. Subject designed to give an idea of operations and processes employed to utilize solid fuels, ores, and minerals and to extract metals from low grade ores. Limited number of laboratory exercises to illustrate the more important principles and to teach the student useful experimental techniques of general applicability to fields of mineral engineering and metallurgy.

3·82. Mineral Engineering II. Study of the unit operations used for the preparation of mineral substances as mined for subsequent use in metal production or the manufacturing industry with emphasis on the principles involved and their relationship to physical and chemical laws and sound engineering design. Experiments illustrating fundamentals and small scale tests of industrial operations included in laboratory work. The following unit operations are covered: comminution, sizing, gravity concentration and magnetic separation.

3·83. Mineral Engineering III. Continuation of 3·82, including amalgamation, flotation, leaching, thickening and filtration. Study of sampling, storage, feeding and transportation of particulate materials.

3·85. Mineragraphy. Examination and quantitative appraisal of mineral and metallurgical materials as an aid in the proper selection of treatment processes or the correction of plant difficulties. Laboratory techniques of dissection of mineral substances, their preparation for microscopic study and the methods of microscopy for minerals examined in thin section, polished section, or as discrete grains.

3·86. Quantitative Mineragraphy (A). Advanced course in mineragraphy in which the quantitative approach is stressed.

3·87. Ore Testing. Practice in choosing concentration methods for specific ore samples, in developing laboratory testing technique, and in preparing reports.

3·89. Mineral Dressing Design (A). A specific problem in mill design, covering the development of the quantitative flowsheet and the drawing up of specifications for, and the general arrangement of, the equipment. Taggart, *Handbook of Mineral Dressing*.

3·90. Advanced Mineral Engineering (A). Informal discussion of topics selected according to the needs of the students. Examples of suitable topics: application of fluid mechanics to gravity concentration, of physical chemistry to flotation, of colloid chemistry to flocculation and thickening, of elasticity and plasticity to comminution.

3·901. Advanced Mineral Dressing Laboratory (A). Study of an ore, a process, or a machine in the field of mineral dressing.

ARCHITECTURE AND PLANNING

Subjects 4·00 to 4·99

4·031, 4·032. Visual Fundamentals. The structure of two dimensional picture surfaces. The elements: point, line, shape, value, form, texture. Their organization: balance, dynamic equilibrium, tension, rhythm, proportion, etc. Experimentation with graphic tools in order to become acquainted with their potentialities.

4·041, 4·042. Light and Color. Research in the organization of light and color in two and three dimensions. Studies in light modulation with cameraless photography, light modulators, light and shadow boxes. Space organization with light.

4·051, 4·052. Graphic Presentation. Lettering, typographical layout, photomontage, collage, charts, diagrams, posters, etc. Photography. The study of light as a creative medium; photographic observation of surfaces, textures and structures. Documentation of subjects relevant to students of architecture.

4·053, 4·054. Painting (A). Where the student has the opportunity to test his ability to express himself. Display, Exhibition and Stage Technique. Utilization of the previous studies of light, color, and graphic expression in three dimensional relationships.

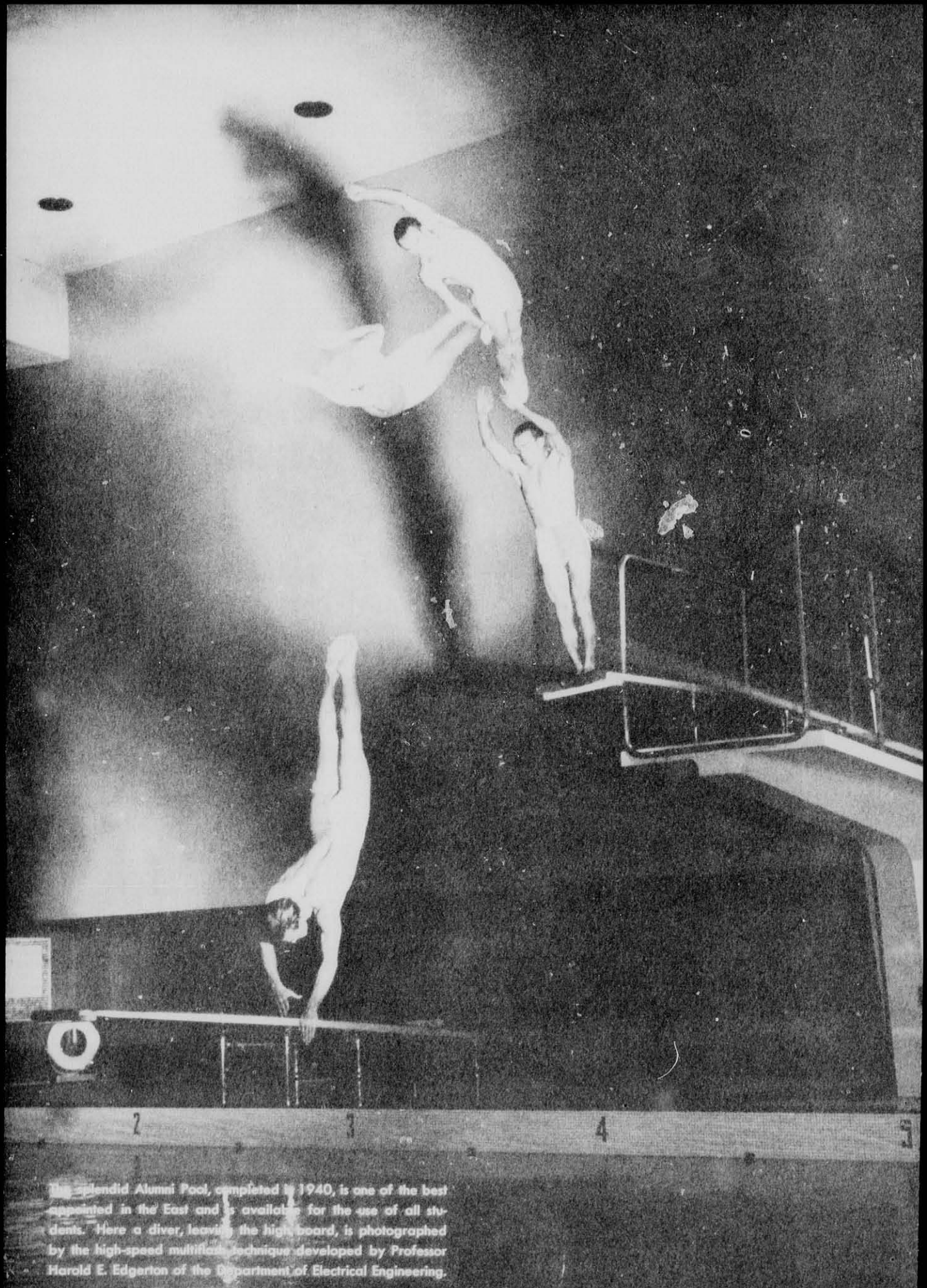
4·07. Shop. Working experience with commonly used materials to develop familiarity with their qualities and the influence of these qualities on their application in design. Use of hand and power tools to inculcate techniques required in future subjects for making quick and accurate architectural models or full-scale furniture designs.

4·12. Urban Sociology. Social characteristics of urban and rural communities and problems which arise in cities in connection with provision of facilities for housing, industry, government, education, recreation, and transportation.

4·13, 4·14. Land Economics. Principles of classification and utilization of urban and rural land. Policies of conservation and control of land and their effects on social development.

4·451, 4·452. History of Architecture. Illustrated lectures comprising a general survey of the Architecture of all

In spring, the broad reaches of the Charles River Basin are churned by the oars of Technology's crews. Rowing is the favorite sport at the Institute. The Varsity and Junior crews are always top contenders in intercollegiate competition and participate in the Poughkeepsie and Seattle regattas.



The splendid Alumni Pool, completed in 1940, is one of the best appointed in the East and is available for the use of all students. Here a diver, leaving the high board, is photographed by the high-speed multiflash technique developed by Professor Harold E. Edgerton of the Department of Electrical Engineering.

Architecture and Planning Continued

periods, supplemented by reference reading, theme writing, and conferences.

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). Fall term: general introductory evaluation of the housing problem; intensive critique of concepts and relationships in housing from social technical, economic, administrative and legislative points of view; historical survey of broadening perspective of the housing movement as well as changing social and economic trends, with attention directed to contemporary solutions in Europe and the United States; written exercises based on extensive readings and class discussions. Spring term: seminar discussions of selected problems in housing with invited guest speakers; afternoon talks and after-dinner discussion groups when guest speakers are present; written reports and extensive readings in special fields. 4·541 and 4·542 a single course running throughout the year.

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. 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). Mainly devoted to preparation of site and utility plans for a specific project.

4·63. Principles of Regional Planning. Principles of regional planning, as evidenced in the study of specific regional planning programs. Emphasis placed upon the interrelationship of various civil engineering and planning problems, and the part which regional considerations play in the planning of civil engineering projects.

4·64. Regional Planning Seminar (A). Critical review of regional, state, and national planning experience in the United States; analysis of principal regional planning problems and investigation into significant current trends in regional planning.

4·641. 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 city and regional planning. Supervised study, with conferences, readings, and reports but without lectures.

4·67. Form of the City (A). The city and its components as aesthetic elements. Role of plan organization, spatial relations, symbol, silhouette, scale, view, movement, light, color, sound, detail, etc. Field observation, group projects, and seminar discussion.

4·681. 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. 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.

4·723. Architectural Design. Condensation of 4·721 and 4·722 for students entering under the Combined Plan of Study with Liberal Arts Colleges.

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. 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.

4·751. Architectural Design. Problems emphasizing basic community needs in housing, recreational, commercial, and educational categories. Emphasis in principal project on disposition of groups of buildings on new sites with analysis of economic considerations, incorporating much of the material in 4·62 as applicable to the development of new communities.

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, and development of the building envelope.

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

Architecture and Planning Continued

and plate girder. Analysis and design of elementary reinforced concrete floor systems, beams, column, and footings. Application to a problem in design. *Mimeograph Notes.*

4·91. Special Problems in Architectural Acoustics (A). Broad study of functional acoustic design in architecture, based on project work in the fields of impedance and absorption measurement of sound-absorptive materials, full-scale study of sound distribution and diffusion in rooms, and investigation of sound transmission through building structures, conducted in the Acoustics Laboratory.

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 requirement in chemistry.

5·01, 5·02. General Chemistry. Fundamental principles of chemical science and the chemistry of the more common elements and their important compounds. Latimer and Hildebrand, *Reference Book of Inorganic Chemistry;* Hildebrand, *Principles of Chemistry;* Bray, Latimer, and Powell, *A Course in General Chemistry.*

5·061, 5·062. Advanced Inorganic Chemistry. Physical and chemical properties of the elements and their compounds, presented in a correlative manner. Facts of inorganic chemistry systematized as far as possible with the aid of a comparatively small number of generalizations. Survey of the more important modern theoretical developments in this field, especially the structural aspects of inorganic substances. Discussion of the results of recent experimental investigations, wherever pertinent.

graduate subjects

5·066. Advanced Structural Chemistry (A). Treatment of the forces operating between atoms which lead to molecular aggregates: one, two, and three electron bonds, multiple bonds and resonance, ionic character and electronegativity, complex formation, van der Waals' forces, hydrogen bonds, and metallic bonds. Methods of determination of molecular structure and the interpretation of chemical properties in terms of structural factors. Pauling, *Nature of the Chemical Bond.*

5·071. Special Topics in Inorganic Chemistry (A). Selected subjects, varying from year to year, presented by the members of the class and the staff, followed by a general discussion by the group. Subjects chosen from current fields of inorganic investigation, and expected to be of sufficiently wide scope to require a literature search in the preparation of the subject for presentation. In successive terms this subject is intended to alternate with 5·912.

5·08. 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.

5·09. Radiochemistry (A). Chemistry of the production, isolation, and identification of radioactive atoms. Introduction to the techniques of preparation and measurement of radioelements. Applications to chemical problems.

5·091T. Radiochemistry Laboratory (A). Laboratory study of special topics including radiochemical analysis, the fission process, and the reactions following nucleogenesis.

Analytical Chemistry

undergraduate subjects

5·10. Qualitative Analysis. Discussion of theories underlying the reactions of qualitative analysis with particular attention to the law of mass action. Practice in writing chemical equations. Laboratory work, conducted on a semi-micro scale, on a large number of solutions and solids, including alloys, pigments, minerals, slags and miscellaneous commercial products. Preparation for quantitative analysis, correlating and systematizing much of the information already obtained in general inorganic chemistry. Noyes and Swift, *Qualitative Chemical Analysis;* Hamilton and Simpson, *Calculations of Analytical Chemistry.*

5·11. Qualitative Analysis. Class-room work essentially the same as that in 5·10, with fewer experiments and analyses performed in the laboratory. Noyes and Swift, *Qualitative Chemical Analysis;* Hamilton and Simpson, *Calculations of Analytical Chemistry.*

5·12. Quantitative Analysis. Discussion of principles of volumetric and gravimetric analysis with detailed attention to the solution of stoichiometric problems. Laboratory work in quantitative analysis by volumetric and gravimetric methods on typical natural and commercial products, and covering acidimetry, the permanganate and iodimetric processes, precipitation methods and gravimetric methods. Emphasis on development of careful laboratory technique. Hamilton and Simpson, *Calculations of Analytical Chemistry;* Pierce and Haenisch, *Quantitative Analysis.*

5·13. Quantitative Analysis. Includes the topics of 5·12 and continues with a correlative study of analytical chemistry for the identification and determination of the more common constituents as well as some of the rarer elements. Analysis of silicates, minerals, ores and alloys including electrolytic and electrometric methods, and an original study of some special analytical problem. Gas analysis.

5·15. Instrumental Analysis. Theory and use of modern optical and electrical instruments in the solution of chemical problems. Practice in the use of the spectrophotometer, flame photometer, fluorimeter, colorimeter, turbidimeter, nephelometer, polarograph, potentiometer, recording potentiometer, conductance bridge and Geiger counter. Willard, Merritt and Dean, *Instrumental Methods of Analysis.*

5·161. Electrical Methods in Instrumental Analysis. Potentiometry, polarography, conductimetry, amperometric titrations, coulometry and applications of self-balancing recording potentiometers. (Special Summer subject.)

5·162. Optical Methods in Instrumental Analysis. Spectrophotometry (visible and ultra-violet) colorimetry, fluorimetry, nephelometry, photometric titrations and flame photometry. (Special Summer subject.)

5·163. Technique of Infrared Spectroscopy. Elementary theory of infrared spectra and infrared instrumentation with laboratory practice in the principal techniques and methods of infrared spectroscopy. Newer models of infrared equipment available for use. (Special Summer subject.)

5·164. Applications of Infrared Spectroscopy. Use of infrared absorption spectra in the solution of chemical problems. Determination of molecular structure by interpretation of infrared and Raman spectra. Methods of interpretation illustrated by application to different fields such as polymers, antibiotics, hydrocarbons, inorganic compounds, amino acids and proteins. (Special Summer subject.)

graduate subjects

5·192. Advanced Analytical Chemistry I (A). Detailed consideration of the theory and application of distillation and condensation, solvent extraction, precipitation and coprecipitation, chromatography, ion exchange, diffusion and electrodeposition.

Chemistry Continued

5·193. Advanced Analytical Chemistry II (A). Analytical Chemistry of the less familiar elements. Problems encountered in the analysis of technical products. General correlation of analytical methods.

5·194. Advanced Analytical Chemistry III (A). Application of statistical methods to analytical problems with emphasis upon evaluation of validity, control chart methods, analysis of variance, fitting of equations to experimental data and the design of experiments. (Not offered 1952–53.)

Organic Chemistry

undergraduate subjects

5·41. Organic Chemistry I. Introduction to the chemistry of carbon compounds. Survey of the important classes of aliphatic and aromatic compounds with attention to reactions and compounds of current industrial interest.

5·412, 5·414, 5·416. Organic Preparations I. Preparation and purification of a series of simple organic compounds by typical reactions illustrating the synthetic techniques of organic chemistry.

5·417. Quantitative Organic Analysis. The determination of carbon, hydrogen, nitrogen, halogens, sulfur and certain functional groups by micro methods.

5·42. Organic Chemistry II. Continuation of 5·41. Study of the synthesis and reactions of polyfunctional compounds. Chemistry of natural products, dyestuffs and pharmaceuticals.

5·424. Organic Preparations II and Qualitative Organic Analysis. Advanced preparations involving special techniques. Identification and separation of mixtures of organic compounds. Introduction to the literature of organic chemistry.

5·426. Qualitative Organic Analysis. Laboratory practice in the identification and separation of mixture of organic compounds.

5·43. Organic Chemistry III. Introduction to the theoretical interpretation of reactivity, reaction mechanisms and molecular structure of organic compounds. Application of theories of electronic structure, acids and bases, steric hindrance and stereochemistry with emphasis on recent developments.

5·44. Organic Chemistry IV. Discussion and evaluation of general synthetic methods of organic chemistry with emphasis on the isolation and characterization of products of biological significance (antibiotics, steroids, and alkaloids).

graduate subjects

5·51. Organic Chemistry: Synthesis, Advanced (A). Survey of organic reactions and the methods by which they are applied to synthetic problems in organic chemistry. (Not offered 1952–53.)

5·52. Organic Chemistry: Mechanism, Advanced (A). Theory and factors which govern the reactivity of organic compounds. Present state of knowledge of mechanism of reactions.

5·54. Physical Organic Chemistry, Advanced (A). Mechanism of representative organic reactions in homogeneous liquid systems. Emphasis on kinetic and other physical methods useful in studying organic reactions, and on the types of experimental evidence upon which current theoretical interpretations of reactivity are based.

5·55. Organic Chemistry: Natural Products (A). Discussion of the chemistry and physiological action of the terpenes, steroids, and some of the more complicated alkaloids. Presentation of methods of isolation; determination of structures and synthesis.

Physical Chemistry

undergraduate subjects

5·60. Physical Chemistry. Physical states of matter; first and second laws of thermodynamics; properties of gases and elementary kinetic theory; properties of solutions; electrolytic conduction. Noyes and Sherrill, *A Course of Study in Chemical Principles.*

5·61. Physical Chemistry I. 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 coordinated with the topics of 5·61.

5·612. Physical Chemistry Laboratory I. Abridgement of 5·611.

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 coordinated with the topics of 5·62.

5·622. Physical Chemistry Laboratory II. Abridgement of 5·621.

5·63. Physical Chemistry I. Composition and physical states of matter; first and second laws of thermodynamics; properties of gases and elementary kinetic theory; properties of solutions; electrolytic conduction.

5·631. Physical Chemistry Laboratory I. Laboratory coordinated with topics of 5·63.

5·64. Physical Chemistry II. Continuation of 5·63. Equilibrium of chemical changes; phase equilibrium; rates of chemical reactions; voltaic cells; third law of thermodynamics; systemization of free-energy values.

5·641. Physical Chemistry Laboratory II. Laboratory coordinated with topics of 5·64.

5·66. Surface and Colloid Chemistry. The structure of surfaces; surface and interfacial tensions, including solid-fluid interfaces; adsorption, and measurements of surface area; rates of heterogeneous reactions; electrokinetic effects; types of colloids, and methods for preparation and purification; methods for studying size, shape and structure of the colloidal particle; applications to natural and synthetic colloidal systems.

5·67. Introduction to Atomic and Molecular Structure. Use of spectroscopic methods to determine the structure of atoms and molecules; elementary theory of atomic spectra; atomic structure and the Periodic Table; theory of molecular spectra. Technique of chemical spectroscopy; analysis of chemical elements by emission spectra; use of infra-red and Raman spectra in chemical analysis and in determination of the structure of organic compounds; ultraviolet absorption of molecules and their electronic structure. Harrison, Lord and Loofbourow, *Practical Spectroscopy.*

5·68. Kinetics of Chemical Reactions. Introduction to the kinetic theory of gases with special emphasis on the calculation of collision frequencies, and consideration of theoretical and experimental aspects of the kinetics of homogeneous and heterogeneous reactions in gaseous and liquid systems. Hinshelwood, *Kinetics of Chemical Change.*

graduate subjects

5·71. Chemical Thermodynamics I (A). Fundamental definitions and concepts; first and second laws of thermodynamics with applications to chemical systems, ideal and real gases, ideal and real solutions; partial molar quantities, chemical equilibrium; third law of thermodynamics and applications to chemical systems; free energy calculations. Noyes and Sherrill, *A Course of Study in Chemical Principles.*

5·72, 5·73. Chemical Thermodynamics II and III (A). Development of the general thermodynamic theory from the first and second laws. Application of the theory to homogeneous and heterogeneous systems in which chemical reactions may take place. Gibbs, *Thermodynamics;* mimeographed notes.

5·74. Statistical Mechanics (A). Introduction to the principles and methods of statistical mechanics, with applications to physico-chemical problems. Properties of ideal gases, real gases, crystalline solids, and liquids.

5·75. Introduction to Atomic Structure and Atomic Spectra (A). Structure of atoms as deduced from results of the deflection of charged particles in electric and magnetic fields and from the emission and absorption of radiation.

Chemistry Continued

Treatment 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.

5·76. Molecular Spectra (A). Introduction to the mechanics of molecular motion, leading to the equations for the energy levels of diatomic molecules. Derivation of molecular constants of diatomic molecules from their band spectra. Derivation of the molecular constants of linear polyatomic molecules from their Raman spectra and infrared spectra. The primary reactions of photochemistry are interpreted in terms of the spectra. Herzberg, *Molecular Spectra and Molecular Structure.*

5·77. Kinetic Theory of Gases (A). Development of the kinetic theory of gases from the modern standpoint with applications to laboratory problems involving gases. Kennard, *Kinetic Theory of Gases.*

5·78. Spectra of Polyatomic Molecules (A). The different kinds of spectra of polyatomic molecules. Detailed consideration of pure rotational spectra (micro-wave region), vibrational spectra (infra-red absorption and Raman effect) and electronic spectra (visible and ultra-violet region).

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. (Alternate years.) (Not offered 1952–53.)

Research

5·90. Special Problems in Chemistry (A). Directed research and study of special chemical problems. For graduate students only.

5·912. Seminar in Inorganic Chemistry (A). Discussion of recent publications of interest to the inorganic chemist. Scope of these topics more limited than those given in 5·071. Given alternately with 5·071.

5·913, 5·914. Seminar in Organic Chemistry (A). Discussion of current journal publications in organic chemistry by graduate students and staff members.

5·915, 5·916. Seminar in Analytical Chemistry (A). Discussion of topics of current interest in analytical chemistry by graduate students and staff members.

5·931, 5·932. Seminar in Physical Chemistry (A). Discussion of topics of current interest in physical chemistry by staff members and students.

5·941, 5·942. Research Conference in Inorganic Chemistry (A).

5·951, 5·952. Research Conference in Analytical Chemistry (A).

Research (A). Research for any of the advanced degrees in inorganic, analytical, organic or physical chemistry.

ELECTRICAL ENGINEERING

Subjects 6·00 to 6·99

6·00T, 6·01T. Elementary Circuit Theory. Introduction to the physical and mathematical aspects of circuit theory. Definitions of voltage, current, charge, and the circuit elements. Resistance circuits, including choice of variables, equilibrium equations, and methods for their solution. Practical application of the solutions leading to Thevenin's theorem, reciprocity, and power relations. Introduction of the energy storage elements and the consideration of the transient and steady-state response of simple first and second order circuits in terms of physical reasoning. The impedance concept and its rôle in determining the sinusoidal steady-state behavior. Use of vector diagrams. The impedance as a function of the applied and the natural frequencies of the circuit and its interpretation in the complex frequency plane. Resonance and its physical interpretation. Amplitude and frequency scaling. The stored and loss energy functions in the sinusoidal steady-state; active and reactive power; their physical interpretations and economic implications. Behavior of more general circuits; mutual inductances; multiple resonant circuits. Polyphase and other circuits embodying symmetry. Throughout the discussions, the principle of duality and its practical application is pointed out. Introductory discussion of simple nonlinear circuits, including iron. Characteristics of magnetic materials, magnetic circuit analogies, and superposed d-c and a-c magnetization, form the concluding part. Classroom instruction supplemented by experimental work in the electrical engineering laboratories.

6·002. Transient Response of Simple Circuits. Essentially the first half of 6·00 dealing with transients.

6·003. Principles of Electrical Engineering. Steady-state alternating current theory for linear circuits with emphasis on use of exponential form of complex quantities, formulation of equations on loop or node basis, development of various equivalent circuits and circuit theorems, loci of complex functions for variable frequency. Transient behavior of linear circuits analyzed by method of transient impedances; solution of higher-degree algebraic equations; use of dimensionless variables. Simple mechanical systems and their electric-circuit analogs; electromechanically coupled systems having magnetic coupling and their electric-circuit equivalents. (Primarily for U.S. Air Force, Army and Navy Graduate Students.)

6·01. Principles of Electrical Engineering (Magnetic Circuits and Transformers). Properties of magnetic materials; magnetic circuits; transformers for power and communications circuits; polyphase circuits; transformers in polyphase circuits; basic principles of electromechanical energy conversion.

6·02. Principles of Electrical Engineering (Electronic Circuits). Characteristics of high-vacuum tubes, gas tubes and transistors. Graphical solution of nonlinear circuit problems. Piecewise-linear and linear equivalent circuits. Basic triode circuits; grounded-cathode, cathode-follower, grounded-grid. Basic transistor circuits. Capacitance, inductance, and transformer coupling. Rectifiers, push-pull. Simple transients. Elements of pulsed circuits. An elementary multivibrator. Simple resonant circuits. Elements of oscillator theory. Cascade amplifiers. Pole-zero patterns. Feedback amplifiers; loop transmission, stability, distortion.

6·031. Principles of Electrical Engineering (Electric Machinery). General theory of alternating-current and direct-current rotating machines. Application of this general theory to direct-current machines. Fitzgerald and Kingsley, *Electrical Machinery.*

6·032. Principles of Electrical Engineering (Electric Machinery). Application of the general theory developed in 6·031 to polyphase synchronous and induction machines, single-phase induction machines, control-type generators, and self-synchronous machines. Introduction to dynamic analysis of electromechanical systems containing electric machinery. Fitzgerald and Kingsley, *Electrical Machinery.*

6·04. Principles of Electrical Engineering (Power Transmission and Distribution). General survey of the engineering and economic factors affecting the transportation of electrical energy from the basic energy-conversion device to the ultimate utilization device, with primary emphasis on

Electrical Engineering Continued

the integrated-system viewpoint. Analysis of performance of individual links in the system, such as gas turbine, hydro or steam generation, overhead lines and cables with both lumped and distributed parameters, as well as network analysis of the over-all transmission and distribution system. Use of the Network Analyzer (a-c calculating board) for the study of comprehensive system problems.

6·10. Elementary Electric Circuit Theory. Discussion of the basic principles of linear passive network analysis and synthesis with the primary objective of laying a foundation adequate for subsequent expansion according to the needs of the student's field of specialization. Consideration of the transient behavior of networks in terms of the impulse and step-function response of various simple circuits, making wide use of the principles of superposition, reciprocity, and Thevenin's theorem. Close correlation of the transient and sinusoidal steady-state response through formulating the impedance function in terms of the complex natural frequencies of the network. Stress on energy and power considerations in both the transient as well as in the steady-state discussions of network behavior. Illustration of the theory with numerous practical examples. Guillemin, *Notes, Introduction to Network Analysis; Electric Circuits*, by Members of the Department Staff.

6·16. Electricity. Fundamental principles of electric and magnetic circuits and application of these principles to the theory of operation of d-c and a-c motors, transformers, and associated devices; types of d-c and a-c distribution systems; computation of loads on wiring systems; design of wiring systems and safe wiring practices; National Electrical Code; requirements for telephone service; elevators treated as traffic problem in vertical transportation.

6·17. Illumination. A study of the design of lighting systems for best seeing. Photometric units and measurements, properties of the eye, characteristics of lamps and luminaires, daylight. Moon and Spencer, *Lighting Design*.

6·18. Fundamentals of Electrical Engineering. Fundamental principles of electric and magnetic circuits 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. Classroom instruction supplemented by experimental work in the electrical-engineering laboratories. Fitzgerald, *Basic Electrical Engineering*.

6·181, 6·191. Electrical Engineering. Electric and magnetic circuit theory. Characteristics of direct and alternating-current machines, with emphasis on selection of machinery and control equipment as affected by torque requirements and duty cycles imposed by the load. Elementary theory of electronic devices and their application in circuits for measurement and control purposes. Experimental work in the electrical engineering laboratories.

6·19. Industrial Electronics. 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. Fitzgerald, *Basic Electrical Engineering*.

6·20. Electronic Control and Measurement. Analysis and design principles of electronic devices for control and measurement in engineering, as applied to phototube devices, water-level controls, sensitive wattmeters, voltmeters, ohmmeters, high-speed recording instruments, 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 of measurement; and oscillators. Emphasis on importance of the non-linear properties of electron tubes either as limitations or as useful characteristics.

6·202. Electronic Control and Measurement. Analysis and design principles of electronic devices for control and measurement in engineering. Detailed consideration of: electronic control of motors; phase-sensitive rectifiers; voltage-stabilized and current-stabilized-power supplies; power oscillators; induction and dielectric heating principles. Typical examples from commercial equipment to illustrate these principles.

6·213. Industrial Feedback Control Systems. Elements of feedback theory presented as the basis for analyzing and designing automatic control systems for industrial processing. Wide cross-section of applications taken from chemical, steel, paper, fabricating, air transportation, and electrical power industries, providing investigation which embraces electrical, mechanical, pneumatic, thermal, and hydraulic servomechanisms, regulators, and feedback control mechanisms.

6·221, 6·222. Electric Power Systems. Study of electric power generation and transmission circuits. Symmetrical components, equivalent circuits and networks for the sequence components, and circuit constants. System fault currents, single and multiple series and shunt unbalances, transient characteristics, and control and relay systems. Power generation and transmission economy, demand and energy costs, and economy loading of units and stations.

6·223, 6·224. Electrical Equipment Application Engineering. Application of electrical equipment to electricity supply systems and the economic aspects of such application. Presentation of the basic principles underlying the choice of electrical equipment for the generation, transmission, and distribution of energy and its utilization by certain major consumers.

6·23. Electrical Implementation. Analysis of methods of measurement, operation, and control for devices, processes, and systems of nonelectrical as well as electrical nature. Comprehensive problems 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; 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. Bridgman, *Dimensional Analysis;* Roters, *Electromagnetic Devices*.

6·241. Case Studies in Electrical Engineering Practice. Given by notable practicing engineers to show the whole problem faced by the engineer including the influence of such matters as economic, legal, public relations, manufacturing sales, and servicing considerations as well as technical engineering. Registration officers to be consulted about the field and instructor for any given term.

6·26. Insulators and Semi-Conductors. Comprehensive introduction to the field of vacuum, gas, liquid and solid insulation. Interpretation on a molecular basis of the properties of materials. Discussion of the applications of dielectrics in modern electrical equipment. (Not offered 1952–53.)

6·271, 6·272. Principles of Illuminating Engineering. Broad survey of the *engineering of light*, including methods of measurement, characteristics of incandescent and fluorescent lamps, flash lamps, photography, photoelectric applications, television, color, characteristics of vision, and lighting design. First term complete in itself, second term devoted to detailed re-examination of most important topics. Moon and Spencer, *Lighting Design*.

6·281. Principles of Wire Communications. 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.

6·291, 6·292. Principles of Radar. Fundamental principles of pulsed radar; analysis of radar timing circuits, modulators, indicators, and receivers; r-f transmission systems; resonant lines and cavities; t-r devices; magnetron transmitters; application of synchros and servomechanisms to radar systems. Reintjes and Coate, *Principles of Radar, Third Edition*.

Electrical Engineering Continued

6·30. Communication Network Theory. Continuation of the discussion begun in 6·00, with particular emphasis upon problems arising in the communications field and 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, including filters.

6·311. Principles of Electrical Communications. Theory and applications of vacuum tube circuits for communications systems. Basic requirements for radio communication. Detailed consideration of characteristics of modulated waves; wideband amplifiers; tuned amplifiers; nonlinear behavior of tubes; harmonic generation and intermodulation; frequency converters; detectors; audio- and radio-frequency power amplifiers; modulators, and oscillators. Noise and interference problems. Brief studies of representative radio transmitters and receivers.

6·312. Principles of Electrical Communications. Detailed studies of various communications topics. Design of inverse-feedback communications networks. Advanced study of vacuum-tube oscillators including frequency stability. Microwave generators including velocity-modulation devices and magnetrons.

6·321. Principles of Electrical Communications. 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; spherical waves; the radiating dipole; the linear antenna; electrodynamics of particles.

6·322. Principles of Electrical Communications. Application of circuit and field theories to transmission and radiation problems; transverse electromagnetic waves along transmission lines; dissipationless lines; dissipative lines; transient phenomena and modulation; recurrent structures; resonant lines; wave guides; antennas; propagation phenomena.

6·331, 6·332. Electrical Communications Laboratory. Study of experimental procedures in communications. Uses of modern laboratory instruments. Measurements on vacuum-tube circuits and passive networks at audio and radio frequencies. Microwave components, basic pulse circuits, and sound systems. Correlation of physical behavior and theory of operation. Special arrangement of programs, under certain conditions, to meet the needs of individual students.

6·34. Electrical Communications Laboratory. Special undergraduate work with vacuum-tube circuits, audio-, radio- and ultrahigh-frequency measurements and acoustics arranged to meet the needs of the individual student. Experience in design, construction, and testing of components of communications systems. Facilities available for a wide variety of experiments dealing with: amplitude- and frequency-modulated transmitters and receivers; radio navigational aids; television systems; pulse circuits; microwave devices; antennas; radar; and acoustics.

6·35. Engineering Acoustics. Characteristics of sound waves, acoustical radiating systems, acoustical elements, acoustical receiving systems, recording apparatus, and of enclosures where sounds are produced. Application of analogous electrical circuits to the solution of electromechanical problems. Detailed consideration of loudspeaker and microphone design; acoustical measuring instruments and techniques; architectural and studio acoustics; and those psychological aspects of hearing related to acoustical design. Selected problems. Beranek, *Acoustic Measurements*, 1949.

6·351. Engineering Acoustics. Presentation of the characteristics of sound waves, acoustical elements, mechano-acoustic circuits, psycho-acoustics; fundamental aspects of room acoustics and noise control. Selected problems and laboratory experiments. (Primarily for Course XIII-A.)

6·37. Principles of Television. Emphasis on transient-response and synchronization problems: transient analysis including a treatment of the superposition integral and of uniform-stretch functions: discussion of synchronization including the ideas of pulse and sweep circuits and scanning. Illustration of principles by application to transmitting and receiving systems.

6·40. Elements of Electrical Engineering. Applications of the fundamental principles of the electric and magnetic circuit and electronics to the generation, distribution and utilization of direct- and alternating-current power. Special attention is given to the study and solution of a comprehensive group of modern industrial problems with consistent emphasis upon the related principles of engineering economics. Hudson, *Engineering Electricity, Third Edition.*

6·511. Electric Power Circuits (A). Theory of equivalent networks as applied to the representation of component parts of power systems on the network analyzer. Theory of symmetrical and related components with applications to the operation of electric power systems under unbalanced steady-state conditions. Transformations among the various systems of current and voltage components through matric manipulation. Components of instantaneous currents and voltages and their use in transient problems. Comprehensive treatment of system performance in the steady state. Edith Clarke, *Circuit Analysis of A-C Power Systems, Vol. I.*

6·512. Electric Power Circuits (A). General theory of traveling waves applied to the practical problems of the protection of electric equipment from lightning and switching surges. Review of the major sources of overvoltages on power systems and protective measures employed. Discussion of circuit breaker design and switching problems with reference to the coordination of system insulation. Review of laboratory and field test techniques; practical problems in the protection field.

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). Basic analysis of systems problems arising in the planning and operation of electric power circuits. Transient two-reaction theory of machines, viewing the machine as a circuit or system element. Systems problems on steady-state operation and transient and dynamic operation during and immediately following disturbances on the system. Technical and economic implications of these problems in system planning and operation. Laboratory study of representative modern power systems on the M. I. T. Network Analyzer.

6·525. Steady-State Theory of the Metadyne (A). General theory of the Metadyne, a generalized type of rotating direct-current electromagnetic machine designed to perform a great range of regulatory, control, voltage transformation, amplification and other functions. Illustrative applications to control and other fields.

6·526. Metadyne Dynamics (A). Study of the stability of the operation of the metadynes. Causes of instability. Means of improving stability. Operation of metadynes under steady periodic currents. Operation under transient currents. Applications on actually working plants with particular emphasis on amplifying metadynes, on traction equipments, on servomechanisms.

6·535. Introduction to Digital Computer Coding and Logic (A). Survey of principles of logical design and of the elements of coding programs for large-scale digital computers, discussed from the user's point of view. Brief description of the logical structure of digital computers operating at M. I. T. and elsewhere. Interpretation of sequences of arithmetical and logical operations into digital computer instructions, with examples chosen from typical engineering, scientific, and business problems and from real-time control applications. Techniques for simplifying and improving the programming and operating of computers by the use of subroutines. Execution

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on the M. I. T. Whirlwind I computer of examples discussed in class to provide first-hand experience with automatic high-speed machines.

6·536. Machine Computation (A). Study of analog computation with emphasis on the management of variables and on the analysis of computing elements and systems. A detailed study of the logical use of the differential analyzer in the treatment of ordinary differential equations forms a basis for further study of the application of analog computing elements in the solution of a variety of mathematical problems (algebraic and integral equations, Fourier transforms, etc.). Introductory study of the accuracy of machine elements. Consideration of the computing viewpoint in analogs, simulators, signal filtering, automatic control. Some economic and operational aspects of the use of machines. Project and optional problems assigned to encourage a variety of interests.

6·537. Digital Computer Applications Practice (A). Advanced treatment of the preparation of coded programs for automatic, electronic digital computers. Techniques for handling various forms of storage and terminal equipment, for detecting errors and mistakes in programs and for controlling scale factors. Emphasis on the use of subroutines. Laboratory work demonstrating performance by Whirlwind I computer of programs prepared by the class. At least one problem of his own choice programmed by each student, as well as prepared on punched paper tape and executed on Whirlwind I computer.

6·538. Electronic Computational Laboratory (A). Study of the basic principles of digital computers by experiments on the following components: synchroscopes and pulse-viewing equipment, pulse generators, bistable circuits, binary counters, decade counters, coincidence circuits, variable delay circuits, frequency dividers, electronic distributors, matrix switches, and magnetic recording equipment. The actual programming and operation of a digital computer as revealed by the solution of several computational problems on the Model 600 punched-card calculators. Principles of electronic analogue computers treated by a study of electronic integrators, electronic differentiators, data conversion equipment, data recording equipment, and associated equipment. Work on the analogue equipment handled in project assignments.

6·54. Pulsed-Data Systems (A). Study of the processes of sampling of continuous data and of smoothing of sampled data. Analysis and design of linear systems employing pulsed data. Investigation of feedback systems employing sampled error data including stability studies of such systems. Transient response of sampled-error data servomechanisms. Study of continuous systems by numerical methods. Study of digital computer operations as data filtering, analysis and synthesis of linear digital computer programs in the frequency domain. Comparison between techniques of numerical analysis and control system design. Design of systems involving digital computers as components. Comparisons between analog and digital computers. Study of optimum linear system design as applied to discrete systems. Comparison of classical "least squares" curve fitting with optimum system design. Survey of methods for handling the approximation problem in discrete systems. Survey of physical characteristics of sampling and holding devices, of analog-to-binary decoders; summary of important considerations involved when these devices are used as components in control systems.

6·56. Mathematical Methods in Electrical Engineering (A). Discussion of selected topics from theory of linear transformations, functions of a complex variable, and closely related material forming the basis for analysis of problems in the general field of Electrical Engineering as well as in Communications and Electronic Control. Topics considered differentiation; integration and expansion of complex functions into series, including point sets and convergence criteria; multivalued functions and Riemann surfaces; types of singularities, including some physical examples afforded by vector fields; partial fraction expansions; conformal mapping functions with applications (Schwarz-Christoffel formula); complex integration including saddle-point and other appropriat methods; Hurwitz polynomials, stability criteria, positive real functions and relations to synthesis of physical systems; Fourier series as a particular form of the Laurent expansion, mean square properties, approximation properties of its partial sums, transition to Fourier and Laplace transforms, their elementary properties and applications; Hilbert transforms and their fields of applications in electrical problems. Guillemin, *The Mathematics of Circuit Analysis.*

6·561. Advanced Network Theory (A). Methods of network synthesis and their application to the design of networks for prescribed driving-point and transfer characteristics. Enlargement of elementary analysis and establishment of necessary and sufficient conditions for the realization of impedance functions. Consideration of the fundamental work of Foster, Cauer, Brune, and Darlington, as well as collaterally significant topics, illustrated with examples, the major objective being a survey of the field of synthesis rather than an exhaustive treatment of the methods themselves. Guillemin, *Communication Networks, Volume II;* Guillemin, *The Mathematics of Circuit Analysis;* Bode, *Network Theory and Feedback Amplifier Design.*

6·562. Advanced Network Theory (A). Reassessment of principal topics in 6·561 in light of more adequate mathematical interpretation, and consideration of practical design problems illustrating the ultimate response characteristics obtainable from linear passive networks with regard to transient as well as steady-state behavior. Discussion of design of filters and other networks for special applications. Fourier and Laplace transform methods and Hilbert transforms with applications. Guillemin, *Communication Networks, Volume II;* Guillemin, *The Mathematics of Circuit Analysis;* Bode, *Network Theory and Feedback Amplifier Design.*

6·567T. Switching Circuits (A). Treatment of the basic principles governing the interconnection of two-valued switching elements to form networks and systems for automatic control. Development and interpretation of switching algebra and its application to the analysis and synthesis of switching circuits. Realization of algebraic switching functions in terms of networks containing relay contacts, electronic elements, and semiconductors. Introduction to the design of sequential systems. Selected projects for individual design and laboratory execution.

6·568. Switching Circuits (A). Advanced aspects of switching circuit theory. Procedures for minimization of switching networks. Circuits for performing specific functions such as selection, code translation, counting, computation, checking. Combination of functional circuits into systems; development of techniques applicable to the design of automatic control systems used in industrial control, telephone switching, digital computation and other systems where response is a function of the combination and sequence of discrete input conditions. Individual and group laboratory projects.

6·571. Statistical Theory of Communication (A). Discussion of messages and noise as stationary random processes. Statistical characteristics of messages and noise, particularly correlation functions and spectra. Determination of correlation functions by electronic means. Detection of signals in the presence of noise by correlation. Theory of the optimum filter, predictor, compensator, differentiator, and general linear system operator. Synthesis of linear systems by means of normal and orthogonal functions.

6·573. Statistical Theory of Noise and Modulation (A). Introduction to probability and statistics. Derivation of statistical properties of shot noise. Noise in linear systems. Noise figures of amplifiers. Noise through nonlinear devices. Quadratic and linear detectors and mixers. Application of the characteristic function method to more general nonlinear devices. Detection of threshold signals.

6·574. Statistical Theory of Information (A). Quantitative study of communication systems based on information theory. Definition of a unit of information; communication by discrete, quantized signals in the absence of noise; efficient codes; effect of noise; channel capacity; equivocation; reduction of equivocation by coding. Extension of the theory to the case of continuous signals; optimum detection; multi-

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plexing; channels in cascade. Application to specific problems of practical interest, including problems outside the field of electrical communications.

6·581, 6·582. Transients in Linear Systems (A). Formulation from physical considerations, of differential equations of circuit and field problems in electrical, mechanical, thermal and acoustical systems permitting linear treatment; analogies; mathematical studies of transient disturbances in these systems, using Laplace transformation method to solve ordinary and partial differential equations. Formulation of difference equations of engineering problems and their solution using the Laplace transformation. Provision of requisite background in complex variable theory for use of the method.

6·585. Application of Integral Equations in Electrical Engineering (A). Applications of integral equations to various problems in electrical engineering, such as problems of electrostatics, skin effect, inter-reflections of radiant energy, and vibrations. Particular attention devoted to the solution of integral equations by approximating the kernal and by use of various numerical and graphical methods.

6·586. Engineering Applications of Field Theory (A). Engineering solutions of the Laplace, Poisson, diffusion, and wave equations in three-dimensional space. A supplement to familiar electric-circuit theory (one-space dimension), showing what happens when the field spreads into a three-dimensional space. Method of separation-of-variables employed throughout. Practical applications to electrostatic fields, magnetic fields, heat flow, diffusion, acoustic and electromagnetic waves.

6·587. Two-dimensional Fields in Electrical Engineering (A). Conformal transformation in the complex plane, Schwarz-Christoffel transformation, applications to engineering problems of current distribution, heat flow, electrostatics, and magnetism. Other methods of handling two-dimensional problems, particularly the graphical method and the numerical-approximation or "relaxation" method of Southwell. L. V. Bewley, *Two-dimensional Fields in Electrical Engineering (1948)*.

6·59. Communications Laboratory (A). Advanced work on a substantial problem or selected group of problems. Opportunity for specialization in pulse systems including television, networks, microwaves, antennas, and acoustics. For students with a mature independence of attack and investigatory ability. Conferences, with opportunity for detailed criticism and discussion.

6·605. Servomechanisms (A). Principles of dynamic behavior of feedback control systems with emphasis upon a quantitative study of system synthesis to meet a wide range of performance specifications. Use of the Laplace transformation as a basis for deriving transfer functions and block diagrams of components and systems for the study of both transient and steady-state behavior, and for interrelating the time and frequency response. Dimensionless magnitude and phase characteristics of transfer functions expressed as vector contours to a linear or logarithmic scale and their relation to system performance treated graphically and in terms of time functions, frequency function, and error coefficients. Brown and Campbell, *Principles of Servomechanisms*.

6·606. Servomechanisms (A). Advanced feedback control system theory embodying quantitative investigation of control system response to random disturbances, the power consumption of feedback devices, the operation of pulsed and sample data types of controller, the design procedures for off-on and other types of discontinuous controllers. Emphasis upon systems involving electric and hydraulic power transmissions, electro-mechanical-hydraulic transducers, magnetic viscous clutches, magnetic amplifiers, and modern data transmission systems. Laboratory work on quantitative measurement and evaluation of system performance.

6·607. Servomechanisms Laboratory (A). Quantitative measurement and design of a wide variety of typical feedback control systems. Program varied to meet particular needs of the student. Project type of problems recommended in contrast to unrelated studies on components.

6·608. Servomechanisms (A). The content of subject 6·606 without the laboratory work. Registration accepted only where satisfactory accomplishment in laboratory work can be demonstrated.

6·61. Atomic Particles and Radiation (A). Fundamental mechanisms in the passage of electricity between electrodes in high vacuum and in gases at normal and high pressures. Principles and techniques in the production of voltages in the 100 to 5000 kv. range by electrostatic, alternating-current, and impulse voltage sources. Electrodynamics of high-energy charged particles; analysis of Van de Graaff accelerators, cyclotrons, betatrons, and synchrotrons. Physical properties of high-energy X-rays, cathode rays, neutrons, and radiations from artificially radioactive materials. Application of high voltages and ionizing radiations to power engineering, medicine, biology, and industry.

6·621. Microwave Circuits (A). Analysis and applications of properties of electromagnetic fields in uniform cylindrical waveguides, with emphasis on those properties which are independent of the shape of the cross-section; reduction of waveguide and discontinuity problems to equivalent transmission line and network problems; matching elements, cavity resonators, and coupling devices; fundamentals of microwave network design.

6·622. Antennas (A). General theory of radiation and its application to the analysis of representative types of antennas; emphasis placed on the design of antenna arrays, microwave reflectors, and lenses.

6·623. Principles of Pulse Circuits (A). Analysis of basic circuits applicable to radar, television, pulse-modulation communication systems, high-speed time measurement, computers and general pulse instrumentation. Graphical and linear-approximation methods applied to overdriven amplifiers, multivibrators, blocking oscillators and cathode-ray-tube sweep circuits. Consideration of counting circuits, pulse-forming networks and pulse amplifiers.

6·626. Principles of Frequency Modulation (A). Typical transmitting and receiving circuits illustrating the special techniques of frequency modulation. Reactance tubes, phase-variation transmitters, centre-frequency stabilizers, limiters, discriminators, interlocked-oscillator detectors. Spectra. Comparison of common-channel, multipath and impulse interference on amplitude modulation and frequency modulation.

6·631. Principles and Applications of Gaseous Electronics (A). Electrokinetic theory of gases, including free paths, mobility, diffusion, ionization, recombination and space charge effects. Potential distribution between electrodes immersed in a gas, and theory and characteristics of glow, spark and arc discharges. Grid control of arc tubes, including mercury and hydrogen thyratrons, ignitrons. Spark tube control for d-c pulses and microwave switching. Gaseous light sources. Current voltage and energy considerations in circuit interruption involving arcs. Cobine, *Gaseous Conductors*. (Alternate years.)

6·632. Electronics in Instrumentation, Control, and Energy Utilization (A). Principles of analysis and design of electronic instruments for measurement and control systems including nuclear power, spot welders, and stroboscopes. Engineering application of electronic apparatus with emphasis on counting and timing methods, polyphase rectifiers, grid-controlled rectifiers, inverters, and voltage and current stabilizers.

6·633. Electronic-Circuit Theory (A). Analysis of circuits employing electron tubes. Characteristics of high-vacuum tubes, critical review of graphical and equivalent-circuit methods used in amplifier analysis, push-pull amplifiers, conditions for maximum power in nonlinear systems, and general feedback-amplifier theory (based to some extent on Bode, *Network Analysis and Feedback-Amplifier Design*).

6·64. Dielectric Phenomena and Materials (A). Study of the response of matter to electric, magnetic and electromagnetic fields. Discussion of the parameters ϵ, μ and σ of Maxwell's equations, the macroscopic phenomena of polarization and their interpretation in terms of molecular physics,

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An understanding of the properties and performance of insulators, semiconductors and conductors, and an appreciation of the present research problems obtained by proceeding from a consideration of atoms and molecules in the gaseous state to liquids and solids. A field of common interest to physicists, chemists and electrical engineers with the lectures directed to students of the three departments.

6·651, 6·652. Electric Power Systems (A). Generation and transmission of electrical energy. Power system planning and interconnection. Thermal efficiency and commercial economy of various heat cycles. Equivalent circuits, grounding systems, primary and secondary networks, Cable circuits and insulation characteristics. Relay characteristics in terms of circuit constants. Load curves, theory of incremental heat rates, economic conductor sizes, generation and transmission costs, rate structures and incremental costs and loading.

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.

6·691. Advanced Acoustics (A). Theoretical and practical foundation for acoustical research. Theoretical portions on derivation of wave equations, including viscosity, heat conduction and vorticity; statistics of noise; distribution of sound in rectangular rooms and ducts; propagation of sound in acoustical materials. Practical portions on psychological phenomena in acoustics with demonstrations; design of acoustical materials and broadcast studios. Selected problems.

6·692. Advanced Acoustics (A). Advanced applications of acoustics. Practical portions covering design of auditoria; advanced acoustic measurements; instrumentation for and trends of research in ultrasonics; industrial applications of acoustics. Theoretical portions covering derivation of sound distribution in large auditoria; advanced aspects of sound waves in rooms. Selected problems.

6·694. Electro-Acoustic Devices (A). Principles and apparatus involved in the production, measurement, transmission and reproduction of sound by electrical means. Laboratory measurements of the performance of transducers. (Alternate years. Not offered 1952–53.)

6·695. Special Problems in Acoustics (A). Advanced problems in acoustics, electro-acoustics or vibrations. Opportunity for individual study in the Acoustics Laboratory under a staff member.

6·73. 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.

6·74. Advanced Electrical Machinery 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 Measurements 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. Twelfth Edition*, 1947.

6·756. Electrical Measurements Laboratory. For college transfer students who have been allowed partial credit for 6·75 and 6·76.

6·76. Engineering Electronics Laboratory. Characteristics of electronic devices and their use in engineering applications, including rectifiers, thyratron control circuits, amplifiers and oscillators.

6·78. Electrical Machinery Laboratory. Polyphase circuits, symmetrical components, transformers, single and polyphase induction motors, and power electronics. Ricker and Tucker, *Electrical Engineering Laboratory Experiments, Fourth Edition; Instructions for Students in Electrical Engineering Laboratories, Thirteenth Edition*, 1949.

6·781. Electrical Machinery Laboratory. Steady-state and dynamic aspects of synchronous machines, single and polyphase induction motors, servo motors, rotating amplifiers, regulating systems, transformers, and power electronics. *Textbooks same as for* 6·78.

6·79. Electrical Machinery Laboratory. Steady-state and transient behavior of synchronous machines, artificial transmission lines, servo motors, metadyne machines, regulating systems, and special purpose machinery. *Textbooks same as for* 6.78.

6·80. Electrical Measurements Laboratory. For Electrical Engineering students who desire work in addition to that included in any one of subjects 6·75, 6·76, 6·83, or 6·84, and for any other students requiring a special program in electrical measurements laboratory. Arranged to suit the requirements of the individual student.

6·82. Electrical Measurements Laboratory. Selected topics in the field of electric and magnetic measurements; properties of alternating- and direct-current circuits; electron tubes and their applications as amplifiers, oscillators, and rectifiers; construction and use of the cathode-ray oscilloscope.

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. Laboratory projects performed by students under conditions simulating industrial practice. Practical projects devised by students from general field of material presented in 6·23, subject to counsel of instructor and limitations of equipment.

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, Thirteenth Edition*, 1949.

6·86. Electrical Machinery Laboratory. For Electrical Engineering students who desire work in addition to that included in 6·78, 6·781, or 6·79, and other students requiring a special program in electrical machinery laboratory. Arranged to suit the requirements of the individual student.

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 cooperative students in testing, manufacture, engineering and research in plants of the General Electric Company located in Lynn, Schenectady, Pittsfield, Syracuse, Erie, Bridgeport, and Philadelphia. The output of this company ranges from minute vacuum tubes to heavy power units, and embraces the fields of power, communications, illumination, and electronics.

6·911—6·914. Boston Edison Public Utility Practice. Work done by cooperative students in maintenance of lines and of electric and steam plants, testing and standardizing of equipment, conduct of sales department, engineering and research related to public utility problems.

6·941—6·944. Bell Telephone Laboratories. Work performed by cooperative students in the development of communication apparatus, circuits and equipment for the Bell Telephone System.

6·951—6·954. General Radio Industrial Practice. Work done in the plants of the General Radio Company, Cambridge, in research, engineering, manufacture and testing of high-grade measuring instruments especially adapted to the fields of communications and electronics.

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6·961—6·964. PHILCO CORPORATION INDUSTRIAL PRACTICE. Work done by cooperative students in testing, manufacture, engineering and research in the plants of the Philco Corporation in Philadelphia, Pa., which operates an experimental television broadcasting station and specializes in the manufacture of communication and electronic devices.

6·971—6·974. AMERICAN GAS AND ELECTRIC SERVICE CORPORATION PRACTICE. Work done by cooperative students in the field of high-voltage transmission and intermediate-voltage distribution. Includes maintenance, operation, testing, as well as system planning. Opportunity to visit many of the steam and hydraulic plants of this organization which is spread out from North Carolina, through Virginia, Ohio, and Indiana. Research and development in 500 kv, 60 cycle transmission as well as in many other phases of public utility practice.

6·981—6·984. NAVAL ORDNANCE LABORATORY. Work performed by cooperative students in the field of acoustics, physical optics, terrestrial magnetism, piezoelectricity, explosive phenomena, interior ballistics, electrochemistry, X-ray techniques, mechanical computation, applied statistics, numerical mathematical methods, exterior ballistics, gas dynamics, supersonic aerodynamics, hydrodynamics, plastics research and technology.

6·991—6·994. AIRFORCE CAMBRIDGE RESEARCH LABORATORIES. Work performed by cooperative students in the field of microwave optics, solid state physics, geophysics, communication and radar electronics. Construction, maintenance, testing, analysis and circuit design. Participation in varied problems of organized research directed primarily toward National Defense.

BIOLOGY

SUBJECTS 7·00 TO 7·99

7·01, 7·02. GENERAL BIOLOGY, I AND II. Introduction to the study of plant and animal organisms, including man. First Term: Nature of life; relation of biology to physics and chemistry; cell theory; physical structure of protoplasm; how cells work; synthesis and food; food requirements; digestion; systems of the animal body (anatomy — physiology); growth; reproduction; heredity; introduction to members of the plant kingdom. Second Term: Introduction to members of the animal kingdom, ecological principles, plant and animal classification, evolution, cytology, histology, cytochemistry, plant and animal diseases, viruses, immunity, history of biology, biological institutions and interests; future of biology.

7·03. GENETICS. Discussion of the facts and theories of heredity and their relation to the present state of biological theory in general.

7·10. GENETIC CYTOLOGY. Lectures and laboratory exercises considering the cell as a structural and functional unit, with equal emphasis on the roles of nucleus and cytoplasm in cellular processes and in relation to the phenomena of heredity, variation, and mutation in organisms. Discussion of structural modifications for specific physiological activities (contractility, secretion, etc.) and an introduction to the principles of cytochemistry.

7·11. EMBRYOLOGY. Classroom and laboratory work on development of animals from the germ cells to organ systems.

7·14. COMPARATIVE ANATOMY. Comparative gross anatomy of vertebrates. Laboratory work consisting of the dissection and study of the structure. Classification and general zoölogy of vertebrates.

7·19. GENERAL PHYSIOLOGY I. Physical chemical basis for the structure and colloidal properties of protoplasm.

7·20. GENERAL PHYSIOLOGY II. 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. Laboratory coordinated with the topics of 7·19.

7·212. GENERAL PHYSIOLOGY LABORATORY II. Laboratory coordinated with the topics of 7·20.

7·31, 7·32. BIOLOGY SEMINAR (A). Designed to give graduate students experience in critical evaluation of research and in public speaking by presenting oral reports of this work before staff and students.

7·50. PHYSICAL CHEMISTRY OF PROTEINS (A). Considerations of corpuscular proteins including fractionation, physical-chemical characterization, internal structure, surface structure, and modification by physical and chemical agents. Examination of protein interactions such as the corpuscle-fibril transformation and antigen-antibody interactions.

7·51. PHYSICAL CHEMISTRY OF PROTEINS LABORATORY (A). Laboratory experiments designed to illustrate the principles of 7·50.

7·80. BIOCHEMISTRY. 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 enzymes emphasizing their general properties; kinetics of reactions catalyzed by them; conditions which control their activity.

7·811. ENZYMOLOGY LABORATORY (A). Study of the methods of purification of enzymes, determination of their catalytic activity and chemical properties, as well as effects of environmental factors on enzymes.

7·82. ADVANCED BIOCHEMISTRY (A). Lectures and laboratory exercises emphasizing current trends in biochemical investigation and illustrating special problems, techniques and approaches of biochemical research; training in the planning and solution of biochemical problems and presentation of results.

7·831. BIOCHEMISTRY OF MICROORGANISMS. General survey course covering the biology, chemistry and physiology of the yeasts, molds, and bacteria. Emphasis placed on modern developments in the field, especially as they contribute to an understanding of general processes in plant and animal life. Historical, taxonomic and morphologic considerations of microbiology given as a background. Laboratory work on various general techniques of microbiology as well as quantitative aspects of the metabolic activities of microorganisms.

7·832. BIOCHEMISTRY OF MICROORGANISMS (A). Emphasis on quantitative aspects of the metabolic activities of microorganisms. Investigation of problems in the general biochemistry of yeasts, molds, and bacteria, by analytical and research methods now in use in various laboratories. Isolation and identification of various metabolic products, metabolic balance sheets, and respiration studies.

7·85. BIOPHYSICS I. Optical methods useful in biochemical and biological research. Techniques used in microscopy (including ultra-violet and electron microscopy), polarization optics, and X-ray diffraction.

7·86. BIOPHYSICS II (A). Spectroscopy, photography, isotopic tracers, the ultracentrifuge, and other physical equipment and techniques applicable to biological and biochemical problems. Biological effects of radiant energy.

7·882. BIOPHYSICS LABORATORY (A). Laboratory coordinated with the topics of 7·86.

Biology Continued

7·90. Seminar in Enzymology (A). Designed to acquaint the student with recent advances in the field of enzymology. Special emphasis on enzymes concerned with respiration, phosphorylation, and intermediary metabolism.

7·91, 7·92. 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. 7·91T: principles of electrical measurements and the construction and operation of electrical instruments 7·92: principles of electronics and electronic devices, including amplifiers, oscillographs, photoelectric cells, X-ray tubes, and dosimeters.

7·93. Selected Topics in Biology (A). Class work in various fields of biology not covered by the regular subjects of instruction.

7·941, 7·942. Research Problems (A). Directed research in a field of biological science, but not contributory to graduate thesis.

7·95. Electron Microscopy (A). Principles of electron optics, the electron microscope, interaction of electrons with matter, methods in electron microscopy, applications of electron microscopy.

7·96. Electron Microscopy Laboratory (A). Properties of electron lenses, use of the electron microscope, preparation of specimens, techniques in electron microscopy, selected experiments.

7·97. Tissue Ultrastructure (A). Discussion of the molecular architecture of cell and tissue constituents as revealed by electron microscopy, X-ray diffraction, polarization optics and cytochemical reactions. Study of nerve, muscle, connective tissue and other fibrous structure. (Alternate years.)

7·98. Tissue Ultrastructure (A). Continuation of 7·97, Study of chromosomes, plasma membrane, mitotic mechanisms and cytoplasmic constituents (mitochondria, plastids, particulates). (Alternate years.)

PHYSICS

Subjects 8·00 to 8·99

General Physics

8·00. Entrance Physics. Entrance requirement in Physics. No laboratory work is given.

8·001. Physics. Brief survey of physics for graduate students in Architecture or Economics to remove undergraduate deficiencies in physics.

8·002. Science Teachers Program. For teachers of science in secondary schools. Review of fundamentals of physics and chemistry, together with lectures on current developments in physics, chemistry, biology, geology, and meteorology and inspection trips to various Institute laboratories. Informal meetings for general discussions of problems and methods of teaching science.

8·01. Physics (Mechanics). Fundamental laws of particle mechanics, preceded by geometrical optics. Free use of elementary calculus during second half of the subject.

8·012. Physics (College Transfer). Given first term for college transfer students already allowed partial credit for 8·01 and 8·02 on the basis of a previous substantial course in general physics. Not to be taken by any student who must take or repeat 8·01 and 8·02.

8·02. Physics (Mechanics and Waves). Divided into two parts: (a) rigid body mechanics, hydrodynamics and elasticity; (b) oscillations and waves — mechanical, acoustic and optical. Free use of elementary calculus throughout.

8·03. Physics (Electromagnetism). Fundamental laws of electricity and magnetism and their applications to circuits and the dielectric and magnetic properties of matter. Electrostatics, direct currents and magnetic fields, and time-varying electromagnetic fields. Free use of calculus.

8·031. Physics (Electromagnetism). Fundamental laws of electricity and magnetism presented from the standpoint of field theory. Electrostatics, steady currents and their magnetic fields, and time-varying electric and magnetic fields. Designed primarily for students intending to pursue further work in electromagnetism and modern physics. Free use of calculus throughout.

8·032. Physics (Electromagnetism). Essentially the same material as in 8·03, but designed primarily for the needs of students in the School of Architecture and Planning and the School of Humanities and Social Studies.

8·034. Physics (College Transfer). Given second term for college transfer students already allowed partial credit for 8·03 and 8·04 on the basis of a previous substantial course in general physics. Not to be taken by any student who must take or repeat 8·03 and 8·04, or 8·031 and 8·041, or 8·032 and 8·042.

8·04. Physics (Modern Physics). Elementary kinetic theory of gases, introduction to atomic structure and topics in modern physics.

8·041. Physics (Electromagnetism and Electromagnetic Theory of Light). Continuation of 8·031. Electromagnetic waves, electric and magnetic properties of matter. Electromagnetic theory of light and radiation. Quantitative character of 8·031 continued with free use of calculus.

8·042. Physics (Modern Physics). Essentially the same material as in 8·04, but designed primarily for the needs of students in the School of Architecture and Planning and the School of Humanities and Social Studies.

8·05. Atomic Physics. The atomic structure of matter, Avogadro's number, electric, magnetic and optical properties of atoms and molecules, X-ray diffraction. Mechanics of elementary particles, Rutherford's experiment and the nuclear atom. Optical and X-ray spectra, energy levels and photons. Introduction to theory of relativity and wave mechanics. The vector model. Pauli's exclusion principle and the periodic system of elements.

8·06. Nuclear Physics. Survey of the principal fields in nuclear physics designed for undergraduates. Static properties of atomic nuclei, binding energy, nuclear models. Radioactive transformations. Properties of charged particles, neutrons and gamma rays. Transmutation, fission, artificial radioactivity.

8·07. Thermodynamics and Statistical Mechanics. Equations of state of solids, liquids, and gases, and discussion of specific and latent heats. First and second laws of thermodynamics and general thermodynamic formulae with applications to the properties of matter. Elementary statistical mechanics and kinetic theory with applications to the theory of specific heats and black body radiation.

8·071. Thermodynamics and Statistical Mechanics. Similar to 8·07, but for non-physics majors. First and second laws of thermodynamics, equations of state, thermodynamic functions. Elementary kinetic theory, mean free path, transport phenomena. Elementary statistical mechanics, entropy and probability, fluctuations.

8·08. Electronics. Electron ballistics, including introductory relativistic mechanics and principles of high energy particle accelerators; theory of space charge; fundamental processes in low pressure gaseous discharges, Townsend discharge, theory of probes; Fermi-Dirac statistics, thermionic

Physics Continued

emission, Schottky effect, high field emission, secondary emission and photoelectric effect.

8·09. Techniques of Experimental Physics. 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.

8·101. Atomic Structure Laboratory. Study of selected topics in modern physics, including absorption and emission spectra, Zeeman effect, inelastic impacts, photoelectric effect, X-rays, Rutherford scattering.

8·102. Electronic Devices Laboratory. Characteristics of selected electronic devices. Passive networks, including filters, a-c electronic devices such as multivibrators, elementary microwave electronics, electrical apparatus of nuclear physics, including Geiger counters and scaling circuits.

8·11. Experimental Physics. Introduction to experimental research techniques. Assigned laboratory exercises, including setting up and carrying through experiments concerned with fundamental principles in optics, nuclear, atomic, and molecular physics. Designed to bridge the gap between elementary laboratory and research in modern physics.

Acoustics

8·13. Vibration and Sound. Steady-state and transient analysis of vibrating systems: simple and coupled oscillators, strings, membranes; electromechanical coupling and motional impedance; radiation and transmission properties of sound; acoustic impedance, filters and tuned lines; sound waves in rooms.

8·131. Experimental Acoustics. 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 room acoustics.

8·132. Architectural Acoustics. Principles of acoustical designing to achieve good hearing conditions and control of noise in rooms and buildings; design criteria; analysis of sound absorption and transmission; acoustical properties of room shapes, structures, and surface materials; laboratory demonstrations.

8·135. Special Problems in Acoustics (A). Advanced problem in acoustics or vibrations with assigned reading and consultations.

Optics and Photography

8·15. Photography. Elementary subject primarily an elective for students not in Course VIII.

8·16. Optics. Fundamental principles of geometrical, physical and physiological optics. Refraction at spherical surfaces, thick lenses, the limitation of rays by apertures, lens aberrations, the resolving power of optical instruments, diffraction, interference, polarization, radiation light sources, the eye, photometry, color, photoelectricity, the design and construction of optical instruments, stereoscopy, and description of the performance of well-known optical systems such as telescopes, microscopes, photographic objectives, and projection systems.

8·17. Color Measurements. Measurement and specification of color in the objective and subjective sense and the application of such methods to industrial problems. Experiments illustrate the photometric and chromatic properties of the human eye and give experience in the technique of spectrophotometry and colorimetry.

8·18. Special Problems in Optics (A). Experimental work in the optics laboratory with assigned reading and consultation.

Electronics

8·21. Physical Electronics (A). Introduction to the theoretical and experimental aspects of physical electronics, including electron emission from solids (thermionic emission, photoelectric emission, secondary emission and strong-field emission); excitation of electrons in luminescent materials and other solids; excitation and ionization of gases by electrons; and gas discharge phenomena.

8·212. Physical Electronics Laboratory (A). Lectures and laboratory for the development of techniques useful for research in physical electronics and their application to the experimental investigation of important phenomena of physical electronics.

8·231. Electrical Discharges in Gases (A). Fundamental processes of electron emission from cathodes and interaction with gas. Various types of discharges, including ultra-high frequency discharges, the Townsend discharges and breakdown, Geiger-Mueller tubes, the cathode fall, plasma, and anodic parts of glow discharges and arcs.

8·232. Theory of Electrical Discharges in Gases (A). Development of the Boltzmann transport equation and its application to the velocity distribution of electrons in various types of discharges. Calculation of the Townsend coefficients and of breakdown potentials. (Alternate years.)

8·25. Special Problems in Electronics (A). Advanced problem in electronics, with assigned reading and consultation.

X-rays and Crystal Structure

8·27. X-rays and Crystal Physics. X-ray apparatus, production of X-rays, absorption, scattering, refraction, X-ray spectra. Theory and application of the diffraction of X-rays in matter to the determination of the structure of crystals, and the atomic and molecular arrangement in liquids and amorphous solids. General review of the structure of matter as determined by X-ray diffraction analysis.

8·28. X-Ray Diffraction (A). Selected topics of advanced nature in the 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.

8·30. Special Problems in Crystal Physics (A). Advanced problem in X-ray diffraction or crystal physics with assigned reading and consultation.

Spectroscopy

8·32. Line Spectra (A). Experimental and theoretical phases of spectroscopy. Production of spectra and spectroscopic analysis. Characteristics of atomic spectra and their interpretation in terms of current theories of atomic structure.

8·34. Special Problems in Spectroscopy (A). Experimental work in the Spectroscopy Laboratory, with assigned reading and consultation.

Solid State and Structure of Matter

8·361. Quantum Theory of Matter I (A). Physics of atoms, interatomic forces, and the solid state, treated from the point of view of quantum mechanics, intended for students of metallurgy, chemistry, and other fields, as well as physics. Schrödinger's equation. Atomic structure. Interatomic forces, homopolar and ionic bonds, valence and ionic compounds.

8·362T. Quantum Theory of Matter II (A). Continuation of 8·361. Metallic lattices, energy bands, properties of metals and insulators. Lattice defects in crystals. Properties of alloys. Dielectric and magnetic behavior of solids. Nuclear vibrations in molecules and solids. Irreversible processes, diffusion of atoms. Interaction of matter and radiation.

8·363. Selected Topics in Theory of Solids I (A). Discussion of selected topics, changing from year to year, chosen from the theory of semiconductors, dielectric and magnetic behavior of solids, lattice defects in crystals, properties of alloys, and other subjects.

8·364. Selected Topics in Theory of Solids II (A). Continuation of 8·363.

Physics Continued

8·38T. Special Problems in Magnetism (A). Either experimentation or study in some aspect of magnetic phenomena.

8·411. Statistical Thermodynamics I (A). Principles of thermodynamics. Conditions of equilibrium and stability. The thermodynamic potentials. Derivation of the thermodynamic formulae. Phase transitions of the first and second kind. Ferroelectricity. Nernst's law. Statistical foundations. H-theorem. Ensembles. Canonical and microcanonical distributions. Fluctuations. (Alternate years. Not offered 1952–53.)

8·412. Statistical Thermodynamics II (A). Statistical mechanics of special systems. Ideal gases. Boltzmann, Fermi-Dirac and Bose-Einstein statistics. Real gases. The adiabatic method. Polyatomic molecules. Solids. Lattice vibrations and specific heat. Electronic structure of solids. Metals, insulators, semiconductors. Irreversible processes. Electrical and heat conductivity. Relaxation effects. Para-, dia-, and ferromagnetic properties of matter. Phase transitions in solids. Outline of a theory of liquids. (Alternate years. Not offered 1952–53.)

8·42. Low Temperature Physics (A). Experimental and theoretical discussion of phenomena at very low temperatures, including the third law of thermodynamics, specific heats, magnetic susceptibilities, the production of low temperatures, magnetic cooling, the properties of liquid helium, superconductivity, and second-order phase transitions.

8·43. Microwave Physics (A). Lectures and experiments on microwave methods appropriate to physics, and the physical problems that can be investigated by microwaves. Standing wave measurements, impedance of cavities, properties of microwave circuits, oscillators, and measuring equipment. Application to electrical conductivity of solids, paramagnetic and ferromagnetic resonance absorption, microwave processes in gaseous discharges, and molecular spectroscopy in the microwave region, each topic treated by a man active in the particular field.

8·45. Special Problems in Solid State Physics (A). Advanced problems in the physics of the solid state, with assigned reading and consultation.

Nuclear Physics

8·511. Nuclear Physics I (A). Advanced experimental nuclear physics, including description of the properties of nuclei and nuclear transformations, observational methods and instruments and correlation of experimental results with current theory. Charge, mass, radius, nuclear moments, statistics, parity, and selection rules for nuclear transitions. Interaction between particles, binding energy, nuclear models. Radioactive transformations, theory of statistics and fluctuations.

8·512. Nuclear Physics II (A). Continuation of 8·511. Ionization, scattering, and radiative losses for swift charged particles. Properties of neutrons. Origin of gamma rays and their interaction with matter. Transmutation; fission; reactions induced by charged particles, gamma rays, and neutrons; excitation functions. Artificial radioactivity, nuclear spectroscopy.

8·513. Nuclear Physics Laboratory (A). Study of the properties of particles from natural, artificial and fission disintegrations and the corresponding measuring instruments. Use of counters, coincidence amplifiers, ionization chambers, and the cyclotron.

8·52. Advanced Applied Nuclear Physics (A). Advanced applied nuclear physics. Physical problems involved in the use of radioactive and stable isotopic tracers. Industrial and engineering applications. Units, standards, instrumentation, and techniques. Biological effects of radiation. Physical principles of radiation therapy and dosimetry. Occupational hygiene in nuclear physics. Radiation hazard evaluation. Shielding. Safe handling and disposal of radioactive materials.

8·541. Advanced Topics in Nuclear Physics I (A). Intensive analysis of basic experiments. Observation of the apparatus in use, and computation of fundamental quantities from results of current research. Major topics are: (1) Nuclear forces; neutron and proton scattering and meson production, using Van de Graaff generators, cyclotron and synchrotron. (2) Electromagnetic interactions; spins and moments of nuclei from experiments with molecular beams, microwave resonances, and angular correlations of nuclear emanations.

8·55. Theory of Nuclear Structure (A). Review of the current theories of the structure of atomic nuclei. Nature of internuclear forces. Calculation of nuclear binding energies, collision, excitation functions for transmutation, fission including reactions induced by neutrons, light or heavy charged particles, gamma rays. Theory of alpha and beta radioactivity.

8·56. Cosmic Rays and High Energy Phenomena (A). Mesons and their occurrence in cosmic rays and interaction with nuclei and heavy particles, showers, cascades. Artificial production of mesons and their properties.

8·57. Neutron Physics, with Applications to Nuclear Energy (A). Properties, production and interactions of neutrons. Measurements of nuclear cross sections. Slowing-down, resonance capture and diffusion of neutrons. Elementary theory of homogeneous and heterogeneous nuclear reactors. Time behavior, critical size, control and shielding of nuclear reactors. Design, construction and operation of nuclear power plants.

8·60. Special Problems in Nuclear Physics (A). Experimental work on radioactivity, nuclear bombardment, and general nuclear research, with assigned reading and consultation.

Theoretical Physics

8·71. Introduction to Theoretical Physics I (Mechanics) (A, except for Course VIII). Mechanics of particles, planetary motion, rigid bodies, vibrating particles, vibrating strings and membranes, elasticity and hydrodynamics. Use of Lagrange's equations and generalized coordinates, ordinary and partial differential equations, Fourier series, and vector analysis.

8·72. Introduction to Theoretical Physics II (Electromagnetic Theory) (A, except for Course VIII). Electrostatics and magnetostatics. Maxwell's equations, the potentials, Poynting's theorem. Plane waves in empty space, reflection and refraction. Wave guides and resonant cavities. Spherical waves, field of oscillating dipole. Radiation from antennas and antenna arrays, and from atoms and molecules. Interference, diffraction, scattering. Electron theory of dielectric constant, permeability, and polarization.

8·731. Introduction to Quantum Theory I (A). Qualitative discussion of quantum phenomena, relation to classical mechanics, Schroedinger formulation. Motion of free particles, one dimensional problems, transmission through potential barriers, binding, virtual levels using both exact and approximate methods. Central force fields, Zeeman and Stark effects scattering. Many-body problems, complex atoms, molecules, valence. Interaction with radiation.

8·732. Introduction to Quantum Theory II (A). Operator formulation of quantum theory. Matrix mechanics. Symmetry and integrals of motion. Generalized angular momenta. Pauli spin theory, composition of angular momenta. Perturbation theory, variational methods, etc. Many-body problems. Applications to nuclear physics including the two- and three-body problems, binding energy of light nuclei, scattering of particles by nuclei, alpha decay.

8·791. Methods of Theoretical Physics I (A). Solution of physical problems systematized by grouping them according to the partial differential equation they satisfy. Boundary conditions and methods of solution peculiar to each equation, including separation of variables, eigenfunctions, Green's function, integral equations, variational and perturbation procedures, integral representations, conformal transformations. Applications to problems in electrostatics, hydrodynamics, acoustics, quantum mechanics, etc.

Physics Continued

8·792. Methods of Theoretical Physics II (A). Continuation of 8·791, with emphasis on solutions for vector fields, electromagnetic fields, elasticity, etc. Special emphasis given, in alternate years, to either: (1) Electromagnetic wave theory, including wave guide theory, radiation scattering and propagation of microwaves, etc.; or (2) Relativity, including special relativity, relativistic dynamics with application to particle accelerators, selected topics in general relativity.

8·80. Advanced Mechanics (A). Transformation theory of dynamics, perturbation theory, theory of orbits. Applications to light and electron optics. (Alternate years. Not offered 1952–53.)

8·86. Advanced Quantum Mechanics (A). High energy phenomena. The special theory of relativity followed by a treatment of the Dirac equation and the fine structure of hydrogen spectra. General field theory, quantization of electron, electromagnetic and meson fields. The theory applied to the Compton effect, meson production, nuclear forces, etc. (Alternate years. Not offered 1952–53.)

8·90. Special Problems in Theoretical Physics (A). Reading, consultation, and original investigation on a problem in theoretical physics.

CHEMICAL ENGINEERING

Subjects 10·00 to 10·99

10·11. Chemical Engineering. Designed to acquaint the student with the engineering method as applied to chemical problems, by the use of the project and case system.

10·15. Thesis Reports. Preliminary work taken before S.B. thesis in Chemical Engineering. Written and oral reports on proposed thesis.

10·17. Industrial Chemistry. Techniques of industrial chemical calculation and their application to the chemistry of fuels and combustion. Lewis 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 types of apparatus. Extensive problem work.

10·21. Industrial Chemistry. Continuation of 10·18. Industries dealing with amorphous solids, including glass, ceramics, leather, paints, textiles, paper, rubber, etc. Lewis, Broughton and Squires, *Industrial Chemistry of Colloidal and Amorphous Materials.*

10·25. Industrial Chemistry (A). Industrial stoichiometry and the technology of more important chemical industries, with emphasis on applied physical chemistry. Discussion of the interrelationships of the important industries and problem work on the various processes. For graduate students primarily interested in industrial chemistry and particularly for new students from other schools who have had insufficient training in industrial stoichiometry.

10·26. Industrial Chemical Laboratory. A laboratory and design study of the evolution of a chemical process through the successive stages which culminate in the design of the necessary plant, and exemplifying the integration of chemistry and engineering. Effective presentation of conclusions is developed through oral and written reports.

10·27. Chemical Engineering Laboratory. A program of laboratory experiments and reports dealing with fluid flow, heat transfer and other unit operations such as evaporation, absorption, distillation, drying, filtration and combustion.

10·272. Chemical Engineering Laboratory. A continuation of 10·27.

10·28. Chemical Engineering. Thermal properties of matter and the energy relationships underlying mechanical and chemical processes, including discussion of the first law of thermodynamics as applied to both batch and flow processes, and such operations as combustion, compression and handling of fluids and thermal control of chemical reactions. Development of second law and its elementary applications. Weber, *Thermodynamics for Chemical Engineers.*

10·29. Chemical Engineering. Quantitative engineering applications of the second law, including heat engines, heat recovery, particularly in chemical operations, thermal level of heat in relation to industrial processes, chemical equilibria and thermodynamic efficiency of chemical processes. Weber, *Thermodynamics for Chemical Engineers.*

10·30, 10·30T. Engineering Equipment. For students in Course X-B. Instruction and practice in testing engineering equipment such as pumps, fans, turbo-blowers, blowing engines, motors, generators, etc., commonly used in chemical engineering operations. Emphasis on determining the operating characteristics of such equipment under plant conditions. (10·30T not offered 1952–53.)

10·31, 10·32. Chemical Engineering. Basic principles underlying the unit operations of chemical industry; material and energy balances, rate laws, and equilibrium considerations. Application of primary unit operations in 10.31 to problems in heat transmission, evaporation, condensation, and filtration. Application of laws of mass transfer in 10.32 to distillation, absorption, extraction, air conditioning, and drying. Walker, Lewis McAdams and Gilliland, *Principles of Chemical Engineering; Flow of Heat Notes*, August 1950.

10·311. Heat Transfer. Fundamentals of conduction, convection, and radiation of heat, with applications to problems arising in practice. (Primarily for selected officers of the U. S. Navy and Coast Guard.)

10·33. Analytical Treatment of Chemical Engineering Processes (A). Mathematical techniques for handling rate problems such as diffusion, heat transfer and chemical reaction which are basic to most chemical engineering operations. Training in setting up ordinary and partial differential equations corresponding to specific physical situations, and in methods available for their solution, including various graphical constructions. Sherwood and Reed, *Applied Mathematics in Chemical Engineering.*

10·35. History of Science and Technology. History of the most important advances in science and technology during the last century. Not only the biographies of the greatest scientists and inventors but also what led these men to make their discoveries and inventions discussed from a philosophical point of view. Main purpose of the course — to offer historical examples of how essential a philosophical approach is to solve scientific and technological problems satisfactorily. Emphasis on the importance of logical reasoning and strict adherence to experimental facts for the advancement of science and technology. Discussion from this point of view of life histories of such men as Michael Faraday, Louis Pasteur, Wilhelm Roentgen, Thomas Edison, Wilhelm Ostwald, Lecomte du Nouy, and many others.

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

Chemical Engineering Continued

on behavior of complex mixtures, correlation of data, and methods of approximation. Weber, *Thermodynamics for Chemical Engineers.*

10·41. Distillation (A). Basic principles of distillation, as applied to binary and multi-component mixtures. Problems involve the vapor-liquid equilibria of ideal and non-ideal solutions, batch and continuous simple distillations, steam distillations, vacuum and pressure distillation, and rectification. Special attention is given to the distillation of systems of limited miscibility, azeotropic distillation, extractive distillation, and adsorption distillation. Robinson and Gilliland, *Elements of Fractional Distillation.*

10·45. Distillation and Absorption (A). Distillation, including rectification of binary and complex mixtures. Diffusional processes, with attention to design computations for gas absorption equipment. A combination and condensation of subjects 10·41 and 10·46, using same texts.

10·46. Absorption and Extraction (A). Basic principles of equilibria, mechanism and rate of interaction. Quantitative applications including the absorption of single gases, such as sulfur dioxide, ammonia and hydrochloric acid, and complex mixtures, such as light oil, casing-head gasoline, refinery gases, and the like. Attention to graphical methods. Basic principles of extraction by liquids, solvent recovery by absorption and the leaching of various solids. Sherwood *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. Extensive use of graphical methods. Trends of present development. McAdams, *Heat Transmission.*

10·52. Chemical Engineering II (A). Emphasis on basic theories in flow of fluids and mass transfer. Application to problems of advanced character and attention to recent developments. Walker, Lewis, McAdams and Gilliland, *Principles of Chemical Engineering.*

10·53. Chemical Engineering Design (A). Open only to students completing the field work of Course X-A. Integrated design of a new plant from the viewpoint of both chemical engineering and economics.

10·55. Economic Balance in Chemical Industry (A). Development of original power in the solution of problems in chemical industry. Problems covering a wide range of topics, with quantitative analysis of various factors under the control of the designer, determining the optimum design from the viewpoint of cost and economic return. Emphasis on economic balance applied to unit operations and processes.

Applied Chemistry

10·62. Advanced Thermodynamics (A). Further study of physical and chemical equilibria, particularly in heterogeneous systems. Special emphasis on prediction of thermodynamic properties by theoretical and empirical techniques. Consideration of the effects of surface and force field energies.

10·63. Industrial Chemistry II (A). Chemical industries dealing primarily with amorphous materials, including thermoplastics, textile fibres, cellulose products, leather and rubber. Survey of the general principles of colloidal chemistry followed by analyses of important problems encountered in these industries. Lewis, Broughton and Squires, *Industrial Chemistry of Colloidal and Amorphous Materials.*

10·65. 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, etc.; discussion of industrial applications, equipment requirements, and opportunities for researeh. Emphasis on the design of reactors involving heterogeneous catalysis.

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. Hauser, *Colloidal Phenomena.*

10·662. Colloid Chemistry (A). A continuation and extension of 10·661, with special attention to the science and technology of matter in the colloidal state. Hauser, *Colloidal Phenomena.*

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. Hauser and Lynn, *Experiments in Colloid Chemistry.*

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. Mason and Manning, *Technology of Plastics and Resins.*

10·691. Colloid Chemistry of Silicon (A). Survey of the chemical and physical properties and molecular structure of substances containing silicon as their basic constituent. Correlation of theoretical considerations of structure with colloidal properties of scientific and industrial importance. Hauser and le Beau, *Silicic Chemistry.*

FUEL ENGINEERING

10·70. Principles of Combustion (A). Open to students wishing to specialize in the engineering phase of fuel engineering. Emphasis on the application of fundamental principles in combustion reactions, including high output power plants of rocket and jet types. Problems illustrating the quantitative application of principles to fuel utilization. Hottel, Williams and Satterfield, *Thermodynamic Charts for Combustion Processes.*

10·71. Fuel Engineering (A). For students with an adequate background of stoichiometry, physical and organic chemistry and thermodynamics. Application of combustion principles to problems of design and operation of equipment for fuel processing and utilization. Particular emphasis on power generation involving compressible flow systems.

10·74. Furnace Design (A). Principles and calculations of furnace design and construction dealing with rates of heat transfer and with flow of gases in furnaces. Emphasis on radiant heat transmission from gases, surfaces and clouds of particles. Quantitative design and layout of several furnaces, retorts or still-settings.

School of Chemical Engineering Practice

(See also N1–N3 Engineering Practice School at Oak Ridge, page 169)

10·81. School of Chemical Engineering Practice — Bangor Station (A). Conducted in the plants of the Eastern Corporation at South Brewer, Maine, manufacturers of writing papers and sulphite pulp, and of the Penobscot Chemical Fibre Company at Oldtown, Maine, manufacturers of soda and sulphite pulp. Operations include production of chlorine and caustic by electrolysis, of sulfite liquor by absorption, the recovery of soda by leaching, evaporation, smelting and electrical precipitation and many applications of drying.

10·82. School of Chemical Engineering Practice — Parlin Station (A). Conducted in the Cellulose Products plant of Hercules Powder Company in Parlin, New Jersey. The central operations of nitric acid production and nitration of cellulose involve many problems of distillation, catalysis at high pressure, corrosion and disposal of fume and waste.

Chemical Engineering Continued

10·83. School of Chemical Engineering Practice — Buffalo Station (A). Conducted in the Lackawanna Plant of the Bethlehem Steel Company. Blast furnace, open hearth and steel finishing operations, together with by-product coke production, involve a wide variety of work in such fields as combustion, heat transfer, flow of fluids, absorption and distillation.

10·84. School of Chemical Engineering Practice — Bangor Station. Similar to 10·81. Given for seniors during the second period of the academic year.

10·85. School of Chemical Engineering Practice — Parlin Station. Similar to 10·82. Given for seniors during the second period of the academic year.

10·86. School of Chemical Engineering Practice — Buffalo Station. Similar to 10·83. Given for seniors during the second period of the academic year.

General

10·90. Experimental Research Problem (A). Designed to meet the needs of special and graduate students who wish to carry out some minor investigation in a particular field. Subject and hours arranged to fit individual requirements.

10·991, 10·992. Seminar in Chemical Engineering (A). For graduate students engaged on doctorate theses.

GEOLOGY AND GEOPHYSICS

Subjects 12·00 to 12·99

12·011. 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 Manual of Mineralogy.*

12·012. Mineralogy. Continuation of 12·011, covering a study of the common silicate minerals. Warren, *Determinative Mineralogy;* Hurlbut, *Dana's Manual of Mineralogy.*

12·04. X-ray Mineralogy. Elementary X-ray diffraction methods and their use in mineralogy.

12·05. Mineralogical Seminar (A). Presentation and discussion of literature bearing on certain phases of theoretical mineralogy.

12·06. Mineralogical Research (A). Supervised research on some mineralogical or crystallographic problem, with the intention that each investigation will result in a publication.

12·14. Petrology. Occurrence and origin of igneous and metamorphic rocks, with emphasis on correlation with experimental work. Turner and Verhoogen, *Igneous and Metamorphic Petrology;* Barth, *Theoretical Petrology.*

12·15T. Petrography. Laboratory study with the polarizing microscope of thin sections of igneous, metamorphic, and sedimentary rocks. Rogers and Kerr, *Optical Mineralogy;* Wahlstrom, *Igneous Minerals and Rocks;* Pettijohn, *Sedimentary Rocks.*

12·161, 12·162. Mineral Deposits and Petrology Seminar (A). Discussion of igneous and metamorphic rocks, mineral deposits, and problems bearing on their genesis.

12·17. Petrology Laboratory (A). Techniques of petrological research with emphasis on applications of the Universal stage to mineralogical and petrofabric problems. Arranged to suit the requirements of individual students.

12·20. 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.

12·22. Geometrical Crystallography (A). Geometrical fundamentals of crystallography; indices, the elements of symmetry, elementary group theory, the derivation of the crystal classes, space lattices, and space groups.

12·231. Optical Crystallography. Discussion of principles of optical crystallography, illustrated in the laboratory by the immersion method of crystal identification. Larsen and Berman, *Microscopic Determination of the Non-opaque Minerals* (U. S. G. S. Bull. 848); Wahlstrom, *Optical Crystallography.*

12·232. Advanced Optical Crystallography (A). Determination of the optical properties of crystals using Universal stage, minimum-deviation, and variable temperature-wavelength methods. Opportunity to undertake optical research problems.

12·24. Theoretical Crystallography. Introduction to the theory of the structure of crystals, and application of crystal structure concepts to crystallography and mineralogy, including elementary crystal chemistry, structures of the silicates, polymorphism and transformations, disordered structures, solid solution and segregate phase formation, crystal growth and habit, crystal imperfection and lineage structure, and plastic deformation of crystals.

12·27. Crystallographic Research (A). Supervised research on some crystallographic problem.

12·301. Physical Geology. Objective study of the earth, based upon laboratory and field studies. Emphasis upon the identification and classification of rocks, and upon the structural relations of rock masses.

12·302. Historical Geology. Earth history including the nature and distribution of lands and seas during the past, and the evolution of plants and animals on the earth. Dunbar, *Historical Geology.*

12·303. Geological Surveying. At Nova Scotia Centre for Geological Sciences. Training in surveying methods and in handling instruments commonly used by geologists in the field.

12·304. Field Investigations and Reports. At Nova Scotia Centre for Geological Sciences. Geological examination of areas selected for either scientific or economic interest. Specific areas assigned to each group of students for survey and preparation of geological sections, maps, and reports.

12·306. Historical Geology. Same as 12·302 omitting part of the laboratory work.

12·307. Physical Geology. Same as 12·301 omitting the laboratory work.

12·308. Historical Geology. Same as 12·302 omitting the laboratory work.

12·321. Engineering Geology. Geology adapted to the needs of engineers. Ries and Watson, *Elements of Engineering Geology.*

12·322. Engineering Geology. Relations of geology to engineering problems, with reviews of actual cases.

Geology and Geophysics Continued

12·40. Mineral Deposits. Occurrence and origin of ore deposits. Lindgren, *Mineral Deposits, Fourth Edition.*

12·41. Mineral Deposits Laboratory. Determination of ore minerals by microchemical analysis and by use of the metallographic microscope on polished sections; and study of mineral relationships for the interpretation of processes of deposition. Short, *Microscopic Determination of the Ore Minerals* (U. S. G. S. Bull. 914).

12·432. Advanced Mineral Deposits Laboratory (A). Study of specimens or suites of specimens from mineral deposits; metallographic or petrographic work.

12·44. Geology of Oilfields. Geology of natural gas, petroleum and coal with emphasis on structural features and genesis.

12·45. Oilfield Reservoirs. Physical properties of reservoir rocks: electric logs, radioactivity and other logs; microscopic structures; porosity, permeability and elementary principles of fluid flow. Equilibria of reservoir fluids, saturation and estimation of reserves in oil and gas fields.

12·461. Geology of Petroleum and Coal (A). Origin and stratigraphy of coal, oil shale, and petroleum, and consideration of geology and economics of the major fuel deposits. Treatment of elementary physical principles in underground fluid equilibrium and flow, and of methods used in estimating reserves in oil fields.

12·462. 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 to location of new oil fields.

12·51. Paleontology. Study of the past plant and animal life of the earth through comparison of fossils with living plants and animals. Shimer, *Introduction to the Study of Fossils;* Shrock and Twenhofel, *Principles of Invertebrate Paleontology.*

12·52. Advanced Paleontology (A). Laboratory work and assigned reading on fossil invertebrates and index fossils, or on some aspect of stratigraphic paleontology. Shrock and Twenhofel, *Principles of Invertebrate Paleontology;* Shimer and Shrock, *Index Fossils of North America.*

12·581T. Sedimentology. Survey of the chief types of sediments and sedimentary rocks, with some consideration of the environmental conditions under which sediments are formed and deposited. Twenhofel, *Principles of Sedimentation.*

12·582. Advanced Sedimentology (A). Laboratory, and microscopic study of the important primary and secondary physical, chemical and structural characteristics of sedimentary rocks using hand specimens, polished specimens and thin sections. Arranged to suit preparation and requirements of individual students.

12·583. Sedimentology Seminar (A). Discussion of latest literature on the origin, deposition, classification and significance of sediments and sedimentary rocks.

12·65. Special Problems. For seniors desiring special laboratory or field work on geologic problems.

12·66. Special Problems (A). For graduate students desiring special investigation of some geological subject or special laboratory or field work on geological problems.

12·701. Structural Elements. At Nova Scotia Centre for Geological Sciences. Field study of significant structural features at selected localities and in areas of group investigation. Lahee, *Field Geology.*

12·702. Structural Geology. Primary structural features of igneous and sedimentary rocks and the nature and causes of secondary structural features, joints, fissures, faults, folds and rock cleavage, their manner of formation and significance.

12·721, 12·722. Tectonics Seminar (A). Discussion of the structural evolution of typical regions and of the relation of metamorphic and igneous rocks to orogenic belts. Introduction to microtectonics and experimental rock deformation, with discussion of regional structures to which petrofabric methods have been applied. Assigned reading and reports.

12·73. Regional Geology. Introduction to continental structure and stratigraphy based on the geology of North America.

12·80. Geochemistry. Cosmic abundance of the elements. Geochemical rules and their application to an understanding of the distribution of the elements in the primary minerals and rocks and in the products of weathering. Importance of water in weathering cycle. Redox potentials. Natural radioactivity and enrichment of certain isotopes in minerals. Rankema and Sahama, *Geochemistry.*

12·81. Spectrochemical Analysis (A). Elementary theory of spectroscopy. Excitation sources, particularly the D-C arc discharge. Qualitative and quantitative analysis with particular emphasis on the analysis of minerals, rocks and soils with the D-C arc. Ahrens, *Spectrochemical Analysis.*

12·86. Elements of Seismology. The nature of earthquakes and their effects, and the propagation of seismic waves and their bearing upon the structure of the earth. Seismic instruments and the applications of seismology to prospecting and engineering.

12·87. Introduction to Geophysics. Principles of geophysics, and their application to geophysical exploration.

12·881, 12·882. Geophysics Seminar (A). Selected topics in the physics of the earth: seismology, geomagnetism, geothermal problems, figure of the earth, gravitational problems and geologic age measurement.

12·89. Isotope Geology (A). Measurement and uses of the relative abundance of isotopes in geological materials; methods of measuring geological time, radioactive production of heat, and the quantity of radioactive elements in rocks and minerals, with demonstrations.

12·91. Elements of Mining. Fundamentals of mining practice, including prospecting, exploration, drilling, shaft-sinking, drifting, explosives, blasting, timbering, haulage, hoisting, ventilation, drainage, mining law, health and safety. Mining terminology. Opportunity for mine inspection trips. Young, *Elements of Mining.*

12·92. Mining Methods and Practice. Continuation of 12·91. Mining systems, costs, engineering and administration. Attention concentrated on adaptability and operation of representative methods of mining as applied to either open-pit or underground mining of metals and non-metallics. Opportunity for mine inspection trips.

12·94. Mineral Economics. World mineral resources, their economic importance and industrial potential. Effects of distribution, control, monopolies, cartels, and tariffs on availability of mineral raw materials. Current mineral problems, national and international.

12·95. Mine Valuation (A). Methods of examination and principles of valuation to equip the student with the theory of valuation and its practical application to representative types of mineral property. Emphasis on sampling, sampling calculations, estimation of ore, costs, selling prices, markets, profits, the interest rate, depletion, and taxation. Parks, *Examination and Valuation of Mineral Property.*

12·96. Mineral Economics Seminar (A). Detailed study or report on a particular mineral, area, or condition developing in the mineral field.

12·97. Mine Valuation Seminar (A). Optional study; engineering report on valuation of a mineral property, or detailed investigation of some phase of the problem, e. g., taxation.

NAVAL ARCHITECTURE AND MARINE ENGINEERING

SUBJECTS 13·00 TO 13·99

13·01. NAVAL ARCHITECTURE I. Stability of ships in intact and damaged conditions, trochoidal wave theory, oscillations of ships, and fundamental considerations in structural design. Laboratory work at the stability tank consisting of three inclining experiments under different conditions of loading and simulated damage. Manning, *Fundamentals of Naval Architecture.*

13·02. NAVAL ARCHITECTURE II. Resistance and propulsion of ships, design of propeller and rudder, launching ships. Laboratory work in the ship model towing tank and propeller tunnel consisting of towing tests for ship models and tests of model propellers. Manning, *Fundamentals of Naval Architecture.*

13·022. SHIP PROPULSION AND MANEUVERING (R). Resistance of ships; ship propelling apparatus, screw propeller; propulsion of ships; powering of ships; rudders and maneuvering of ships. (Restricted to selected officers of the U. S. Navy.)

13·03. PRINCIPLES OF SHIP DESIGN (A). Principles and procedures involved in the preparation of the preliminary design of ships. Manning, *Basic Design of Ships.*

13·031. PRELIMINARY DESIGN OF SHIPS (A). Preparation of the preliminary design of a ship selected by the student. Manning, *Basic Design of Ships.*

13·032. PRELIMINARY DESIGN OF SHIPS (A). Continuation of 13·031.

13·04. ADVANCED 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, sub-division, powering, analysis of performance, economics of design, general arrangement, cargo handling, launching, heating, ventilation, air conditioning, hull piping systems, etc. Discussion of naval and merchant vessels.

13·05. ADVANCED HYDROMECHANICS OF SHIP DESIGN (A). Advanced work in the fields of ship resistance, propulsion, directional stability and allied topics including work in the ship model towing tank.

13·12. WARSHIP GENERAL ARRANGEMENTS (R). Principles involved in the general arrangements of warships and in the design and installation of hull systems, fittings, and auxiliary machinery. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·13. WARSHIP STRUCTURE, THEORY I (RA). Stresses in a warship and the design of the hull structure. Hovgaard, *Structural Design of Warships.* (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·14. WARSHIP STRUCTURE, THEORY II (RA). Continuation of 13·13, including problems peculiar to submarines. Lectures and seminars. Hovgaard, *Structural Design of Warships; Technical papers and reports.* (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·15. WARSHIP BASIC DESIGN I (RA). Principles and procedures to be followed in the preparation of the preliminary design of warships. Manning, *Basic Design of Ships.* (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·16. WARSHIP BASIC DESIGN II (RA). Fundamental considerations involved in the selection and provision of the military features of warships. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·17. HISTORY OF WARSHIPS (R). Presented in the form of a seminar, supplemented by lectures by members of the Faculty and other authorities. Designed to give a perspective view of the characteristics of warships, including the interrelationships of such characteristics and the Naval policies of the several powers, particularly the United States. Emphasis on warship developments of World War II and possible developments of the future. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·20. ELEMENTARY SHIP DESIGN. Comprises fairing warship lines, construction of a half-model and indoctrination lectures by the staff. (Primarily for Course XIII-A.)

13·21. WARSHIP FORM DESIGN (R). Work in the drawing room which includes calculations for and drawing of displacement and other curves, cross curves of stability, curves of statical stability, and floodable length curves for a warship from preliminary design data. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·22. WARSHIP GENERAL DESIGN (R). Analyses of general arrangement problems and the preparation of general arrangement plans. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·24. WARSHIP STRUCTURE, DESIGN I (RA). Determination of requirements for longitudinal strength of a warship, the preparation of a structural design for a midship section and arrangement of shell and deck plating and framing. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·241. WARSHIP STRUCTURE, DESIGN (RA). Abridgement of 13·24 including only the preparation of a structural design for a midship section. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·25. WARSHIP STRUCTURE, DESIGN II (RA). Continuation of 13·24, including the preparation of structural designs for a transverse bulkhead, stem and bow framing, stern framing with stern post and propeller struts and a transverse strength analysis. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·26. PRELIMINARY DESIGN OF WARSHIPS (RA). Work in the drawing room which includes the preparation of the necessary plans and calculations for the preliminary design of a warship. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·40. NAVAL ARCHITECTURE AND MARINE ENGINEERING I. Introduction to the design of ships and their propelling machinery on a generally descriptive level. Ship types; nomenclature; structure; functions of regulatory bodies; steam machinery plants and their components; Diesel machinery; fuels; deck machinery and ship service systems.

13·41. SHIP AND ENGINEERING DRAWING. The lines drawing, principle of flotation, integrating rules, and computation of areas, volumes, and moments. Curves of form. Equilibrium and stability of floating bodies. Methods of design and construction of wood hulls. Elementary marine engineering drawing.

13·42T. HULL FORM DESIGN. Displacement and metacenter calculation; curves of form; calculations of stability; cross curves and curves of statical stability; floodable length calculation.

13·43. SHIP STRUCTURAL DRAWING. The design of a ship's structure in compliance with the requirements of the American Bureau Shipping Rules; thereafter checking the adequacy of the structure by the balancing of the ship on a wave to determine the bending moment, and calculating the moment of inertia of the mid-section of the ship to establish the maximum stress in compression and tension. (Not offered 1952–53.)

13·45. SHIP STRUCTURES, DESIGN. Lectures on structural design of ships, including general and local stresses, elastic stability, and the design of shell, inner bottom, decks, framing, and bulkheads. Drawing room work, including calculations for launching and general strength. Hovgaard, *Structural Design of Warships;* American Bureau of Shipping, *Rules for Building and Classing Steel Vessels.*

13·45T. SHIP STRUCTURES. Study of the general and local stresses in ships, both longitudinal and transverse, including some consideration of dynamic loads. Discussion of shipbuilding materials, structural sections, continuous beam and elastic stability theories with application to ship structure. Lectures on riveting and welding, culminating in the factors involved in the design of the midship section longitudinally

Naval Architecture and Marine Engineering Continued

continuous material; examination of bulkheads and framing from the theoretical aspects in conjunction with A. B. S. Rules requirements.

13·46. Ship Design. Lectures on the basic principles of ship design and the methods of preparing the preliminary design of a ship. Drawing room work, including structural design of midship section, structural design of a main transverse bulkhead, structural design of strength deck, all in accordance with classification rules and the preparation of the preliminary design of a merchant ship. Manning, *Basic Design of Ships.*

13·46T. Ship Design. Lectures on the basic principles of ship design and the methods of preparing the preliminary design of a ship. Drawing room work consisting of the preliminary design of a merchant ship, including the determination of principal dimensions and external form, internal arrangements to satisfy subdivision cargo stowage and accommodation requirements, the design of the salient structural features, and the machinery and shafting arrangement. (Not offered 1952–53.)

13·47. Ship Design. Lectures on rules and regulations affecting ship design and on structural design of ships. Drawing room work, including calculations for stability and floodable lengths, general arrangement plans of cargo ships with particular attention to cargo handling arrangement, load line calculation, midship section plan.

13·47T. Ship Design. Lectures on rules and regulations affecting ship design and on structural design of ships. Drawing room work, including general arrangement plans of cargo ships with particular attention to cargo handling arrangement, load line calculation, midship section plan. (Not offered in 1952–53.)

13·52T. Marine Engineering I. General consideration, with calculations, of boiler performance, reciprocating engines, turbines, condensers, evaporators and Diesel engines. Properties of motors, generators, electric drive systems, generating and distribution systems, and special equipment.

13·53. Marine Engineering II. Machinery for ship propulsion and auxiliary machinery, particularly electric motors, generators, and distributing systems; ventilation equipment and pumps. Steam turbine design principles. (Not offered 1952–53.)

13·54. Marine Engineering Dynamics. Dynamical problems of Marine Engineering. Elementary vibration theory, the balance of rotating and reciprocating machinery. Torsional vibration of reciprocating machinery, vibration of turbines, vibration of ships.

13·55. Marine Engineering. Brief review of nozzle and blade design followed by computation of the important dimensions of several turbines and comparison of their principal features 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; fans, blowers and centrifugal pumps.

13·56. Marine Engineering Economics. Economic aspects of marine engineering; comparison of fuels, and the various types of steam and Diesel propelling machinery for different types of ships and trade routes; the economical operation of propelling machinery and auxiliaries at sea and in port; heat balances; boilers, main engines, auxiliaries and auxiliary systems; turbo-electric and Diesel-electric drives; gas turbine developments.

13·61. Marine Engineering Design. Discussion and design of reciprocating parts of a large Diesel engine, including study of dynamic forces involved; engineering factors which determine the size of machinery components and details.

13·61T. Marine Engineering Design III. Design projects including dynamic forces and stresses on selected marine machinery parts and provisional design of same. (Not offered 1952–53.)

13·62. Marine Engineering Design. Provisional design and calculations for main propelling units of a steamship; determination of sizes of auxiliaries; machinery layout; diagrammatic arrangements of principal piping systems; application of modern heat transfer formulas; propeller design; other marine engineering problems. (To be taken simultaneously with 13·55.)

13·62T. Marine Engineering Design IV. Provisional design of a surface condenser. Design considerations of certain marine auxiliaries. (Not offered 1952–53.)

13·70. Warship Electrical Engineering (RA). Critical examination of the principles of electrical engineering as applied to the generation and distribution of electric energy in warships; selection of machinery and equipment; determination of systems. Lectures, seminars, outside reading, design studies, and calculations. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·71. Ship Propulsion I (A). Design of important components of ship propulsion plants, with emphasis on current trends and selection of units to meet requirements of various types of ships. Lectures, seminars, and outside reading. (Students to attend selected lectures in 13·75.)

13·711T. Ship Machinery Design I (A). Design studies, including calculations, of components of ship propulsion plant. (To be taken simultaneously with 13·71.)

13·72. Ship Propulsion II (A). Continuation of 13·71. (Students to attend selected lectures in 13·76.)

13·721T. Ship Machinery Design II (A). Selection and arrangement of machinery in a selected ship.

13·73. Mechanical Vibration (A). The free and forced vibration of systems of a single degree of freedom; complex variable and vector representation; Fourier Series; harmonic analysis by tabular and mechanical methods; systems of several degrees of freedom; torsional systems; the balance of rotating machinery and reciprocating engines; the elements of torsional vibration problems in reciprocating engines.

13·74. Mechanical Vibration (A). Advanced theory of the torsional vibration of reciprocating engines, including uniform distributions, forced vibration, calculation of amplitude, branched systems, etc. The transverse vibration of uniform and irregular beams and the application to the vibration of turbines and other rotating machinery; Rayleigh's, Stodola's and other methods; separation of normal modes of vibration; vibration isolation; La Grange's theorem; non-linear systems; self-sustained oscillation.

13·75. Warship Propulsion I (RA). Critical interpretation leading to useful application of the formal and theoretical content of Naval Engineering to foster discrimination in practice. Selection of machinery units supported by related design studies and calculations. Lectures, outside reading, critiques. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·76. Warship Propulsion II (RA). Continuation of 13·75T with emphasis on the propulsion plant as a whole and its arrangement. Supported by studies and calculations. Selection and arrangement of machinery with emphasis on student exploration. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·78. Propeller Theory (A). Theoretical and mathematical development of marine propeller design as based on modern airfoil theory; application to design.

13·79. Propeller Design (A). 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.

13·791. Propeller Design (A). Same as 13·79 but with extensive additional problems in the design and selection of propellers.

13·81, 13·82. Ship Operation I, II. Engineering and economic aspects of ship operation; various items making up the operating expenses; calculations for operating expenses and profits on various trade routes, comparison of different types of machinery for different sizes of ships and various lengths of voyage; influence of size of ship, sea speed, block coefficient, port speed, and length of voyage on operating expenses; cubic and dead-weight ships; the design of cargo

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and passenger vessels from the owner's point of view; tonnage measurements, fuel conservation; 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 ship operation. (Not offered 1952–53.)

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; coordination of inland transportation with ocean shipping. 13·85 must be taken simultaneously. (Not offered 1952–53.)

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. Preparation 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. (Not offered 1952–53.)

13·85. Cargoes in World Trade. Geography of the world's resources in minerals and in the products of agriculture and forestry; movements of raw materials and manufactured goods in marine transportation; study of present and probable future ocean trade routes; inland movements of cargoes to and from the ports; economic influences on world trade; means of financing international transactions; tariffs and other restrictions to foreign trade.

13·86. Steamship Management. Organization of steamship companies, agencies, ocean shipping documents, ocean rates and regulations, conferences, chartering, marine insurance, admiralty law, construction and operating subsidies. (Not offered 1952–53.)

ECONOMICS AND SOCIAL SCIENCE

Subjects 14·00 to 14·99

General Economics and Theory

14·01. Economic Principles I. Introduction to fundamental economic concepts, such as production, money, banking, labor, business organization, international trade, government fiscal policy, with primary emphasis upon the level and fluctuations in national income and employment. Stress on current economic problems. Special sections will be offered with greater emphasis on preparatory material for (a) Labor Relations or (b) International Relations, for students who plan further work in those areas without 14·02.

14·02. Economic Principles II. Continuation of 14·01 with emphasis on the composition and pricing of national output, competition and monopoly, and international trade. Case studies of particular industries, with stress on current economic problems.

14·03. Prices and Production. Synthesis of the various tools employed in different branches of economic analysis giving particular attention to the pricing process and to variations of output in the business cycle.

14·09. Economic Problems Seminar. This seminar, especially designed to complete a three-term Humanities combination in economics, will take up selected problems of business and public policy, chosen because of their current interest or because of their continuing significance for engineers and scientists. Some problems, calling for the further development and application of the analytical techniques of 14·01 and 14·02, will be selected by the instructor for general reading and discussion; others will be selected by the students for individual investigation. (Sections limited to fifteen students.)

14·111, 14·112. Current Economic Problems. Discussion of booms and depressions, inflation and deflation, money, unemployment, debts, taxes, investment, foreign trade policy, and other economic problems of current interest. Open to graduate students only.

14·113. Principles of Economics and Labor Relations. Introduction to general economics combined with discussion of employer-employee relations. *Economics:* discussion of the problem of full employment, involving a study of the national income and its determinants. *Labor relations:* Development of the labor movement and of trends in labor legislation. Concrete problems as encountered in industry today — wage determination, seniority and layoff methods, grievance procedures, union management cooperation, etc.

14·114. Economics, Finance, and Statistics. An introductory discussion of the following: (1) the determination of national income and its fluctuations — composition and pricing of the national output; (2) the functioning of money and capital markets in our economy — some problems involved in raising funds by business enterprise; (3) drawing inferences from data — how economists and business men use statistics. (Restricted to Sloan Fellows.)

14·115. Economic and Financial Policies II. Discussion of financial institutions, especially the money-banking system. Monetary and fiscal policies in relation to fluctuations in national income and employment. Business financial policies. (Restricted to Sloan Fellows.)

14·116. Economic and Financial Policies III (A). (a) Problems in industrial economics, with special attention to price policy. (b) Problems in international economics. Study of questions involving the relation of government to industry. (Restricted to Sloan Fellows.)

14·121, 14·122. Economic Analysis (A). Interdependent growth of theory and fact, general theory of equilibrium under competition and monopoly. Findings revalued under conditions which more closely approach reality.

14·132. Schools of Economic Thought (A). Economic ideas developed by different groups of economists in recent times.

14·151. Mathematical Approach to Economics (A). Use of mathematical methods in all fields of economics.

14·191, 14·192. Economics Seminar (A). Special social problems or economic problems of particular industries. (Open to graduate students only.)

14·195, 14·196. Reading Seminar in Economics (A). Reading and discussion of special topics in Economics. Open to advanced graduate students by arrangement with individual members of the staff.

Industrial Economics

14·20. Building Economics. Social, political, industrial, and economic factors affecting the location, construction, financing, and marketing of buildings — with emphasis on low-cost housing.

14·21T. Economics of Patents and Invention. Discussion of the process of research, invention and technical innovation and the operation of the patent system, also comparison

Economics and Social Science Continued

with patent systems of other countries. Emphasis on the role of inventions in different types of industries. Cases used for illustrative purposes.

14·271. Problems in Industrial Economics (A). Small and large enterprises in the American economy; market structures; degrees of monopoly and competition; requisites of public policy.

14·272. Government Regulation of Industry (A) Follows 14·271. Development of anti-trust policy, generally and in specific cases. "Public utility" price fixing, government ownership as alternative.

14·281. Economics of Invention and Innovation (A). Designed for engineers and economists interested in the social function of science. Comparison of the organization and functioning of science in the United States and other countries, notably Russia. The role of science in American universities, industrial and government research, the use of science to combat business depressions, the patent system in relation to technical progress, and problems arising from the development of atomic energy.

14·282. Economics of Invention and Innovation Seminar (A). The function of science in industry. The process of invention and problems concerned with translating scientific discoveries into practical applications in industry. The relationship between the organization of an industry and the level of its research practice. The management of research in large and small companies. Discussion in several of these seminars led by directors of research in different companies.

14·291, 14·292. Industrial Economics Seminar (A). Readings, discussions, reports on such topics as industrial price policies, government regulation of industry, competitive practices and other phases of industrial economics.

Statistics

14·30. Elementary Statistics. A first course in the theory and application of statistics and probability to engineering and administrative problems. Binomial, Poisson and normal distributions. Elements of statistical inference. Correlation.

14·31. Elementary Statistics. Frequency distributions, moments, elements of probability, probability distributions, elements of sampling, confidence limits, regression and correlation of two variables.

14·31T. Introduction to Quantitative Method. Elementary statistical method integrated with private and national-income accounting techniques. Approach through examination of particular problems requiring use of both techniques of analysis.

14·32. Statistical Quality Control. Application of statistical methods to industrial problems including sampling inspection, control charts, engineering tolerances, and design of experiments.

14·33. Econometrics. Formulation and statistical testing of quantitative economic theories, with special emphasis in 1951–52 on the analysis of consumer behavior. Estimation problems in systems of economic equations. Time series.

14·371, 14·372. Statistical Theory. An elementary subject in statistical theory. Moments, elements of probability, probability distributions, sampling theory, regression and correlation of two and more variables, tests of statistical hypotheses, theory of estimation, non-parametric methods, analysis of variance, sequential analysis.

14·382. Economic Statistics (A). Study of selected statistical techniques which have proved useful in economic applications. Frequency distributions, sample design, contingency tables, ranking methods, regression techniques.

National Income and Finance

14·40. Money and Income. Introduction to the study of factors affecting the level of national income and relationships of financial institutions to these factors. Survey of the financial organization of society: the money-banking system, credit institutions, capital markets, fiscal policy, international financial relations.

14·43. Public Finance. Effects of government revenue and expenditure programs on the level and distribution of economic activity; intergovernmental fiscal problems; relationship of fiscal to other economic policies.

14·451. National Income (A). Economic problems involved in maintaining national income and employment.

14·461. Monetary and Banking Problems (A). Commercial and central banking in relation to price levels and employment. Analysis of such problems as bank asset management, Federal Reserve organization and policy, interest rates, money markets, the Treasury and the banking system, proposals for monetary reform with some historical background.

14·472. Fiscal Policy (A). Analysis of alternative tax, expenditure, and debt policies with particular reference to the Federal Government; relation of various fiscal policies and procedures to economic stability and progress; relation of fiscal to monetary policy.

14·481. Business Cycles (A). Statistical, historical, and theoretical examination of determinants of income, production and employment. Modern methods of analysis, forecasting, and control.

International Economics and Relations

14·51. International Relations. Analysis of basic factors in world politics: the influence of geography, demography, economic resources, nationalism upon national power and foreign relations. Power politics and the balance of power system. The formation and conduct of foreign policy, the adjustment of international disputes. Special emphasis is given to the position and policies of the United States in the relationships among the Great Powers.

14·52. Major Problems in Contemporary World Politics. Case studies in Great Power relationships, the United Nations in action, the treaties of peace, economic and military assistance programs, regional problems and arrangements, international control of atomic energy and proposals for world government examined in light of search for national and collective security.

14·54T. International Trade. Theory of international trade and finance, and application to current problems, such as exchange restrictions, economic development, and foreign aid.

14·571. Major Problems in United States Foreign Policy. Analysis of some of the principal economic, political and military problems facing the United States in its present-day foreign relations. Special emphasis upon the question of national security, relations with the Soviet Union, the Eastern European and German problems, Far Eastern crisis, and the United Nations.

14·572. International Problems. Graduate course dealing with long-run problems of international relations in two focal areas: Western Europe and the Far East.

14·581, 14·582. International Economics (A). The foreign exchange market, foreign trade and commercial policy, with emphasis on the relation of the items in the current account to national income: international finance and the achievement and maintenance of equilibrium in the balance of payments as a whole: current problems of international economics.

Industrial Relations

14·60. Labor Relations. Survey of personnel administration and relations with organized labor, intended primarily for those students who take no other work in labor relations. Discussion of the place and functions of personnel administration, nature of unionism, union policies and practices, and labor legislation. Development of a point of view and a method of analysis through cases presented to the class.

14·61. Industrial Relations. Structure and functioning of management and unions in the handling of industrial relations. Union policies and problems to which they may give rise. Reconciliation of union and management policies.

Economics and Social Science Continued

14·63. Labor Relations. An introductory analysis, made through use of an integrated social science approach, of the institutions which have developed in response to the "human resource problems" of a highly industrialized economy. The course surveys the growth, structure, and objectives of management and organized labor groups and then examines the framework and issues of collective bargaining as parts of a dynamic accommodation process between organizations that have economic, political, and social characteristics.

14·64. Labor Economics and Public Policy. Particular applications of the analytical tools developed in prerequisite subjects to two aspects of the industrial relations scene: (1) the economics of collective bargaining, with special emphasis on the problems presented by wage determination at firm, industry, and economy levels and on the question of economic security; and (2) the development within a free society of public policy towards the collective bargaining participants.

14·671. Problems in Labor Economics (A). Development of the labor movement, and detailed analysis of collective bargaining and union policies on wages, hours of work, entrance to the trade, hiring, layoffs and transfers, make-work and restriction of output, technological change, union-management cooperation, and industry-wide agreements. Major emphasis on the economic aspects and effects of these policies.

14·672. Public Policy on Labor Relations (A). Study of major trends in labor legislation, with emphasis on the legality of union activities, protection of the right to organize and bargain collectively, regulation of wages and hours, governmental machinery for the adjustment of labor disputes, and various types of social insurance. Particular attention given to the broad economic and social questions raised by these trends.

14·681, 14·682. Seminar in Personnel Administration (A). Objectives and methods of personnel administration.

14·691. Research Seminar in Industrial Relations (A). Discussion of important areas for research in industrial relations, frameworks for research, research techniques, and methodological problems. Centered mainly on the thesis research of advanced graduate students.

14·692. Research Seminar in Industrial Relations (A). Continuation of 14·691.

14·693. Collective Bargaining and Union-Management Cooperation (A). Intensive discussion of collective bargaining problems in particular industries and introduction to plans for union-management cooperation in solving production problems and reducing costs.

14·694. Seminar in Union-Management Cooperation (A). Seminar involving active participation in the work being done at a number of firms which are beginning or have developed union-management cooperation programs.

Psychology

14·70. Introductory Psychology. Facts, principles, and theories of learning, memory, thinking, emotion, personality, communication, and intelligence. Application to everyday life and to man-machine systems.

14·71. Case Method in Personnel Administration. Application of two interdependent parts of case method: (1) fact-finding, and (2) generalizing from tested experience to administrative practice. (Not offered 1952–53.)

14·72. Union-Management Relations. Specific problems in union-management-worker relations, and the development of programs to secure greater worker participation through union-management cooperation plans. (Primarily for students in Course XIV.)

14·73. Organization and Communication in Groups. This subject will deal with the problems in organization and communication in groups which have specific tasks to perform. Two-person situations, small informal groups, and larger organizations such as businesses, industrial firms, military units, etc., will be studied. The approach will be made from the point of view of social psychology.

14·75. Experimental Psychology. Problems of method and procedure in the scientific study of living organisms. Analysis of and participation in psychological research.

14·761. Seminar in Human Communication Networks I (A). Theory. Development of conceptual models for studying problems of personal and social organization, based on theoretical and experimental studies of communication networks.

14·762. Human Relations and Labor Relations. An introductory subject including the following topics: (1) the basic principles of human relations; (2) the place and functions of personnel administration, with emphasis on actual case situations: (3) the development of the American labor movement, significant union policies and practices, and basic issues raised by the present strength of unions. (Restricted to Sloan Fellows.)

14·764. Seminar in Human Communication Networks II (A). Methods. Designed to give graduate students direct experience with experimental and observational methods for studying communication patterns. Design of experiments, laboratory testing, and analysis of data.

14·77. Psychology of Communication. Survey of phonetics, acoustic, perceptual, statistical, developmental, behavioral, and social studies of the psychology of language and communication. Particular emphasis is placed upon the effects of verbal habits upon perception, learning, and thinking.

14·771. Interpersonal Relations Seminar (A). Systematic approach to the study of interpersonal processes in two-person and larger groups. Development of such techniques as role-playing, non-directive interviewing, and group-process observation as aids to a strategic understanding of structure and dynamics of interpersonal relations.

14·772. Intergroup Relations Seminar (A). Study of the institutional and organizational structure and dynamics of American society emphasizing how individual and small group motivations and activities are conditioned by their position in the social framework.

14·781. Social Psychology of Industry Seminar (A). Brief consideration of theoretical and experimental bases for a systematic approach to the social psychology of industry. Controlled laboratory study of situations analogous to those encountered in industry.

14·784. Psychological Theory Seminar (A). Designed to cover at an advanced level, modern theories of learning and behavior derived from accounts of clinical experience and experimental work.

14·791, 14·792. Reading Seminar in Social Science (A). Reading and discussion of special topics in the fields of social science. Open to advanced graduate students by arrangement with individual members of the staff.

Sociology, Anthropology, and Government

14·81. Personality and Social Structure. Role of culture in shaping norms of individual behavior, standards of judgment, patterns of social mobility and interaction, within various American communities; comparative studies of other contemporary cultures and sub-cultures. Analysis of structure and function of social institutions, including the family, business, government and education as related to status and role.

14·91. The American Political System. The role and problems of government in modern society. In addition to studying political concepts and processes in the United States, analysis will be made of the adequacy of American political ideas, institutions and the Constitutional system to meet the responsibilities of democratic world leadership.

14·92. Comparative Political and Economic Systems. A comparative study of the organization and use of political power, as well as of capitalism, socialism and communism in modern political systems. Special attention will be given to the British and European Parliamentary systems, the Soviet structure, the rise of dictatorships, rival economic policies, and the economic and political problems arising out of the changing relation of government to private enterprise.

Economics and Social Science Continued

14·93. Issues in Contemporary American Politics. A workshop investigation of problems connected with the formation and implementation of public policy in such fields as pressure politics, relation of government to scientific progress, efficiency and ethics in government, federal centralization and states rights, impact of national security requirements on democratic institutions, government and national economy. (Not offered 1952–53.)

14·95. Government and Economic Policy. Survey of the Government's role in economic life. Primary emphasis on political, administrative and legal techniques developed in the United States for regulation of private economic activity. Reference to problems of specialized government undertakings such as Atomic Energy and the European Recovery Program. (Not offered 1952–53.)

14·982. Law and Politics of Economic Policy (A). Political and institutional problems in implementation of income-stabilization policy; legal and administrative problems in government regulation of business.

GRADUATE SUBJECTS IN INDUSTRIAL MANAGEMENT

UNDERGRADUATE SUBJECTS IN BUSINESS AND ENGINEERING ADMINISTRATION

Subjects 15·00 to 15·99

15·01. Fundamentals of Industrial Management I. Introduction to management of the industrial enterprise. Emphasis on development of fundamental principles as a basis for later professional subjects. Industrial specialization, risk, environment, and organizations. Consideration of basic policy decisions in size of firm, facilities, products, channels of distribution and capital plans.

15·02. Fundamentals of Industrial Management II. Continuation of 15·01. Consideration of basic problems of operating policy. Control of working capital, costs, production, inventories, quality, and distribution. Introduction to fundamentals of administration, organization planning and remuneration systems.

15·11. Introduction to Industrial Management. (Designed as an elective for all courses except XIV and XV.) Basic consideration of fundamental principles and practices of industrial management. Brief coverage of administration, law, finance, marketing, production, accounting, and personnel. Development of relationship of scientist and engineer to functions of industry and operations of management. Analysis of effect of scientific and engineering viewpoints and decisions applied to industry with particular emphasis on use of science and engineering by industrial management. Designed for students interested in industrial operations but with no previous training in these areas.

15·14. New Enterprise Planning. Investigation and analysis of the problems involved in the planning and founding of new enterprises. Examination of methods of contacting business opportunities as well as means by which such opportunities may be evaluated, protected, organized and developed. Opportunity to synthesize the basic functional knowledge gained by prerequisite study into a plan for a composite industrial organization.

15·18. Accounting, Production, and Marketing. A basic study of three important aspects of business management activity planned for students who have had substantial experience in industry: (1) basic methods and problems in maintaining financial and cost control records within a business and in the use of recorded data for policy determination and review of performance; (2) the organization of manufacturing processes, with emphasis directed toward distinguishing fundamental principles from current practice; (3) distribution problems and practices with emphasis on analysis of managerial problems involved in marketing operation. (Restricted to Sloan Fellows only.)

15·30. Personnel Administration. Personnel administration as a staff function to assist line executives. On the basis of case material, fundamental requirements for personnel work discussed as to principles that build and problems that test constructive personnel policies. Selection, placement, and follow-up of employees; basic problem of worker's attitude toward authority; the plant as a social system; man-power problems; recruitment, training and upgrading; management-union relationships; establishment and maintenance of satisfactory working conditions; job analysis and grading; employee evaluation; interviewing as a tool of management; wage administration; employee counseling.

15·301. Personnel Administration. Similar to 15·30. Restricted to School of Industrial Management graduate students; others admitted only by permission of the instructor.

15·41. Finance. 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. Consideration of tax aspects of financial management.

15·411. Finance. Similar to 15·41. Restricted to School of Industrial Management graduate students; others admitted only by permission of the instructor.

15·42. Financial Institutions. Analyzed from the viewpoint of the business man. The following are among the institutions to be studied: banks of various types, investment and trust companies, insurance companies, security exchanges and brokers, finance companies, financial agencies of government, and international financial institutions.

15·46. Financial Administration of Industry (A). Practical problems of internal financial management. Analysis of specific problems confronting business managers in manufacturing, mercantile, and public utility fields. Use of case method, with other readings also required. Emphasis on current financial operations; financial problems relating to taxation, consumer purchasing power and availability of investment funds. Oral and written reports.

15·50. Accounting. Introduction to the ways in which accounting may serve as a tool of management. Practical methods of gathering, synthesizing and presenting business data with primary emphasis on problems of valuation and earnings determination. Both concepts and methods tested in terms of their potential contribution to the solution of business problems.

15·501. Accounting. Similar to 15·50. Restricted to School of Industrial Management graduate students; others admitted only by permission of the instructor.

15·51. Industrial Accounting. Evaluation of alternative courses of action, planning of business programs, and control of current operations. Analysis of the behavior characteristics of business costs and study of the methods of organizing cost data. Case material from a variety of industrial and commercial situations supplemented by selected readings.

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 in-

Industrial Management and Business and Engineering Administration Continued

come, 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, and other special problems, including relation of controller to stockholders and to public bodies.

15·59. Quantitative Analysis of Industrial Problems (A). Exploration of possibilities for extending the areas of quantitative evaluation in industry by wider application of methods successfully used in scientific analysis. Measurement procedures employed in industry and cases illustrating the current work of operations research groups reviewed by faculty members and visiting lecturers. Supervised group experimental projects conducted in cooperation with selected companies. Admission by consent of instructor in charge.

15·61. Business Law. Elementary study of some legal problems involved in the operation of a business enterprise; formation, performance and discharge of contracts, and remedies for breach, the Statute of Frauds; agency and employment relationships and liability of principal and agent in contract and tort; provision of the Uniform Negotiable Instruments Act; use of checks, notes and other negotiable instruments, rights and duties of parties in various banking transactions; organization of corporations, duties and responsibilities of management, rights and remedies of stockholders and creditors; consideration of some legal aspects of corporate finance.

15·64. Patent Law and Invention Management. Law of patents, trade-marks, copyrights and unfair competition. Practice of invention procedure and related legal and business procedure in the development and exploitation of new products and processes in commerce and industry. Detailed discussion on what constitutes patentable invention; methods by which a patent may be obtained; its protection and enforcement after issuance; rights obtained under copyright laws of the United States; and trade-mark laws of both the United States and the several states; the use of these laws and rights in industry.

15·65. Labor Law. Fundamental legal principles underlying formation and operation of labor unions, limitations upon right to strike and right of boycott, and control of union and employer activities through administrative governmental agencies.

15·66. Fundamental Legal Principles (A). Survey of the fundamental principles of the law, of especial significance to the graduate engineer or scientist who is preparing for a career in industrial administration.

15·70. Production. Basic treatment of the manufacturing process; factory organization; location; buildings and equipment; establishment of facilities and layout. Problems of operation; maintenance; stores; purchasing; internal and external transport of materials; inspection; materials and production control. Plant visits and reports.

15·701. Production. Similar to 15·70. Restricted to School of Industrial Management graduate students; others admitted only by permission of the instructor.

15·71. Production Management. Advanced treatment of principles of scientific management for the development of effective policies and techniques in the following areas: administrative analysis; production control; materials control; standardization and simplification; new product research and development; process engineering and estimating; and quality control. Emphasis on the solution of typical problems encountered by operating executives and supervisors.

15·72. Industrial Standardization. Review and analysis of history and theoretical background of standardization movement in industry. Study of existing practices and techniques exemplified by actual industrial situations. Extensive consideration of practical problems of initiation, organization, and development of industrial standardization programs, including managerial evaluation and support. Determination of responsibility, authority, and opportunity of standards engineer in operating organization. Evaluation of present and potential worth as tool of management and relation to other phases of administration. Development of underlying philosophy of standardization as aid to industrial improvement and progress.

15·73. Management Laboratory. Work Simplification and Time Study. Techniques 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, and allowances.

15·74. Advanced Management Laboratory. Advanced techniques in work simplification and motion study, with especial emphasis upon managerial procedures followed in introducing and demonstrating analytical techniques to administrators, executives, and to employees; organization and operation of work simplification training programs, co-ordination with suggestion systems, and maintenance of progress schedules and records of waste elimination.

15·75. Manufacturing Analysis (A). Study of various techniques for analyzing manufacturing situations supplemented by laboratory application of procedures in cooperating companies. Consideration of different methods of analysis and their application both to studies made by management personnel and studies conducted by professional analysts.

15·76. Mass Production Methods. Principles of high volume manufacture. Production engineering and preliminary work necessary for the establishment of mass production facilities, with special emphasis on problems of flexibility, product variety, and standardization. Study of mass production implications of technical processes and control techniques. Problems from plants, plant visits reading and reports.

15·78. Manufacturing Control Seminar (A). Study of procedures and techniques for controlling manufacturing operations conducted from standpoint of top management. Laboratory work in cooperating firms. Emphasis upon development of control philosophy and administrative policy.

15·79. Manufacturing Policy Seminar (A). Seminar in selected topics of broad manufacturing policy, such as long-term planning, unit-plant determination, international operations, diversification, decentralization, and defense production.

15·81. Marketing. 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.

15·811. Marketing. An intensive coverage of the subject matter of 15·81, with some flexibility to allow for special interests of the group. Instruction is on a seminar basis, using the case approach. Particular emphasis is placed upon oral reports and analyses by individual class members. Restricted to School of Industrial Management graduate students; others admitted only by permission of the instructor.

15·82. Sales Promotion: Strategy and Methods. 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 organ-

Industrial Management and Business and Engineering Administration Continued

ization 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 through marketing research and planning, and role of price policy as it affects promotional problems.

15·83. Marketing Research. Basic principles and techniques in marketing research. Original field study by class, each student making a substantial number of field interviews. Training in marketing research methods including planning of the investigation, development of a questionnaire, collection and interpretation of data, techniques of analysis and presentation, and the preparation of written reports.

15·851. Research Methods in Marketing and Related Fields (A). Consideration of areas of knowledge and ignorance particularly in the field of marketing. Evaluation of research methods as developed by various disciplines in their application to fundamental problems.

15·852. Research Methods in Marketing and Related Fields (A). Continuation of 15·851.

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 coordination 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.

15·88. Industrial Marketing Seminar (A). Problems in marketing goods and services to industrial buyers, including coordination of promotional distribution, product, and price policies; critical appraisal of sales planning and control methods; long range planning of marketing activities; appraisal of effects of governmental controls; and other problems of fundamental significance in industrial marketing.

15·90. Technique of Executive Control. Survey of the means by which line executive deals with working group. Nature of executive attitude, responsibilities and methods of supervision, devices for stimulating desire of employee to improve quantity and quality of his work; executive duties; ways of collaborating with other executives and functional specialists; executive public relations; common executive difficulties with subordinates, associates, and superiors; bases of executive proficiency.

15·92. Industrial Problems. Comprehensive treatment of problems, policies, and practices inherent in the direction of a manufacturing enterprise. Intensive in-plant investigation of a manufacturing organization; classroom presentation of significant areas for study and methods for securing data; conferences on techniques of analysis and presentation; and seminars to give insight into current industrial practices and to reflect interdependence of marketing, production administration, product and process engineering, labor relations and financial control.

15·93. Organization (A). Study of organization as a basis for, as well as a tool of, industrial administration. Role of responsibility and authority as motivating forces in organization; the subdivision of responsibility into natural jurisdictions; and the effect of available personnel on theoretical organization. Nature of staff activities and coordinating elements; techniques of appraising and correcting deficiencies of subdivisions; methods of visualizing the processes of administration.

15·94. Contemporary Problems Seminar (A). Contemporary industrial and economic issues and developments. 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. Guests (faculty members and industrialists) participate.

15·951, 15·952. 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 field work, 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. Program includes weekly evening conferences with business administrators and industrialists.

15·97. Public Relations Seminar (A). Study of public relations developments and activities in industry, stressing management responsibilities, problems, and opportunities in public relations. History of public relations and causes for its increasing importance. Public relations fundamentals: objectives, relationships, policies, research and planning activities. Public relations methods: organization, administration, media, and evaluation. Lectures and conferences with business executives and public relations specialists.

15·98, 15·99. Seminar in Administration (A). Study of executive development problems and of fundamental economic, social, and administrative relationships as viewed through the experience of leaders in business, labor, and public administration. (Restricted to Sloan Fellows only.)

AERONAUTICAL ENGINEERING

Subjects 16·00 to 16·99

16·00. Aeromechanics. Dynamics, with applications to aeronautical problems. Kinematics of a point, particle dynamics. Kinematics of plane motion, moment of inertia, general plane motion. Work and energy, impulse and momentum, relative motion.

16·01T. Aeromechanics. Dimensional analysis, variable mass problems, dynamics of groups of particles. General motion of rigid bodies, ellipsoid of inertia, geometric and mass symmetries, Euler's dynamical equations, gyroscope equations. Linear systems, free and forced oscillations, classical and operational methods of analysis.

16·02T. Aerodynamics. Applications of the principles of particle dynamics and thermodynamics to study of real and perfect fluids, with particular reference to aeronautical problems. One-dimensional flow of perfect gases; fundamental equations of three-dimensional fluid motion; applications of incompressible-flow theory to airfoils and wings, including complex variable techniques; effects of viscosity.

16·025. Aeronautical Mechanics. Dynamics of linear, multiple degree of freedom system; free and forced responses; closed-loop systems; the performance function and its properties; stability criteria; auto-pilot systems. Introduction to aerodynamics of non-viscous compressible fluids.

16·03. Aerodynamics — Non Viscous Fluids (A). Extended treatment of two-dimensional airfoils, including v. Mises, Karman-Trefftz, and more general types. Modifica-

Aeronautical Engineering Continued

tion of given profiles to forms with desired pressure distributions. Lifting line theory, with particular attention to discontinuities of various sorts. Introduction to lifting surface theory and load distribution on swept wings.

16·04. Aerodynamics — Viscous Fluids (A). Navier-Stokes equations, laminar boundary layer theory, single and multiple force systems, Reynolds number, Blasius solution, Pohlhausen solution, outer and inner solutions, separation. Turbulent boundary layer theory, Schlichting theory of damped and undamped oscillations, transition, Prandtl momentum mixing length, Karman law of similitude, logarithmic velocity distribution, Taylor vorticity mixing length, turbulent friction drag and layer thickness under pressure gradients, effects of surface roughness and heat transfer.

16·051. Aerodynamics — Compressible Fluids I (A). Characteristic parameters for flow of compressible fluids. One-dimensional flow — DeLaval nozzle. Shock wave; change of states across a shock wave, formation of shock wave and its thickness. Basic equations for two- and three-dimensional flow of non-viscous compressible fluid, Kelvins's theorem, Helmholtz theorem. Two-dimensional subsonic flows: Janzen-Rayleigh method, Galuert-Prandtl method, Karman-Tsien method, velocity and pressure correction formulae. Exact solutions of two-dimensional flow, limiting line, critical Mach number. Transonic flows and Karman transonic similarity law. Two-dimensional supersonic flows: the method of characteristics, Ackeret's theory for thin supersonic airfoils.

16·052. Aerodynamics — Compressible Fluids II (A). Linearized theory for three-dimensional subsonic flows; axially symmetric bodies, velocity and pressure correction formulae; induced velocity of a vortex and extended Prandtl lifting line theory for wings of large aspect ratio. Transonic flows over axially symmetric bodies — Karman similarity law. Linearized theory for supersonic wings of finite span. Method of source and doublet distribution, drag and lift of symmetrical rectangular wings, drag and lift of symmetrical delta-wings. Hypersonic flows: its characteristics and the hypersonic similarity law. Basic equations of viscous compressible flow: Phenomenological derivation and its justification by kinetic theory of non-uniform gases. Superaerodynamics. Boundary layer in compressible flow and its interaction with shock wave.

16·061. Potential Flows (A). One of a series of discussions of advanced topics in aerodynamics. Equations of motion of an inviscid fluid. Range of application of various approximate equations. Lifting surface theory and interference effects in subsonic flow. Two-dimensional symmetric and lifting airfoils in transonic flow. Supersonic wing theories. Reverse flow theorems. Inlet theory. Wing-body and wing-tail interference effects. (Not offered 1952–53.)

16·062. Unsteady Flows (A). One of a series of discussions of advanced topics in aerodynamics. Fundamentals of unsteady flows. Two-dimensional and three-dimensional bodies in incompressible flow. Compressible flow and acoustic theory. Airfoils and wings in subsonic, transonic, and supersonic flow. Very slender bodies in compressible flow. Special problems.

16·063. Viscous Flows (A). One of a series of discussions of advanced topics in aerodynamics. Some special solutions of the Navier Stokes equations and their behavior as viscosity vanishes. One-dimensional and linearized models of boundary-layer-like behavior. Special boundary layer problems in three dimensions, with suction and with time variation. Critical review of the present knowledge of turbulent flows. Isotropic turbulence theory, its physical significance and field of application. Other models illustrating the physics of turbulence. Recent experimental results and techniques in turbulence research. (Not offered 1952–53.)

16·064. Thermal Effects (A). One of a series of discussions of advanced topics in aerodynamics. Nature of aerodynamic heatings. Modes of heat transfer. Physical properties of fluids. Equations of motion of viscous heat conducting compressible fluids. Exact solutions. Boundary layers. Analytical and numerical solutions. Comparison with experiment and discussion. Turbulent boundary layers. Effect of radiation. Stability and effect of variation of transition point on average heat transfer coefficients. Shock wave boundary layer interaction and other special problems. (Not offered 1952–53.)

16·065. Waves and Shocks (A). One of a series of discussions of advanced topics in aerodynamics. Hyperbolic equations. Riemann waves. Interaction of simple waves. Oblique shocks. Reflections and refractions. Shock Tubes. Hydrodynamic analogy. Curved shocks. Diffraction of acoustic waves. Spherical and cylindrical strong shocks. Growth and structure of a shock in a real fluid. Explosions and combustion. Special topics.

16·066. Hypersonics and Superaerodynamics (A). One of a series of discussions of advanced topics in aerodynamics. Nature of the hypersonic problem. Discussion of equations and physical phenomena. Range of validity of continuum theory. Kinetic theory of gases. Application of distribution functions and free path concept to transport phenomena and the equations of fluid flow. Effects of molecular structure. Condensation. Superaerodynamics and slip flow. Special problems. (Not offered 1952–53.)

16·10. Applied Aerodynamics. Application of aerodynamic theory to airplane design and aircraft propellers.

16·105. Applied Aerodynamics (A). Further studies of airplane performance, including the survey of effects of variations of propeller, type of power plant, Mach number — both at trans- and supersonic velocities.

16·13. Airplane Stability and Control. General theory of longitudinal and lateral stability, controllability and maneuverability of airplanes.

16·14. Airplane Design Problems. 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.

16·15. Advanced Stability and Control of Aircraft (A). Various features of stability and control of aircraft are studied, including airplane motion with free controls; rotary derivatives; airplane frequency response to control motion; controls and control forces; etc.

16·18. Guided Missiles (A). Introduction to the problems of the flight of guided missiles, their components, flight path control and guidance.

16·20. Structures. Introduction to methods of analysis of airplane structures with application to bending and torsion of wings and fuselages, landing gears, tension field beams, columns, and sheet-stiffener combinations. Niles and Newell, *Airplane Structures.*

16·21. Structures. 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. Introduction to methods of computing influence coefficients of shell structures. Niles and Newell, *Airplane Structures.*

16·21T. Structures. Study of metals with emphasis on the effects of composition, mode of fabrication, and heat treatment on their engineering properties. Deflections of beams and trusses by virtual work and by Costigliano's theorems. Analysis of indeterminate structures by energy methods. Study of shell beams with ineffective and effective skins including stresses and deflections. Analysis of curved beams. (Not offered 1952–53.)

16·22. Aircraft Structures. Study of methods applicable 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 of determining the stability of systems of members and introduction to the equations of elasticity as applied to isotropic and anisotropic materials. Laboratory work on the calibration

Aeronautical Engineering Continued

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 on investigation and development of methods involving stability criteria or applications of elastic theory, and on probable effects on structural analysis methods to be expected from new trends in design.

16·30. Principles of Automatic Control. Analysis of automatic control systems, including analytical, graphical, and analog methods. Formulation of control system performance equations leading to solutions for transient and steady state inputs. Non-dimensionalized treatment of first and second order differential equations with applications to more involved automatic control loops.

16·31. Principles of Instrumentation and Control (A). Discussion of static and dynamic behavior of operating components used in open and closed loop measurement and automatic control systems. Development of a generalized system of concepts for describing and specifying functional performance of operating systems. Detailed treatment of the theory of systems describable by first and second order differential equations and its use as the basis for analysis of more complicated systems. Emphasis on the use of non-dimensional variables in the solution of dynamical problems. Various procedures for solving differential equations including classical, operational, graphical and analog methods. Use of transient and frequency response characteristics to represent the behavior of both simple and complex systems. Practical examples drawn from the field of measuring instruments and control systems to illustrate applications of the general theory. May be taken simultaneously with 16·33.

16·32. Principles of Instrumentation and Control (A). Continuation of 16·31 dealing principally with the dynamic performance of closed loop control systems. Detailed study of certain control system components to determine the effect of their characteristics upon system performance. Stability, non-linearities and design for optimum response. Use of various analytical techniques including graphical aids and analogs.

16·33. Instrumentation and Control Laboratory (A). To be taken simultaneously with 16·31. Laboratory exercises on instruments and control systems designed to provide experimental familiarity with the principles set forth in 16·31. Static and dynamic performance tests on various instruments are followed by exercises involving control systems.

16·34. Instrumentation and Control Laboratory (A). To be taken simultaneously with 16·32. Continuation of 16·33.

16·35. Special Problems in Instrumentation and Control (A). Problems of interest to qualified individual students in consultation with the instructor.

16·36. Vibration Measurements (A). Lectures and laboratory exercises dealing with the measurement of mechanical vibrations. Detailed studies are made of the components comprising vibration and strain-measuring systems. Included are linear and torsional vibrometers, accelerometers, strain gages, harmonic analyzers, indicating and recording equipment, and calibration apparatus.

16·37. Methods of Analysis in Control Systems (A). Discussion of statistical foundations of control systems analysis, including concepts of stationary and non-stationary random processes. Analysis of output response of variable coefficient linear systems to random inputs. Perturbation methods in error studies for non-linear systems. Emphasis on use of simulator methods.

16·38. Control Systems Components (A). Study of physical components utilized in instrumentation and control systems from the point of view of the effect of their separate performance characteristics on the control system problem. Specification of components to meet particular control system requirements. Consideration of electrical, mechanical, pneumatic, and hydraulic components with emphasis on non-ideal effects.

16·39. Vector Kinematics and Gyroscopic Instrument Theory (A). Generalized theory of accelerations and velocities of bodies in spaces which are moving with respect to inertial space. Specialized application of this general theory and of Newtonian mechanics to development of the theory of gyroscopic instruments. Development of the treatment from the standpoint of the engineer, using both the methods of vector analysis and those of conventional coordinate components. Application of the results of the generalized theory to the analysis of gyroscopic devices used in airborne and marine craft.

16·40. Automatic Control Equipment for Aircraft (A). Discussion of errors and uncertainties associated with the components included in airplane automatic control equipment. Particular emphasis on dynamic errors. Several analytical techniques demonstrated, including graphical, operational and simulator methods. Analysis of gyroscopic and other flight instruments necessary for automatic control. Discussion of various aircraft computer units and comparison of merits of displacement, integral and derivative control. Dynamics of control elements, including servo lag and cable effects, considered. Analysis of complete aircraft system for longitudinal and lateral performance.

16·41. Fire Control Principles (RA). Discussion of static and dynamic behavior of instrument elements from the standpoint of functional performance. Particular emphasis on the theory of systems that can be described by means of first- and second-order differential equations with constant coefficients. Emphasis on the simplifications in analysis possible by use of non-dimensional variables and application of the principles of dimensional analysis to a wide variety of problems. Vector analysis methods used to set up the general requirements of the problems for both airborne and anti-aircraft fire control. (Restricted to selected officers of the U. S. Air Force, Army and Navy.)

16·42. Fire Control Systems (RA). Continuation of the study of fire control instruments started in 16·41. Applications of the theory of gyroscopic instruments to the analysis of fire control gyroscopic equipment. Development, as necessary, of the theory of other components used in fire control systems. Consideration of the dynamic characteristics of fire control systems, including solution time and smoothing action. Study of design factors controlling dynamic performance with reference to possible methods for realizing satisfactory performance in actual systems. (Restricted to selected officers of the U. S. Air Force, Army and Navy.)

16·43. Fire Control Instrument Laboratory (RA). Laboratory work to demonstrate experimentally the principles developed in the lectures of 16·41 and taken concurrently with it. Experiments illustrating general static and dynamic performance of instrument systems following first- and second-order differential equations. Various experiments on the characteristics of fire control instrument components, including gyroscopic elements, data transmission systems, and integrating units. (Restricted to selected officers of the U. S. Air Force, Army and Navy.)

16·44. Advanced Fire Control Instruments Laboratory (RA). Continuation of 16·43. Experiments carried out on service fire control equipment and special demonstration units to study the static and dynamic performance characteristics of typical airborne and antiaircraft equipments. Particular attention given to the problems of solution time, smoothing and tracking. (Restricted to selected officers of the U. S. Air Force, Army, and Navy.)

16·45. Advanced Fire Control Systems (RA). Problems of current interest in fire control systems. (Restricted to selected officers of the U. S. Air Force, Army, and Navy.)

16·46. Advanced Fire Control Systems (RA). Problems of current interest and study of projected developments in fire control. (Restricted to selected officers of the U. S. Air Force, Army, and Navy.)

Aeronautical Engineering Continued

16·47. Rockets, Guided Missiles, an Projectiles (RA). Terminal ballistics, rocket motors and propulsion, interior ballistics of guns, aerodynamics of guided missiles, exterior ballistics of rockets and projectiles, flight paths of ballistic and interceptor guided missiles. Design considerations for guided missiles and rockets. (Restricted to selected officers of the U. S. Air Force, Army, and Navy.)

16·48. Structural Problems in Weapons (RA). Principles of static and dynamic stress analysis of aircraft structures. Theory of shock loading. Effect of structural response on the fire control system. Fundamentals of gun and gun mounting structural analysis. (Restricted to selected officers of the U. S. Air Force, Army, and Navy.)

16·49. Special Problems in Fire Control (RA). Problems of interest to qualified students in consultation with the instructor. (Restricted to selected officers of the U. S. Air Force, Army, and Navy.)

16·50. Rotating Wing Aircraft (A). Discussion of problems of performance evaluation, control and stability, vibration and design, as applied to rotating wing aircraft.

16·53. Principles of Aircraft Power Plants. Analysis and design of rockets, ramjets, turbo-jet, and turbo-propeller engines. Consideration of the limitations on performance imposed by thermodynamics, fluid mechanics, and strength.

16·54. Aircraft Power Plant Problems (A). Problems on the application of power plants to aircraft involving heat transfer, fluid mechanics, strength and vibration.

16·55. Aircraft Power Plant Problems (A). Continuation of 16·54.

16·56. Jet Propulsion Engines (A). Analysis and preliminary design computations for a turbo-jet power plant for a specific purpose.

16·60. Advanced Aeronautical Problems (A). Individual advanced work by properly qualified graduate students. Problems selected in consultation with the instructor.

16·61. Aeronautics Seminar (A). Weekly two-hour seminar given by the staff and the graduate students to discuss current aeronautical problems.

16·62. Aerodynamic Laboratory. Methods and equipment used for research in aerodynamics.

16·63. Aerodynamic Laboratory. Continuation of 16·62 including additional practice in the laboratory.

16·65. Aeronautical Engineering Laboratory. Series of lectures and experiments to illustrate the principles and practices of experimental aeronautics in the fields of aerodynamics, structures and automatic control systems. (Not offered 1952–53.)

16·70T. Aircraft Detail Design. Aircraft drafting room practice and the preparation of airplane assembly, subassembly, and detail part drawings. Lectures and drafting room exercises covering air frame detail design, landing gear and landing gear control system mechanisms, fuel systems, airplane graphics, and the preparation of a weight estimate and balance diagram for a complete airplane.

16·71T, 16·72T. Aeronautical Engineering. Design of an airplane including layout, weight, balance, and performance estimates, structural design and preliminary stress analysis, stability and control analysis including the design of a simple automatic control system. Particular emphasis is placed on individual initiative and independent application of fundamental principles of design and on the presentation of a final report. (Not offered 1952–53.)

16·72. Airplane Design Practice. Preliminary design of a light airplane including weight and balance estimate, general arrangement drawings and preliminary design of primary structure according to C. A. A. requirements.

16·74. Advanced Airplane Design (A). Preliminary design of high performance aircraft, including layout, weight and balance estimates, structural design, aerodynamic evaluation and control and stability analysis. Considerable latitude is allowed in the choice of the type of aircraft to be developed, the design being used mainly as a means of illustrating advanced design problems encountered with high-speed piloted and pilotless aircraft.

16·81. General Aeronautics. Characteristics of aircraft, engines, and propellers for non-aeronautical students.

16·82. Introductory Aeronautical Engineering. Introduction to aircraft, their components and general principles of flight.

16·851, 16·852. Industrial Practice. Approximately six months of practical work carried out by the cooperative students in manufacturing, engineering, research, and developments at the plants of the organizations participating in the cooperative program.

16·91. Aeroelasticity (A). Dynamics of elastic structures; air forces under unsteady conditions; flutter.

16·92. Advanced Aeroelasticity (A). Advanced aspects of aeroelasticity: corrections for finite span and compressibility in flutter calculations; study of wing divergence and aileron reversal.

16·93. Aeroelasticity Laboratory (A). Experimental study of problems in structural dynamics and aeroelasticity.

16·94. Dynamics of Aircraft Structures (A). Application of vibration theory to the determination of the vibration characteristics of the aircraft structure. Determination of the dynamic stresses produced during the transient response of the aircraft structure to rapidly applied forces. Discussion of current structural dynamics problems.

BUILDING ENGINEERING AND CONSTRUCTION

Subjects 17·00 to 17·99

17·21. Building Construction. Discussion of conventional and mass production methods for the construction of residential buildings. Consideration given to the assembly of materials, the sequence of erection, the use of new materials, advanced methods in construction techniques, types of services for home construction, the economic effects of building and zoning codes, labor policies, and planning and field procedures. Class discussions, problem analysis and quantity surveys in the drafting room. Dietz, *Dwelling House Construction.*

17·22. Building Construction. Study plan similar to 17·21. Types of buildings studied: those with non-combustible exterior walls and combustible or fire-resistive floor and roof structures as typified by semi-fireproof or heavy-timber construction and by many types of industrial buildings. Study of foundations, exterior walls, interior frames and floor and roof systems integrated in much the same fashion as in actual practice. Quantity surveys and estimates made from working drawings. Staley, *Semi-Fireproof Construction.*

17·31T. Building Construction. Discussion of the construction of buildings with reinforced concrete or fireproofed structural steel frames. Study of heavy foundations, shoring, relation of frame to exterior walls, floor arches, interior partitions, mechanical equipment, electrical services and architectural balance. Quantity surveys and estimates prepared from working drawings in conjunction with the construction analysis. Voss, *Fireproof Construction.*

Building Engineering and Construction Continued

17·40. Estimating and Job Management. 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. Walker, *Building Estimator's Reference Book.*

17·40T. Job Management. Detailed study of quantity surveys and elementary estimating covered in the subjects of Building Construction including a study of unit prices, job planning, contract relations, labor relations, superintendence, safety in construction and the business aspects of contracting. *Departmental Notes.*

17·401. Advanced Job Management (A). Development of the organization of large projects with particular reference to the initial economic survey, time schedules, job organization, and the integration of construction procedures. Particular emphasis on the character of contract instruments, legal requirements for job insurance and the expedition of materials to accomplish speed and quality. *Departmental Notes.*

17·41, 17·42. Building Management (A). Especially designed to train graduate students in the field of property management. Study of the elements of first cost, expansion, maintenance, rentals, repairs and modernization as applied to commercial and industrial buildings. Work consists of lectures, field surveys, assigned readings and reports. *Departmental Notes.*

17·43. Building Construction. Abridged study of building construction, estimating and job management with particular reference to fireproof construction. Procedure in planning construction operation, sequence of construction, quantity surveying and estimating. Designed to provide civil engineers with essentials of building construction procedure. Voss, *Fireproof Construction.*

17·45. Construction Problems. Continuation of previous courses in Building Construction. Specifications, details, and construction procedure for an actual job in progress, or for an approved project in the field. Discussion of original and alternate specifications and methods from those used or proposed in the actual project.

17·52T. Steel Design. First part: establishment of a connection between the study of applied mechanics and structural theory by graphical and analytical methods. Graphical determination of centroids of areas, moments, the elastic curves of loaded beams, and stresses in reinforced concrete beams. Graphical determination of stresses in trusses. Latter part: design of structural steel building frames, including design of rolled and built-up beams and girders, various types of riveted and welded connections, trusses, columns and wind bracing. Special attention to general steel framing in its relation to architectural details. Grover, *Manual of Design for Arc Welding Steel Structures by Air Reduction;* A.I.S.C., *Steel Construction Manual;* Williams and Harris, *Structural Design in Metals.*

17·53. Structural Design. 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. Peabody, *Design of Reinforced Concrete Structures; Departmental Notes.*

17·53T. Wood Design. Design of wood floor- and roof-framing, wood trusses, columns, trussed girders, and details common to heavy timber construction. Design of rigid frames using laminated construction, design of built-up plywood girders, and of concrete forms. *Departmental Notes.* (Not offered 1952–53.)

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. Peabody, *Design of Reinforced Concrete Structures.*

17·532. Advanced Reinforced Concrete Design (A). Effect of shrinkage and plastic flow. Prestressed members. Plastic theory of design. Special design problems such as rigid frame bents, ribbed barrel arches, chimneys, tanks, and domes. Peabody, *Design of Reinforced Concrete Structures.*

17·54. Structural Design. Design of structural steel building frames, including design of rolled and built-up beams and girders, various types of riveted and welded connections, trusses, columns and wind bracing. Special attention to general steel framing in its relation to architectural details. Grover, *Manual of Design for Arc Welding Steel Structures by Air Reduction;* A.I.S.C., *Steel Construction Manual;* Hauf and Pfisterer, *Design of Steel Buildings; Departmental Notes.*

17·54T. Concrete Design. Same as 17.53. (Not offered 1952–53.)

17·542. Advanced Structural Steel Design (A). Torsion of structural shapes, members curved in a horizontal or in a vertical plane, beams with variable moment of inertia. Special problems involving balcony framing, elevated structures, arches and domes. Heavy moment-resisting beam connections.

17·71T. Materials — Metals. Alloy diagrams and their interpretation. Consideration of the more important nonferrous 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;* A.S.T.M., *Selected Standards for Students in Engineering; Departmental Notes.*

17·72. Materials — Masonry. 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 and concrete aggregates, mortars, natural and cast stone, gypsum products and various masonry specialties used in construction. Includes laboratory testing of masonry materials. A.S.T.M., *Selected Standards for Students in Engineering; Departmental Notes.*

17·73. Materials — Wood. 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;* Dietz, *Construction Materials;* A.S.T.M., *Selected Standards for Students in Engineering.*

17·741. Engineering Properties of Plastics. Engineering attributes of plastics studied, with principal emphasis upon mechanical and structural properties. Work includes an introductory review of the chemistry of plastics to familiarize the student with the various types; the various strength properties; other properties important from an engineering standpoint such as dimensional stability and durability; and methods of manufacture and fabrication, insofar as these modify and influence the engineering properties. Richardson and Wilson, *Fundamentals of Plastics.*

17·742. Engineering Laminates (A). Consideration of the general theory of composite materials. Followed by discussion of specific laminates such as plastics reinforced with paper, textiles, glass fibers, and various types of mats; sandwiches of soft cores and hard faces; plywood and laminated timber; and duplex metals. Considerable attention given the cements and adhesives employed in making up composite materials. Dietz, *Engineering Laminates.*

17·75. Materials. Portions of 17·71T, 17·72, and 17·73 most essential for civil engineering structures, with particular reference to concrete, steel, and wood. Physical and chemical characteristics of these engineering materials with respect to the effects of manufacture and use on their quality, behavior, and durability. Includes laboratory testing of masonry materials. An elective for students in other departments who

Building Engineering and Construction Continued

are unable to schedule the more comprehensive sequence of subjects in Materials. *Wood Handbook; Concrete Manual;* White, *Engineering Materials.*

17·76. Research in Organic Structural Materials (A). Opportunity for laboratory investigation amplifying the work done in courses 17·741 and 17·742.

17·771. Cementitious Materials. Continuation and a more advanced study of the cementitious materials covered in 17·72. Critical studies made of the production processes, including the conditions of calcination, the constitution of the calcined materials, the effect of treatment after calcination, and the effect of interground accelerators, retarders, and other additions. Lea and Desch, *The Chemistry of Cement and Concrete; Departmental Notes.*

17·772. Cement and Concrete (A). Advanced study of the processes of wetting, hydration, setting and hardening of portland cement. Considerable time devoted to the study of particulate materials together with the properties of pastes made with them. Characteristics of fresh and hardened pastes, and their contribution to the properties of fresh and hardened concrete studied critically from the standpoint of placeability, shrinkage, strength, plastic flow, and durability. Lea and Desch, *The Chemistry of Cement and Concrete; Departmental Notes.*

17·78. Research in Cementitious Materials (A). Opportunity for laboratory investigation amplifying the work done in courses 17·771 and 17·772.

17·81, 17·82. Cooperative Seminar. Elective subjects provided for seniors in the Department who wish to work cooperatively on a building project with students in the Department of Architecture.

METEOROLOGY

Subjects 19·00 to 19·99

19·00. General Meteorology. Introductory subject presenting a general treatment of the observational facts, mechanics, thermodynamics, and physics of the atmosphere. Applications of meteorological knowledge to weather forecasting, business, industry, transportation, etc. Laboratory exercises in the use of the weather map.

19·001. General Meteorology. Same as 19·00 without the laboratory exercises.

19·01. Descriptive Meteorology I. Simplified treatment, with a minimum of mathematics, of composition and structure of the atmosphere; elementary thermodynamics and the heat balance of the atmosphere; the circulation principle (geostrophic, gradient, and frictional wind); formation and characteristic forms of atmospheric condensation phenomena. Willett, *Descriptive Meteorology.*

19·012. Descriptive Meteorology (College Transfer). Abridgement of 19·01 and 19·02 for college transfer students who have been allowed partial credit for 19·01 and 19·02. Not to be taken by any student who must take or repeat 19·01 and 19·02. Supplementary training to cover the requirements of 19·01 and 19·02.

19·02. Descriptive Meteorology II. Continuation of 19·01, covering the general circulation of the earth's atmosphere; the secondary circulations, both tropical and extratropical, including the role of air masses and fronts; the tertiary (local) circulations, including drainage winds, local convection, whirlwinds, showers, thunderstorms, land and sea breeze, large scale turbulence eddies, föhn winds, etc. Willett, *Descriptive Meteorology.*

19·14. Long Range Weather Forecasting (A). Principal methods of long range weather forecasting. Detailed treatment of the present Weather Bureau five-day forecasting and verification techniques. Laboratory exercises in application of the five-day prognostic technique. Selected reading of special reports and articles.

19·21. Meteorological Observations. Observation, recording and coding of weather data; use and maintenance of station instruments; teletype circuit operation and procedure.

19·22. Meteorological Instruments (A). Principles and techniques of meteorological instrumentation. Lectures and laboratory exercises in static and dynamic responses of pressure, temperature, humidity and wind instruments. Laboratory and field exercises with surface and upper air instruments. Reduction of observed data to forms suitable for synoptic and dynamic studies.

19·23. Micrometeorological Instrumentation (A). Instruments, techniques and procedures for micrometeorological measurements.

19·30. General Climatology. Distribution of radiation temperature, pressure and wind, hydrometeors and air masses and fronts at the surface of the earth and aloft and of the physical factors determining this distribution. Climatic zones and types. Description of the climate of each continent and of the oceans in terms of dynamics of the atmosphere, of air mass types and frontal activity. Haurwitz and Austin, *Climatology.*

19·32. Microclimatology. Study of physical properties which determine the structure of the lowest layer of the atmosphere.

19·33, 19·34. Applied Climatology I & II (A). Study of modern climatological methods applied to problems of business, industry, agriculture, aviation, the military, and public health. Extensive use of principles and techniques of synoptic and dynamic meteorology, physical climatology and statistics in the development of the climatological method. Lectures on techniques and case method of demonstration. Opportunity to select weather problems for solution and presentation for class discussion and criticism.

19·44. Synoptic Meteorology I. Meteorological elements and their conservatism; practical rules and formulae for extrapolating the movement and development of surface and upper air pressure systems; hydrometeors, clouds and colloidal stability; stability and instability and their relation to weather phenomena. Petterssen, *Weather Analysis and Forecasting.*

19·45. Synoptic Meteorology II (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.

19·50. Introductory Meteorology Laboratory. Explanation of international weather symbols and airways teletype code; decoding and plotting of daily weather reports; identification of cloud types; elementary principles of weather map analysis.

19·51. Synoptic Laboratory I. Analysis of weather maps. Application of practical rules for extrapolating the movement and development of pressure systems. Practice forecasting for selected stations.

19·52. Synoptic Laboratory II. Analysis of weather maps and practice weather forecasting for selected stations, together with practice in special airways forecasting, utilizing the teletype line sequences.

19·53. Synoptic Laboratory III (A). Continuation of 19·52. Advanced methods of analysis and forecasting with

Meteorology Continued

special emphasis on the use of aerological diagrams, cross sections, upper air charts, etc.

19·531. Synoptic Laboratory (A). Content similar to 19·53.

19·60. 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.

19·601. Introduction to Theoretical Meteorology. Simplified treatment of atmospheric statics, dynamics and thermodynamics designed to provide the theoretical background for synoptic meteorology and to prepare the student for more advanced subjects in dynamic meteorology.

19·61. Dynamic Meteorology I. 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.*

19·62. Dynamic Meteorology II. Hydrodynamic equations of motion. Streamlines and trajectories, circulation and vorticity, theory of atmospheric turbulence, its effects on the vertical distribution of wind and other meteorological elements. Energy transformations in the atmosphere. Survey of the wave theory of cyclones. Haurwitz, *Dynamic Meteorology.*

19·64. Dynamic Meteorology III (A). Large scale atmospheric motions. Examination of recent theories of the general circulation. Research in the application of fluid mechanics to meteorology and oceanography. Lamb, *Hydrodynamics.*

19·65. Dynamic Meteorology IV (A). Analysis of certain types of atmospheric flow. Advanced treatment of the dynamics of atmospheric motion, including a detailed study of atmospheric turbulence.

19·651. Low-Level Turbulence and Diffusion (A). Study of theory of turbulence and diffusion in the lower layers of the atmosphere with special emphasis on non-isotropic turbulence.

19·70. Elementary Physics of the Atmosphere. Treatment of atmospheric radiation, the ozone layer and the upper atmosphere, atmospheric electricity, atmospheric optics, propagation of sound in the atmosphere, and icing of aircraft.

19·71. Radar Meteorology (A). Elementary principles of radar and the techniques of storm detection. Analysis of the radar echo from precipitation. Discussion of the potentialities of radar for the examination and measurement of precipitation processes. Brief discussion of radar propagation anomalies. Lectures and laboratory work with operating radar systems.

19·72. Physical Meteorology (A). More detailed study of radiation theory as applied to the atmospheric heat balance; structure and composition of the stratosphere with special reference to the ozone layer. Theory of the visual range; physical theory of atmospheric condensation and precipitation processes.

19·83. Oceanography. Principles and methods of physical and dynamical oceanography, and the current systems of the oceans with special emphasis on their meteorological significance. Sverdrup, *Oceanography for Meteorologists.*

19·91. Meteorological Seminar I (A). Weekly reviews and discussions by staff members and students, of recent meteorological contributions published in current periodicals, and of original research.

19·911, 19·912. Meteorological Seminar I, II (A). Same as 19·91.

19·94. Special Problems in Meteorology. Reading, consultation, and original investigation on meteorological problems.

19·95. Special Problems in Meteorology (A). Reading, consultation and original investigation on meteorological problems of more advanced nature than those in 19·94.

FOOD TECHNOLOGY

Subjects 20·00 to 20·99

20·01T, 20·02T. Chemistry and Technology of Food Supplies I, II. Chemical composition, production, consumption, statistics, and methods of treatment of food materials. General commercial methods of production and handling of raw foods, such as milk, eggs, meats, cereals and other vegetable food supplies, and their preparation for commercial distribution or for later manufacturing processes. Fundamental principles involved in physical processes such as refrigeration, dehydration, and salting, and the microbiology and chemistry of the processes. Laboratory work including numerous exercises involving the chemical analysis of various foods and food products. Prescott and Proctor, *Food Technology;* Woodman, *Food Analysis.*

20·04. Chemistry of Foods. Analytical methods, fundamental basis of nutrition; extent, character and legal status of food adulteration. Woodman, *Food Analysis.*

20·11. Technology of Food Products. Methods of food preservation and manufacture. Semi-plant scale operations in dehydration. Production of fruit juices and concentrates, canning processes, and quick-freezing of various foods. Cruess, *Commercial Fruit and Vegetable Products;* Tanner, *The Microbiology of Foods.*

20·12. Technology of Food Products. A continuation of 20·11 with reference to the products and technological processes of the meat-packing industry, fisheries, dairy products, and special technical procedures involving heat penetration, sterilization, and packaging. Tressler and Evers, *The Freezing Preservation of Fruits, Fruit Juices and Vegetables.*

20·13, 20·14. Chemical Engineering Food Applications. Fundamental principles of chemical engineering operations with emphasis upon application in the food industry. Flow of heat and fluids, absorption, extraction, evaporation, distillation, drying, filtration, etc. General discussions supplemented by extensive problem work. Walker, Lewis, McAdams, and Gilliland, *Principles of Chemical Engineering.*

20·21. Flavor Evaluation (A). Study of the senses of taste and smell and their interrelationship with other senses. The concept of flavor and its estimation by the senses. Natural and synthetic flavors, their preparation, composition and use in food products. Flavor changes in food products. Introduction to organoleptic technics.

20·22. Food Acceptance (A). Study of the factors influencing the acceptance of foods by individuals and by large groups. Consumer acceptance testing. Sensory difference testing. Development and maintenance of specifications and standards for food acceptance. Analysis of variables and attributes for the control of food products.

20·32. Chemistry of Nutrition. The needs of man and animals for calories, carbohydrates, fats, proteins, amino acids, minerals, and vitamins.

20·322. Chemistry of Nutrition Laboratory. Analysis for nutrients of representative foods by chemical, colorimetric, fluorometric, and microbiological techniques.

Food Technology Continued

20·34. Applied Nutrition (A). Nutrient requirements of man and animals; laboratory and clinical methods for determining requirements and nutritional status; techniques for measuring adequacy of dietaries; genetic and environmental factors influencing nutrient content of foods; food habits; population feeding programs; school lunches; communal feeding, etc.; international nutrition problems.

20·36T. Advanced Nutrition (A). Digestion of food and metabolism of nutrients, including: occurrence of nutrients in plant and animal products; stability of essential nutrients during plant growth, harvesting, storage, manufacture, and preparation for serving; influence of diet on intestinal synthesis of vitamins; synergistic action of nutrients; absorbability of nutrients from alimentary tract; endocrines and nutrition; dynamics of body constituents; isotopic and radioactive techniques; measurement of food proteins; amino acid analysis; methods of research with animals.

20·38T. Nutritional Evaluation of Food Processes (A). Consideration of losses or gains in nutritional values of foods and food products during transit, treatment and storage. Discussion of the effects of the following operations: harvesting, transportation, refrigeration, freezing, concentrating, dehydration, bleaching, refining, blanching, canning, pickling, salting, brewing, fermenting, baking, steaming, boiling, frying, roasting, and toasting. Procedures for minimizing these losses in vitamins, minerals, amino acids and other nutrients are suggested.

20·41. Bacteriology. Biology, physiology, biochemistry and biophysics of bacteria. Pure culture studies, identification of unknown bacteria, effects of physical and chemical agents on bacteria, food intoxication and infection, anaerobiosis, water and milk bacteriology. Frobisher, *Fundamentals of Bacteriology.*

20·42. Industrial Microbiology. Fundamental studies involving industrially important fermentations. Cultural and production methods, biochemistry. Applications of microbiology in the food, brewing, leather and textile industries. Ethanol, yeast, vinegar, butanol and acetone, organic acids, antibiotics. Prescott and Dunn, *Industrial Microbiology.*

20·43, 20·44. Advanced Industrial Microbiology (A). Selected problems in the use of yeasts, bacteria and molds for the production of substances of industrial or potential value. Emphasis on the study of the most recent cultural and production methods and the biochemistry of the fermentations or the changes concerned. Biochemical activities of the acetic acid bacteria; preparation of organic acids, alcohols, alcoholic beverages, yeast, butanediol, antibiotics, enzyme products, lipids, sterols, and other substances; saccharification of starches and cellulosic materials; microbiological determination of amino acids, vitamins; and relation of certain biological agents to the textile, timber and leather industries. Prescott and Dunn, *Industrial Microbiology;* Smith, *Industrial Mycology;* Bern-Hauer, *Gärungschemisches Praktikum.*

20·46. Bacteriology of Foods (A). Quantitative study of the handling and storage of foods and their bacterial deterioration. Food storage in atmospheres of inert gases, food fumigation, recent advances in food packaging, and relation of bacteria thereto.

20·51, 20·52. Advanced Food Technology (A). Technical problems in special food industries, involving the use of dehydration, sterilization, homogenization equipment, and special applications of physics, chemistry, and biology in food technology. Mrak and Stewart, *Recent Advances in Food Research.*

20·53. Food Applications of Ionizing Radiations (A). Introduction to theory and application of ionizing radiations to the sterilization of foods and pharmaceuticals. Effects of radiations on bacteria, molds, insects, enzymes, foods and their constituents.

20·61, 20·62. Food Technology Seminar (A). Presentation of recent advances in food technology and research and analysis of the fundamental principles involved.

20·71. Research Problems (A). Special research techniques in food technology.

20·81. Selected Topics in Food Technology (A). Surveys and investigations arranged by individual conference.

20·82. Food Technology. Origin, composition, transportation, handling, storage, processing, and control of the more important animal and plant foods, with emphasis on the chemical, biological, and engineering factors relating thereto, including certain of the processes of the milling, baking, meat-packing, canning, dairy, fisheries, refrigeration and quick-freezing industries; also some of the food specialties, such as vitamins, with special attention devoted to equipment used in new processes.

ATHLETIC PROGRAM

Subjects A1 to A99

A1, A2. Athletic Program. Required for all male students registered as freshmen. Swimming test taken by all found physically qualified by Medical Department. Swimming instruction provided for individuals who cannot meet swimming requirements. Instruction offered in the following athletic activities: Softball, Touch Football, Sailing, Tennis, Basketball, Volleyball, Badminton, Squash, Handball, Advanced Swimming, and Golf. Practice and participation on freshman teams for inter-collegiate competition may be substituted for required instruction.

GRAPHICS

Subjects D1 to D99

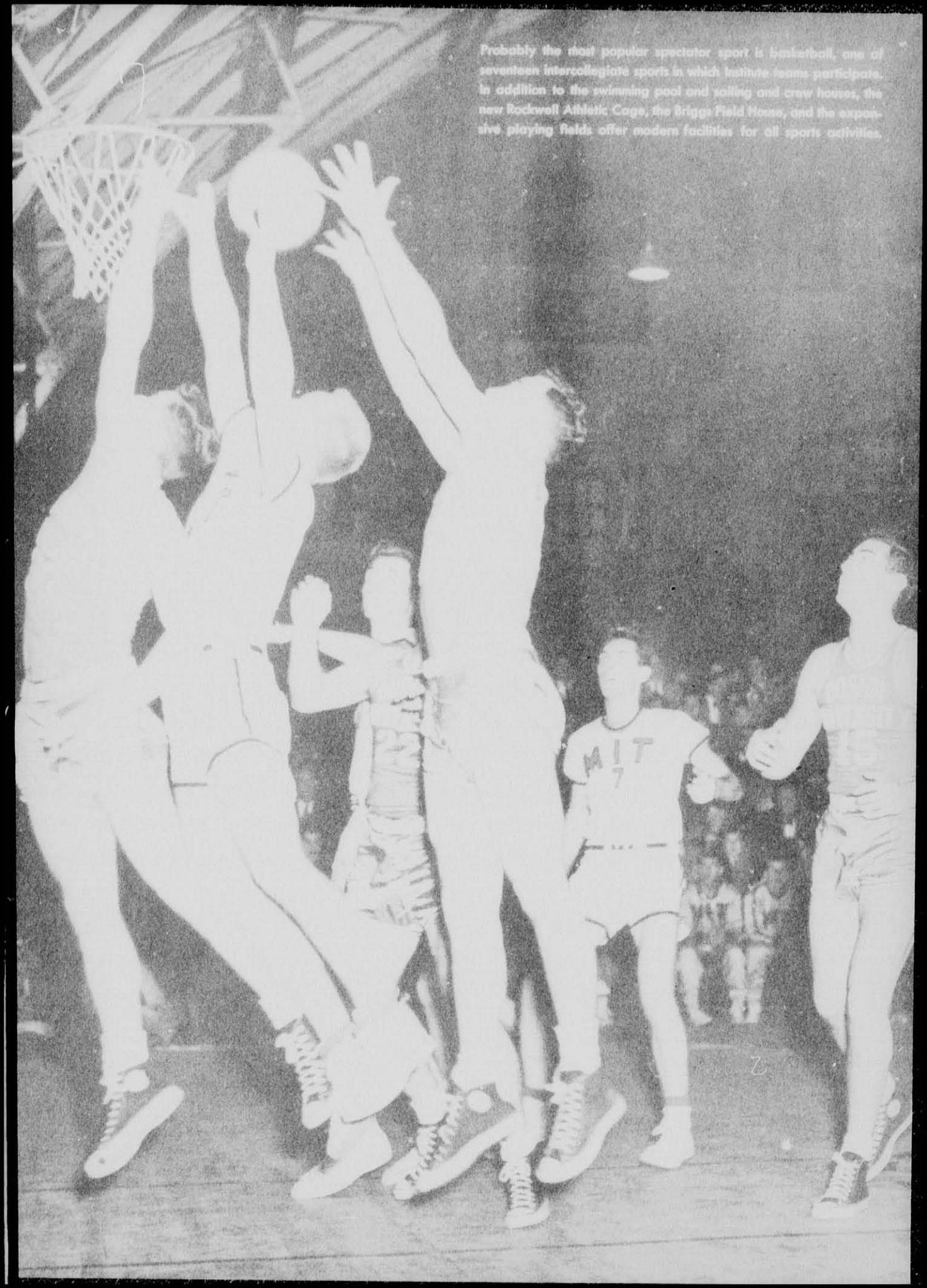
D11. Engineering Drawing. Introduction to basic graphical methods of interest to the technical student. Instruction in the correct use of drawing instruments and materials. *Plane Graphics:* Construction and properties of plane curves, composition and resolution of vectors, graphical calculus, simple empirical curves. *Space Graphics:* Drawing in orthographic projection, pictorial views, sectional views, dimensioning, conventional representation, freehand sketches, and working drawings of machine parts. Choice between two versions given to student with most of the material identical. Greater emphasis in version (a) on plane graphics, and in version (b) on space graphics and working drawings.

D12. Descriptive Geometry. Fundamental concepts of descriptive geometry, including reference systems, representation of point, line and plane; fundamental problems of posi-

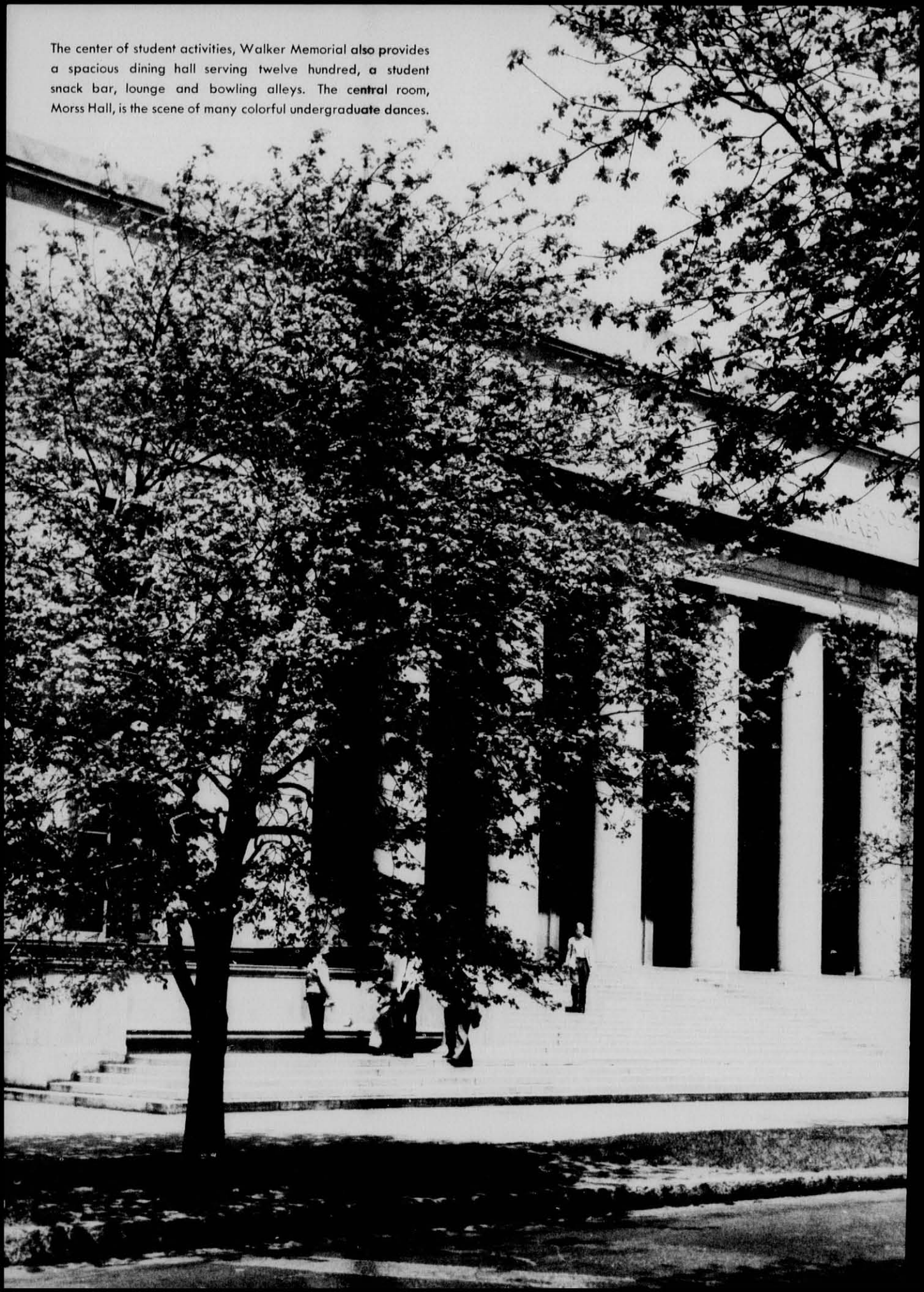

The Massachusetts Institute of Technology Symphony Orchestra, under direction of Klaus Liepmann, Assistant Professor of Music, rehearses in Walker Memorial.



Intercollegiate sailing had its birth at M. I. T. The Sailing Pavilion, located directly in front of Walker Memorial, houses the Technology-designed dinghies, as well as a number of larger craft, comprising the largest sailing fleet in the world. Every student is eligible to participate, and sailing is by far the most popular recreational activity.



Probably the most popular spectator sport is basketball, one of seventeen intercollegiate sports in which Institute teams participate. In addition to the swimming pool and sailing and crew houses, the new Rockwell Athletic Cage, the Briggs Field House, and the expansive playing fields offer modern facilities for all sports activities.



The center of student activities, Walker Memorial also provides a spacious dining hall serving twelve hundred, a student snack bar, lounge and bowling alleys. The central room, Morss Hall, is the scene of many colorful undergraduate dances.

Graphics Continued

tion, of perpendicularity and of measurement. Solutions of 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. Watts & Rule, *Descriptive Geometry.*

D31. Nomography. Nomographic methods for solving equations in three or more variables and their application to scientific data. Plane geometry foundation and concurrent presentation of advanced determinant theory with adequate algebraic background. Central projection in nomographic technique, interpretation in terms of general projective transformation, corresponding determinant operator, and graphical and analytical methods. Errors of Lo-Ho. Discussion of classical and modern necessary and sufficient conditions for nomographic form as presented by Duporcq, Gronwall, Kellogg, Thomas, and others. Quasi-alignment diagrams and applications of the principle of duality to alignment diagrams based upon empirical data. Project problem, preferably from the Institute, carried out by each student. Douglass and Adams, *Elements of Nomography; Mimeographed Notes.*

D32. Advanced Graphics. Graphical transformations and their applications in solution of engineering problems. Projective transformations in photogrammetry, perspective, axonometry, construction of conics. Duality transformation applied to conversion of network chart to alignment diagram. Inversion. Anamorphosis, and the transformation of curvilinear network charts into rectilinear networks. Construction of special coordinate papers. Conics, and construction of tangents and osculating circles. Correlation of graphical and analytical methods. Application of conics to streamlined shapes of aircraft. Wrapped surfaces, with graphical methods for their construction and for development of flat patterns. Graphical calculus and the solution of empirical differential equations. Approximate graphical methods of Harmonic Analysis in which a few terms of a series are found. Graphical Operators. Overlay techniques. Linkages. Emphasis on graphical methods and on empirical problems. Opportunity and encouragement for the student to pursue projects connected with his own field of engineering. *Mimeographed Notes.*

ENGLISH

Subjects E1 to E99

E1. Entrance English.

E25. English Composition. Students who in the collective judgment of members of the Department of English and History have failed at the end of H11, H12, H21, or H22 to meet certain standards of expression and therefore have received a deficiency in composition required to take this subject. It may be prescribed at any time for juniors and seniors whose use of English in their professional courses is unsatisfactory. Instruction carried on in frequent group meetings and in individual conferences, at hours to be determined by the instructor. No credit given for this subject.

E27. Creative Writing. Consideration of materials and techniques of fiction, poetry, and drama through detailed study of models and practical application in writing. Considerable reading in novels, short stories, dramas, and poems. Limited to juniors and seniors showing evidence of creative ability and sincere interest in writing. Minimum manuscript requirement 1,000 words a week. Each student encouraged to practice the type best suited to his taste and experience. Permission of instructor required for enrollment.

E28. News Writing. Detailed instruction in journalistic form and its use. Development of ability to write with conciseness and precision. Discussion and evaluation of journalistic construction from viewpoint of organization, form, and reader-appeal. Practical experience in news-writing and make-up in cooperation with *The Tech* to fulfill the laboratory requirement.

E31. Books and Men. Literature of Western Civilization. Reading and discussion of great books from Homer to present. Selected writing of the past, offering insight into experience of man as an individual, into his social experience, his attitude toward nature of universe, and the schemes of value used to regulate his life. Considers relation of content to form, provides introduction to such literary types as epic, drama, novel, poetry, and short story. Readings from Homer, Greek drama, Horace, Dante, *Song of Roland, Volsunga Saga,* the Bible, Chaucer, Marlowe, Shakespeare, Dekker, Renaissance poetry.

E32. Books and Men. Continuation of E31 with readings from Swift, Pope, Voltaire, Balzac, Goethe, Zola, Dostoevsky, Ibsen, Shaw, Eliot, Frost, Sandburg, Silone, Faulkner.

E35. Reports. Preparation and presentation of business and engineering reports. Practice in investigation of subjects, arrangement of material and its presentation in report form. Subjects covered range from simple memoranda and business letters to longer, more comprehensive reports.

E36. Seminar in Technical Writing. Practice in preparation of technical papers, reports, and articles for both professional and non-professional readers.

E37. Public Speaking. Designed to afford knowledge of principles of expression and argumentation in business discourse and everyday life. Use of the voice; practice in vocal elements of quality, pitch, force and time, for securing better authority, resonance, and confidence. Practice in specific speech situations: extemporaneous, impromptu, and read speech; business meeting, sales talk, and after-dinner speech.

E38. Public Speaking. Continuation of E37. May be taken separately with permission of instructor. Study of parliamentary procedure. Duties of the chairman and master of ceremonies. The logical development of subject matter. Voice recording and analysis. Designed through practice and criticism to assist the engineer in his professional work and to give confidence in himself.

E41T. The Literature of Greece. Deals with writings of the Greeks from the time of Homer to, roughly, the Christian era of Rome. Readings from Homer, Homeric Hymns, Hesiod, Sappho, and other early lyricists, dramatists, Thucydides, Plato, later lyric and pastoral writers, and Lucian's satiric dialogues. Emphasis upon development of the several types of literature and the changing setting of ideas and attitudes of a growing, expanding, and perhaps decaying civilization. Includes such relationships to our own days as time allows.

E42T. Non-Western Literature. Examines available non-western literature, some primitive songs and stories, including early Chinese and Vedic hymns, parts of the Hindu epics of *Mahabharata* and *Ramayana,* Confucian and Buddhist writings, Chinese courtly poetry, Japanese prose, Hindu drama, and Persian epic, lyric and philosophic verse. Comparison with the near-eastern work of *Gilgamesh* and the stories and lyrics of the Hebrews. Stresses attitudes of Eastern peoples and their taste in the arts revealed through pictures of their painting and sculpture.

E43T. Techniques of the Drama. Examination of drama as literature and as stage production. Techniques of dramatic composition and problems of production in plays of the great eras of dramatic literature from classical to modern. Analysis of motion picture as most important and influential dramatic form of twentieth century. Attendance at plays and motion pictures to stimulate discussion on literary and social values as well as on aspects of production.

English Continued

E44T. The Nature of Poetry. Aims to stimulate understanding and appreciation of essentials of poetry. Selected works of poets from Chaucer to contemporary Americans discussed in terms of the variety of influences — social, psychological, literary, technical — shaping them. Lectures, readings, and informal discussions by poets in the vicinity.

E45T. Shakespeare and His Contemporaries. Reading and discussion of Shakespeare's major plays, representative plays of Elizabethan and Jacobean dramatists — Marlowe, Jonson, Dekker, Webster, Heywood, Massinger, Ford, Beaumont and Fletcher — and selections from Elizabethan prose fiction and poetry. Emphasis upon Shakespeare's plays, an understanding of what they say and an appreciation of what they have of enduring value for a twentieth-century reader. Evaluation of the plays within literary, cultural, and intellectual traditions of Elizabethan age.

E46T. The Imaginative Mind since 1880. Reading and discussion of selected writing of last seventy years, revealing changes and influences shaping modern imagination and its forms of expression. Offers insight into modern imaginative concept of man, his subjective psychological experience, his search for an objective code of values in a world of social, political, religious, economic unrest dominated by science and industry. Study of scientific, social, and psychological ideas associated with Darwin, Marx, and Freud, characteristic of twentieth-century literature. Readings from Stendhal, Zola, Butler, Dostoevsky, Hardy, Joyce, Conrad, Mann, Proust, Shaw, Ibsen, Yeats, Eliot, Frost, and others.

E47T. Nineteenth-Century American Literature. Emphasis on the major works of a few writers rather than on short selections from works of many. Study of background against which stand such works as tales and poems by Poe; essays by Emerson; *The Scarlet Letter* and four stories by Hawthorne; *Moby Dick, Billy Budd; Walden* and two essays by Thoreau; *The Adventures of Huckleberry Finn;* poems by Emily Dickinson; *Leaves of Grass; The Portrait of a Lady; The Red Badge of Courage; McTeague;* and *Sister Carrie.*

E48T. Twentieth-Century American Literature. Study of such novels as *The Financier, Winesburg, Ohio, Babbitt, Manhattan Transfer, The Great Gatsby, A Farewell to Arms, Look Homeward, Angel, Light in August.* Shorter works of fiction by Burns, Caldwell, Capote, Cather, Clark, Farrell, Mailer, K. A. Porter, Irwin Shaw, Stein, Steinbeck, Warren, Welty, Wharton, and Richard Wright. The poetry of Cummings, Eliot, Frost, Jeffers, Pound, Stevens, with briefer selections from Aiken, Elizabeth Bishop, Hart Crane, Jarrell, Robert Lowell, MacLeish, Masters, Millay, Marianne Moore, Robinson, Rukeyser, Sandburg, Shapiro, Van Doren, Wilbur, and William Carlos Williams.

E49T. Russian Literature of the Nineteenth Century. Deals primarily with the major works of Russian fiction in the nineteenth century. Special emphasis on novels, but some memoirs and plays included. Authors studied are Aksakov, Turgenev, Tolstoy, Dostoevsky, Pushkin, Chekov, and Gogol. Some attention paid to authors' lives and development of Russian novel during the hundred years in question, but primary attention given to content and meaning of works themselves.

E50T. The Bible. Selected books of the Old Testament, The Gospels, Book of Acts, and Epistles of Saint Paul from New Testament. Some attention paid to historical context within which the various books were written, and to literary form. Primary emphasis upon the Bible as the source of Christian ethics.

E57. Special Readings. Subjects offered to selected groups by visiting professors and to advanced students who may require a special program.

E58. Special Readings. Continuation of E57.

HISTORY

Subjects H1 to H99

H11. Introduction to the Humanities and Social Sciences. Introduction to the study of the individual and society with emphasis on human behavior in small groups and the local community. Interdisciplinary approach to which many of the social sciences contribute. Material for analysis drawn from literature and student's own experience. Emphasis on written expression, through frequent themes and long final paper on student's own community, and on oral communication through class discussion.

H12. Introduction to the Humanities and Social Sciences. Study of the individual and society continued by using historical comparisons. Greece in the fifth century B.C. and the Renaissance analyzed as societies which have contributed significantly to present-day civilization but are remote enough in time and place to provide comparisons and contrasts in human behavior. Special attention given to the literature and art of these periods. Emphasis on written and oral expression continued.

H21. Introduction to the Humanities and Social Sciences. Continuation of H12 with emphasis on the development, character, and aims of different types of societies, economies, and political systems since the eighteenth century. Historical development and contemporary issues discussed, with examples from countries which have developed in the liberal tradition, chiefly the United States, France, and England. Emphasis continues on written composition in form of research and problem reports.

H22. Introduction to the Humanities and Social Sciences. Continuation of H21 with examples from countries which have developed in the authoritarian tradition: Soviet Russia, Japan, Nazi Germany. Includes case study from an underdeveloped area and concludes with brief survey of selected problems of world order arising from the conflicting aims and interests of the national societies previously studied. Emphasis continues on written composition in form of research and problem reports.

H31. Topics in American Civilization before 1860. Study of selected topics in the period from 1775 to 1860. Analysis of major trends and issues in several fields and their bearing on the present. Discussion of rise of industry, westward expansion, sectional conflict, reform movements, political and economic theory, and literature. Emphasis on interplay of social, economic, political, and intellectual forces.

H32. American Government and Society since 1860. Political effects of social and economic changes in modern American life with examination of political issues raised by such developments as industrial expansion, growth of cities, rise of big business and organized labor, and changing world position of the United States. Influence of these and other factors on political institutions, political thought, and the structure of parties.

H33. History of American Foreign Policy. Topical study of American foreign policy, such as its constitutional structure, public opinion, economic factors, geographic and strategic considerations, and international conditions. Consideration of basic principles evolved for American foreign policy and changes effected by growth of the nation as a world power.

H34. The Rise of China and Japan. Study of basic problems of the Far East. Consideration of traditional cultures of China and Japan in their geographical settings, early relations of the West with eastern Asia and revolutionary

History Continued

ferment released by those contacts, breakdown of self-sufficiency and isolation of China and Japan, and resulting cultural changes.

H35. Nationalism and the Growth of Nations in the West. Survey of essential elements from which nations have been built: settlement clusters, language areas, culture patterns, communication habits, economic regions, political units; and the part played by leaders, ideas, and events. Cases drawn mainly from Europe and the Western Hemisphere. Survey of conditions for rise of modern nationalism and problems posed by existence of national distinctions in an industrial era.

H36. Modern Europe. Selected problems and topics in history of modern Europe. Deals with effect on European life of such forces as nationalism, industrialism, and liberalism, rise of European civilization to its height, search for European order, and influence of Europe on the world.

H51. Introduction to Economic Development. Study of selected examples of economic development with emphasis on interdependence of such factors as population, resources, capital formation, technology, social and political institutions and trends. Examples from various countries and periods during last several centuries with emphasis upon first major period of American industrial development, 1845–1900. Attention also given to world setting of national developments. (Not offered 1952–53.)

H52. Modern Industrial Society. Comparative study of economic development in the twentieth century. Cases studied will be: continued U. S. economic development, 1900–1950; decline of British economy since 1890; Russian economic development since 1885, with emphasis on Soviet period. (Not offered 1952–53.)

H55. History of Engineering. Study of development of modern engineering from its beginnings to about 1900. Importance of engineering advance among economic and social changes which center around the Industrial Revolution. Concentrates on aspects of greatest importance for future engineering development: coal, steel, textiles, machinery, transportation, electric power.

H56. Technology and Society. Functional analysis of selected cases of interaction between technology and other elements in society from classical antiquity to the present. Study of various technological phenomena — developments in fuels, metals, machines, and processes — to determine how they affected and were affected by scientific, economic, political, and religious thought and activity.

H61. American and British Leadership. Study of motivations, roles, and contributions of selected leaders in American and British politics and society since 1850. Emphasis on the relation between individuals studied and institutions with which or within which they worked, and on their success or failure to translate adequately felt economic or social needs into policy. Readings in biographies and autobiographies.

H62. History of Russia. Study of the emergence of Russia as a great power, its relations with the West, expansion into Asia, the Revolution, and history and character of the Soviet state.

H63. Topics in American Foreign Policy. Study of selected problems of American foreign policy, such as the relationship of the United States to Europe, to Latin America, or to the problem of world organization. (Not offered 1952–53.)

H64. Historical Studies in Innovation. Examination of process of innovation in industry with attention to nature of environment in which innovation takes place, personality of innovator, areas of resistance and means of accommodation to new ideas or new instruments. Influence of innovations upon technological development, administrative policy, and social arrangements. Case histories such as introduction of continuous aim firing in the U. S. Navy, introduction of Bessemer Converter, and introduction of electric motor.

H65. Contemporary Problems in Economic Development. Study of areas currently in various stages of process of industrialization, regional problems of the United States, Point Four program. (Not offered 1952–53.)

H67. Technology and Society in the United States. Relationship of technological development to social progress in the United States. Examination through selected case studies of influence of invention, development of mass-production techniques, and other technological phenomena on society and thought in the United States.

H71. Basic Ideas of Western Politics and Ethics, 500 B.C.–1500 A.D. Survey of development of fundamental ideas and institutions of Western Civilization. Discovery of generalized thinking — science — in the search for truth, ideas of predictability and fitness — law and justice — in the search for political stability, ideas of personality and soul in search for a meaningful life. Rise and collapse of scientific progress and political power in the Roman era, new start by early Christians with new attitude toward persons, work, and the universe, rise of communities and experimentation in new social order in Middle Ages, and such resulting western traditions as division of political and spiritual power and legacy of continuing technological and social changes in a self-transforming civilization.

H72. The Rise of Modern Political and Social Science, 1500–1914. Continuation of approach of H71. Background of ideas represented by Renaissance, Reformation, and Age of Reason, with concentration on new basic patterns of scientific and social thought that emerged. Study of conceptions of mechanism, organism, and society and their application to political and social problems. Attempts to apply reason to society studied in ideas of Machiavelli, Hobbes, Locke, Hume, Adam Smith, Madison, Robespierre and Kant. Changes in conservative position traced in Burke, Hegel, Nietzsche, Cecil Rhodes, Spengler, and Pareto. Evolution of liberalism traced in Bentham, J. S. Mill, Herbert Spencer, and Lloyd George.

H73. Science and Philosophy from the Greeks to Copernicus. Study of the course of civilization around the growth of scientific ideas, from the Pre-Socratics to Copernicus, including the birth of scientific thought with accompanying philosophical ideas, idealistic reorganization, medieval view from its origins to its breakup with Copernicus and the age of discoveries. Particular emphasis upon the vital link between scientific, philosophical, and social ideas.

H74. Science and Philosophy from Galileo to the Present. Continuation of H73 to modern times including the foundation of modern natural philosophy, the Age of Reason, the foundation of modern physics, chemistry and biology, centered around such figures as Lavoisier, Faraday, and Darwin, and the conflict of nineteenth century ideas, arising from these developments.

H77. American Intellectual History to 1865. Examination of main currents of thought and opinion shaping the American mind since the Revolution. Readings primarily from original sources, drawn from American literature, political thought, economic theory, science, philosophy, and religion. Such topics as Federalism, Jeffersonian and Jacksonian Democracy, Transcendentalism and other expressions of Romanticism, and the mind of the South.

H78. American Intellectual History from 1865 to the Present. Continuation of H77. Includes such topics as Nationalism, Laissez-Faire, Imperialism, the Progressive Movement, Naturalism, Pragmatism, the New Conservatism.

H81. Contemporary Ideas on Political and Economic Development. Continues emphasis of H71 and H72. Topics include "hard-boiled" schools of thought: Sorel, Pareto, Vaihiger; Pragmatists and Institutionalists: John Dewey, William James, Veblen, the "pragmatic revolt." Problems of the "Welfare State": Herbert Hoover, J. M. Keynes, war and "total mobilization," economic planning, and the problem of freedom. Responses to crisis: Fascism, Communism, Democratic Socialism, Catholic views of reform, current philosophies of hope and despair, and perspectives beyond 1950.

History Continued

H82. Nationalism and National Development. Studies the interplay of political ideas and social institutions in the case of nationalism in the present era. Ideas of nationality surveyed and contrasted with the verifiable realities of peoples and countries. Effect of urbanization and industrialization on nationalism studied, as well as effect of nationalism on further political and economic development. Leaders and decisions studied against background of broad trends and particular movements. Forces making for national sovereignty surveyed and contrasted with trends toward federal government, economic unions, or international organization.

H83. Philosophy of Science. Studies the interconnection between the chief philosophical ideas that still stand up from the past, and the scientific philosophy arising from twentieth century physics. Includes Kant, Schopenhauer, Hegel, Marx, Darwin, Kierkegaard as the Unscientific Postscriptor, Russell, Bridgman, Einstein, Planck, Bohr, and Carnap.

H84. Topics in the History of Science. Topics to be arranged in accordance with the interests of students, and to be given, when possible, in cooperation with members of the School of Science.

H91. Special Topics in History. Provides for the periodic presentation by members of the staff of topics in history not included in other course offerings and for individual reading by qualified students.

H92. Special Topics in History. Continuation of H91.

H93. Problems in American Political Economy. Examination of political and social problems attending development of federal regulation of American economy, 1865 to 1938. Emphasis on function of politics in reconciling conflicting demands of various social groups and on discrepancies between real and felt economic needs of these groups.

MODERN LANGUAGES

Subjects L1 to L99

SUBJECTS are offered in German, French, Spanish and Russian. At the elementary level stress is laid chiefly on the acquisition of the minimum essentials for a reading or speaking knowledge, depending on the language. The first two terms of German and the first term of Russian emphasize vocabulary and structure of the technical language. The second semester of Russian has the development of speaking ability as its primary aim. Pronunciation, speaking ability and understanding the spoken language are the objectives of the first two semesters of French and Spanish.

The intermediate level is principally concerned with the development of a broad reading vocabulary. The reading texts include some scientific matter, but also introduce fiction, drama, and historical or descriptive works of a nature to open up to the student the genius, institutions and social organization of the country involved.

Advanced subjects in modern French and German literature and thought are conducted entirely in French and German respectively.

Special subjects in scientific German, French, and Russian, open to graduate students only, are offered in addition to the above. As opposed to the more general objective of the undergraduate subjects, these have a narrowly limited purpose; namely, to prepare each student to read technical and scientific material in his own field.

Two elective seminar subjects offered by the Department treat language in general, the problems it raises and, wherever possible, their solution.

L11, L12. Elementary German. Necessary foundation in German language for scientific and literary purposes. Training in pronunciation, elementary grammar, acquisition of useful vocabulary, reading of varied matter, some of which deals with science. Texts (subject to modification): L11, Zeydel, *A Basic Course in German;* L12, Lenz, *Scientific German*, Remarque, *Drei Kameraden.*

L13. Intermediate German. Training in reading and understanding ordinary technical and scientific articles as well as narrative prose. Serious literature of a more mature nature introduced in the second semester. Texts (subject to modification): L13, Wizinger, *German Science Readings.*

L14. Intermediate German. Reading, translation, and discussion of representative German works, scientific and technical papers, short stories, plays. Emphasis on the nineteenth and twentieth centuries. Study of German modes of expression, German thought and life as seen through German eyes. Some discussion in German.

L15T. German Literature 1919–33. The course will give a thumbnail sketch of German literature from the ushering in of the Weimar Republic to the Burning of the Books. The student will acquaint himself with selected writings of authors who enjoy a European reputation, and others who occupy a niche as innovators or r s of social trends (Mann, Kafka, Fallada, Frank, Toller, Kaiser, Brecht and others). Conducted in German. Prerequisite: ability to understand spoken and written German easily.

L16T. Literature of Postwar Germany. Study of the evolution of German opinion and life since 1945 as seen in the current works of German writers; books and periodicals consulted. Conducted in German. Prerequisite: ability to understand spoken and written German easily.

L17. Scientific German. Intensive preparation for graduate language requirement in German. No previous study of German required. Group meetings for discussion of ways to facilitate comprehension of grammatical and syntactical difficulties. Section meetings by Courses for reading material in the field of the student. (Open to graduate students only.)

L20. Great Books and Authors in German Literature. Reading and discussion in German of outstanding works in the drama, poetry and prose fiction of German literaure. Period 1750–1900. Two plays of each of the following: Lessing, Goethe, Schiller and Grillparzer Selections from the poetry of Goethe, Schiller and Heine and from that of the Romantic School. Prose fiction: Goethe, *Leiden des jungen Werthers.* Selections from *Wahrheit und Dichtung* and *Die Italienische Reise;* Heine, *Die Harzreise.* One play of each of the following: Hauptmann, Hofmannsthal, and Schnitzler. Selections from the poetry of Hofmannsthal, and Rilke. Two novels to be chosen from the prose fiction of Gottfried Keller, and Conrad Ferdinand Meyer. Emphasis will be placed upon the comparative nature of literature. Prerequisite: ability to understand spoken and written German easily.

L51, L52. Elementary French. Necessary foundation for French language and literature, or for scientific studies. Training in pronunciation, elementary grammar, acquisition of useful vocabulary and reading of varied matter, part of which deals with French institutions and the history of France, practice in hearing and speaking French. Texts (subject to modification): Hendrix and Meiden, *Beginning French.*

L53. Intermediate French. Continuation of pronunciation and practice in conversation, reading of matter dealing

Modern Languages Continued

with France, some standard modern authors, discussion of current French problems.

L54. Intermediate French. Reading, translation, and discussion of representative French works, particularly from the nineteenth and twentieth centuries. Short stories, plays and poetry. Study of typical literary art forms of French and investigation into French modes of life and thought. Some discussion in French.

L55T. Contemporary French Literature. Reading and study of post-war literary works for the light which they throw on French thought and action in present-day society. Conducted in French. Prerequisite: ability to understand spoken and written French easily.

L56T. French Literature of the Third Republic. Reading and study of French literary works from 1870 to 1940. The great figures of this period. Economic, social, and philosophical trends as reflected in literature. Conducted in French. Prerequisite: ability to understand spoken and written French easily. (Not offered 1952–53.)

L57. Scientific French. Intensive preparation for graduate language requirement in French. No previous study of French required. Group meetings for discussion of ways to facilitate comprehension of grammatical and syntactical difficulties. Section meetings by Courses for reading material in the field of the student. (Open to graduate students only.)

L59. Great Books and Authors in French Literature. Reading and discussion of great works in the drama, poetry, and prose fiction of French literature. One play of each of the following: Corneille, Racine, Molière, Marivaux, Beaumarchais, and Hugo. Selections from the writings of Montesquieu, Voltaire and Rousseau. Selections from the poetry of Ronsard, Du Bellay, Lamartine, Hugo, de Vigny, de Musset and Gautier. Prose fiction: Mme. de la Fayette, *La Princesse de Cleves;* Voltaire, *Contes philosophiques;* Balzac, *Eugenie Grandet;* Flaubert, *Madame Bovary;* de Maupassant, *Contes et Nouvelles;* Zola, *La Bête Humaine.* Emphasis will be placed on the comparative nature of literature. Some discussion in French. Prerequisite: ability to understand spoken and written French easily. (Not offered 1952–53.)

L75. Language and Society. Seminar to examine the social functions of language, the interrelations of language and culture; types of languages, primitive and modern; advantages and disadvantages of various systems of writing; the implications of illiteracy; international communication; language planning.

L76. Applied Semantics. Seminar to stimulate meaning-consciousness through the discussion of questions such as: What happens when we make or interpret a statement? Why do words get confused with things? What causes semantic blockages? How can they be removed? What are the verbal means of mobilizing emotions? How is language used by the politician, the salesman, etc.? What are the most commonly practiced tricks in verbal argument? When is clarity not enough?

L81, L82. Elementary Spanish. Emphasis on spoken Spanish, pronunciation, intonation, vocabulary building, and essentials of grammar. Texts (subject to modification): Leslie, *Spanish for Conversation;* Camba, *La Rana Viajera;* Callcott, *Los Puritanos;* Ortega y Gasset, *Rebelión de las Masas.*

L83, L84. Intermediate Spanish. Brief grammar study, more advanced conversation, 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;* Quintero, *Doña Clarines.* (Not offered 1952–53.)

L91, L92. Elementary Russian. Elementary grammar; practice in reading scientific Russian. Practice in hearing and speaking in second term. Enables a good student by the end of year to read scientific articles in Russian; also lays the foundation for continued study of the language. Texts (subject to modification): Znamensky, *Elementary Scientific Russian Reader* (L91), *Conversational Russian* (L91 and L92).

L93, L94. Intermediate Russian. Continuation of pronunciation and practice in conversation, reading of matter dealing with Russia, some standard modern authors, reading of scientific Russian, individual written translations from recent scientific works. (Not offered 1952–53.)

L97. Scientific Russian. Intensive preparation for graduate language requirement in Russian. No previous study of Russian required. Group meetings for discussion of ways to facilitate comprehension of grammatical and syntactical difficulties. Section meetings by Courses for reading material in the field of the student. (Open to graduate students only.)

MATHEMATICS

Subjects M1 to M99

M1. Entrance Algebra.

M3. Entrance Solid Geometry.

M4. Entrance Trigonometry.

M10. Calculus. Brief survey of Analytical Geometry and Calculus for graduate students in Architecture and Economics whose preparation in mathematics does not cover the requirements for admission to the Graduate School. (Not offered 1952–53.)

M11. Calculus. Fundamental ideas of differential and integral calculus. Differentiation and graphical representation of algebraic functions and of the sine and cosine. Integration of simple algebraic and trigonometric functions. Applications to problems in geometry and mechanics: maxima and minima, velocity and acceleration, plane areas, volumes, arc length, areas of surfaces of revolution, center of gravity, moment of inertia. Analytic geometry of the straight line and the conic sections. Thomas, *Calculus and Analytic Geometry.*

M12. Calculus. Further study of differentiation and integration: trigonometric, inverse trigonometric, exponential, logarithmic and hyperbolic functions. Polar coordinates and parametric representation. Elementary vector analysis in the plane, vector velocity and acceleration. Determinants and simultaneous equations. Thomas, *Calculus and Analytic Geometry.*

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. Thomas, *Calculus and Analytic Geometry.*

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, Revised.*

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, *Fourier Methods.*

M32. Elementary Statistics. General survey of the practical application of statistical methods to scientific and engineering problems, covering frequency distributions, moments, precision of measurements, tests of significance, correlation, theory of large and small sampling, analysis of variability, and experimental design.

M331. Applied Statistical Methods. Aimed at equipping the research worker to apply statistical techniques effectively to his own problems with emphasis on the under-

Mathematics Continued

lying logic of statistical methodology and on efficient computational procedures. A self-contained subject covering probability theory, significance tests, sampling theory and practice, experimental design, multiple and partial correlation, applied matrix algebra. (Not offered 1952–53.)

M333, M334. Applied Statistics Seminar. Primarily for those professionally interested in the field of statistics. Discussion of applications of statistical methods in industry and in analysis of physical and economic data, and of applications in present-day technical journals. (Not offered 1952–53.)

M341, M342. Modern Statistical Theory. Rigorous development of mathematical statistics, including such topics as generalized distribution function, characteristic functions, statistical inference, sampling theory, tests of significance, maximum likelihood statistics, hypothesis testing, theory of estimation, regression theory, introduction to multivariate statistical analysis, and time series analysis. References: S. S. Wilks, *Mathematical Statistics;* H. Cramer, *Mathematical Methods of Statistics;* N. Wiener, *Stationary Time Series.* (Not offered 1952–53.)

M351, M352. Advanced Calculus for Engineers (A). Ordinary differential equations; numerical and graphical methods, integration by power series, Legendre and Bessel functions. Laplace transforms. Characteristic value problems; series of orthogonal functions, in particular, Fourier series. Vector analysis; orthogonal curvilinear coordinates. Partial differential equations of mathematical physics. Functions of a complex variable; calculus of residues, conformal mapping. Hildebrand, *Advanced Calculus for Engineers.*

M36. Advanced Calculus (A). Elementary functions of a complex variable; Taylor's series; partial differentiation and implicit functions; vectors, curves and surfaces in space; line integrals; analytic functions of a complex variable; contour integration. Franklin, *Methods of Advanced Calculus.* (Not offered 1952–53.)

M37. Advanced Calculus (A). Gamma and Beta functions, elliptic integrals, vector analysis, second-order linear differential equations, Legendre polynomials and Bessel functions, Fourier series and partial differential equations, calculus of variations. Franklin, *Methods of Advanced Calculus.* (Not offered 1952–53.)

M371, M372. Operations Research. Two-term course designed for fourth year and graduate students who wish to become familiar with the operational methods developed particularly in the armed services during World War II. While as many uses as possible of this scientific method to industrial and business problems will be considered, many of the applications will necessarily have to come from military examples for which they were developed.

M381, M382. Theory of Functions (A). Course in complex variables. Complex numbers, series, analytic functions, Cauchy's theorem, residues, contour integration, conformal mapping, Riemann surfaces, integrals and products, entire functions. Knopp, *Function Theory.*

M39T. Methods of Applied Mathematics (A). Operations with matrices and determinants; linear vector spaces; characteristic-value problems. Techniques of calculus of variations; Hamilton's principle and Lagrange's equations; variational principles for deformable bodies; direct and semi-direct methods. Formulation and solution of simple linear difference equations; application of finite-difference methods to approximate solution of partial differential equations. Formulation and treatment of integral equations; Green's function; analytical and numerical methods of solution. Hildebrand, *Methods of Applied Mathematics.*

M411. Numerical Analysis (A, except for Course XVIII). Theory and practice in polynomial approximation, interpolation, numerical differentiation, numerical integration, and approximate solution of ordinary differential equations, including error analysis, with particular emphasis on methods adaptable to digital computing machines.

M42. Introduction to Hydromechanics. General theory of perfect fluids. Bernoulli's equation. Theory of potential motions. Motion of rectilinear vortices. Gravity waves and related hydraulic problems. Elements of the theory of viscous fluids. Poiseuille flow. Stokes flow. Boundary layer theory. (Not offered 1952–53.)

M421, M422. Theoretical Hydromechanics (A). General theory of perfect fluids, fundamental concepts and basic relations. One-dimensional motion. Two-dimensional motion involving subsonic and supersonic speeds; application of the theory of complex variables. Application of the theory of characteristics to hydrodynamical problems. Three-dimensional motion involving subsonic and supersonic speeds; theory of lifting surfaces. General theory of viscous fluids, fundamental concepts and basic equations, examples of exact solutions. Flow at low Reynolds numbers. Flow at high Reynolds numbers, boundary layer theory. Hydrodynamic stability. Turbulent flows, mixing length theories and statistical theories. Other selected topics of current interest.

M441. Projective Geometry. More precise study of curves and surfaces of the second degree than given in M11 and M12. Fundamental notions of projective geometry including Pascal's theorem and the theory of involution. Plücker coordinates, pentaspherical coordinates and Non-Euclidean geometry. (Not offered 1952–53.)

M442. Elementary Differential Geometry. Plane and space curves. First and second differential form of a surface. Theorems of Meusnier and Euler. Lines of curvature, asymptotic lines, conjugate lines, geodesics. Theorems of Gauss and Codazzi. Developable surfaces, surfaces of rotation, Liouville surfaces. Differential parameters. Problems of mapping. Struik, *Differential Geometry.*

M451, M452. Fourier Series and Integrals (A.) Elementary theory of Fourier series and integrals as developed along modern lines. Stress on practical applications and development of the necessary analysis from the beginning.

M461. Seminar in Mathematics (A). Reading, consultation and discussion of current mathematical research.

M481, M482. Topology (A). Discussion of basic concepts of Topology: topological spaces, metric spaces, closed sets, open sets, connected sets, mappings, general concept of dimension. Demonstration of classical theorems on the topology of Euclidean spaces (Invariance theorem, Jordan theorem, Fixed Point theorem), using the modern methods of mapping into spheres. Applications of two-dimensional topology of function theory and differential equations. Combinatorial topology: Complexes, Betti groups. Proof of the invariance of Betti groups. Duality theorems. Homology theory in topological spaces.

M483. Advanced Topology (A). Differentiable manifolds. Fibre bundles and their characteristic cohomology classes. Existence of tensor fields with prescribed properties on a differentiable manifold. Imbedding in Euclidean space. Differential forms and de Rham's theorem. Content varying from term to term so that graduate students taking the subject in successive terms may have an introduction to several important phases of topology. (Not offered 1952–53.)

M491, M492. Geometry of Manifolds (A). Real and complex manifolds, Riemannian and Hermitian manifolds, differential forms, abelian integrals, theta functions, the Riemann-Roch theorem, the generalized Gauss-Bonnet theorem, relations between curvature properties and topological properties, the Hodge theorem, Kahler manifolds; with applications to Riemann surfaces and functions of one and several complex variables. (Not offered 1952–53.)

M52. Topics in the Theory of Numbers (A). Distribution of primes, including the prime number theorem and a detailed study of the Riemann Zeta-function. (Not offered 1952–53.)

M54. Mathematical Laboratory. Practical instruction in numerical, graphical and mechanical calculation and analysis as required in the engineering or applied mathematical sciences, numerical solution of equations; graphical methods; nomography and the construction of graphical charts; curve fitting to empirical data, approximate methods of integration, differentiation and interpolation; use and principles of construction of instruments employed in calculation, and many kindred topics. Lipka, *Graphical and Mechanical Computation.*

Mathematics Continued

M551, M552. Functions of a Real Variable (A). Theory of the Lebesgue integral with applications to important topics of the theory of functions of a real variable. Connections between real and complex variable theory. Content varying from one year to another, so that graduate students taking the course for successive years can have an introduction to several important chapters of the theory of functions. (M552 not offered 1952–53.)

M561, M562. Functions of a Complex Variable (A). First term: Entire functions, behavior of the circle of convergence. Second term: Theorems on mappings and other selected topics. Content varying from one year to another so that graduate students may take the course in successive years.

M571, M572. Differential Equations (A). Existence theorems and approximation methods. Various aspects of the linear differential equations including boundary problems, solution of certain more common equations by series and integrals, singularities in complex domain. Relationship between integral and differential equations. Schmidt-Fredholm theory of linear integral equations. Non-linear differential equations studied by analytical and topological methods. Singularities of various types with stress on physical interpretation. Poincare-Liapounoff stability theory. Periodic orbits. Limit cycles. Perturbation methods.

M581, M582. Continuous Groups (A). Elementary properties, subgroups and quotient groups, covering groups, Haar measure, Peter Weyl theorem, Tannaka theorem, Lie groups, Lie algebras of Lie groups, complex groups, complexification of real Lie groups, structure theorem for Lie algebras and Lie groups, topological structure of Lie groups. (Not offered 1952–53.)

M591, M592. Partial Differential Equations (A). Geometric approach to first and second order partial differential equations. Elliptic, hyperbolic and parabolic equations. Singular solutions and their importance. Physical significance. Characteristics and wave fronts. Non-linear equations. Integral equation methods. Variational methods. Courant-Hilbert, *Methoden der Mathematischen Physik*, Vol. II.

M61. Mathematical Logic (A). Classical calculi of propositions and classes together with their principal applications. Tracing of the main lines of Whitehead and Russell's derivation of classical analysis from logic, emphasizing the marked resemblance between its intermediate stages and various developments in modern algebra. An account of the general theory of logical and mathematical systems, according central places to the theorems of Goedel on incompleteness and the axiom of choice, and to the theory of constructive decidability.

M62. Modern Algebra. Polynomials, determinants, linear equations, linear transformations, matrices, linear independence, introduction to groups.

M63. Algebra (A). Group theory, including the fundamental theorem on Abelian groups and rotation groups. Elementary theory of rings and fields. Elementary divisors of matrices, reduction to Jordan and other canonical forms. Quadratic and Hermitian forms; symmetric, Hermitian, orthogonal, and unitary matrices. The dual of a vector space, introduction to tensor algebra.

M631. Integral Equations (A). Objectives: (1) to show how to express physical problems in the form of integral equations, (2) to provide a treatment of the theory of integral equations, and (3) to describe the methods available for solving such equations. Applications to problems arising in several branches of physics and engineering.

M633. Abstract Algebra (A). Groups with operators and rings of endomorphisms. Theory of fields and their extensions. Introduction to valuation theory. Structure of rings and algebras.

M634. Topics in Algebra (A). Study of algebraic number fields, including such topics as factorization of ideals, splitting and ramification of prime ideals, the group of units, quadratic and cyclotomic fields, general ideal theory and valuation theory. Content varying from year to year so that graduate students may take the subject in successive years. (Not offered 1952–53.)

M635, M636. Topological Algebra (A). Uniform structures, topological groups, vector spaces, rings and fields; Banach spaces and algebras. Applications to harmonic analysis on groups, group representations, and operator theory. (Not offered 1952–53.)

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. (M642 not offered 1952–53.)

M651, M652. Analytical Mechanics (A). Treatment of analytical dynamics of particles and rigid bodies, mainly by Lagrange's equations in generalized coordinates and Hamilton's canonical equations. Contact Transformation, Hamilton-Jacobi theory, theory of vibrations, and non-holonomic systems. (Not offered 1952–53.)

M66. Foundations of Probability (A). Definition of probability as measure: conditional probabilities and expectations: law of large numbers: product-measure and measure in function space: discrete and continuous stochastic processes: Markoff processes: introduction to ergodic theory. (Not offered 1952–53.)

M67. Algebraic Curves (A). Projective spaces. Intersections of plane algebraic curves, Plücker's formulas, the dual curve, the genus. Infinitely near points, Cremona transformations, the resolution of singularities. Linear series on a curve and the Riemann-Roch theorem. (Not offered 1952–53.)

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. Bliss, *Calculus of Variations*. (Not offered 1952–53.)

M691, M692. Characteristic Value Problems (A). Linear algebra, orthogonal functions, linear integral equations; characteristic value problems of mathematical physics; applications of the calculus of variations; special functions defined by characteristic value problems. Courant-Hilbert, *Methoden der Mathematischen Physik*, Vol. I; or Margenau and Murphy, *The Mathematics of Physics and Chemistry*.

M73. Review of Mathematics. Review of college algebra, trigonometry, elementary calculus, differential equations. (Primarily for selected officers of the U. S. Army, Navy and Coast Guard.)

M76. Theory of Probability (A). Elements of combinatorial analysis. Random variables and expectations. Laws of large numbers. The central limit theorem and its applications. W. Feller, *An Introduction to Mathematical Probability and its Applications*.

M78. Introduction to Theory of Elasticity. Analysis of stress and strain in two-dimensions and three-dimensions. Problems in plane stress and strain using Airy's stress function. Pure bending and torsion of cylindrical rods. Flexure and buckling of beams. Bending and buckling of flat plates.

M791, M792. Theoretical and Applied Elasticity (A). Analysis of stress and strain in three dimensions. Stress-strain relations. Minimum principles in elasticity, their theory and application to the approximate solution of boundary value problems. Theory of plane stress and strain, Airy's stress function, use of elements of complex variable theory. Bending of flat plates, linear and non-linear theory. Bending and stretching of thin shells. Elastic stability theory. Elements of the finite deformation theory of elasticity. (Not offered 1952–53.)

M831, M832. Analysis. 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,

Mathematics Continued

continuity, convergence, series, integration, theory of functions of real and complex variables. Franklin, *A Treatise on Advanced Calculus.*

M833. Analysis. Real number system. Elements of set theory, countability, cardinal and ordinal numbers. Open and closed point-sets, connected sets, boundaries, regions, metric spaces, compactness, Heine-Borel theorem, mappings, continuity.

M84. Introduction to Complex Variables and Applications. Introduction to those parts of the classical theory of functions which are most essential to applications to physics and engineering. The use of residue theory and contour integration in evaluating real integrals. Applications of conformal mapping to boundary value problems arising from the theory of flow of heat, electricity and fluids. R. V. Churchill, *Introduction to Complex Variables and Applications.*

M90. Mathematical Reading (A). Reading of advanced mathematical treatises under the supervision of some member of the department. Choice of treatise and allotment of time according to individual cases. For graduate students finding it desirable to do advanced work not provided for in the regular subjects. Open to undergraduates only under exceptional circumstances.

MILITARY SCIENCE AND AIR SCIENCE

Subjects MS11 to MS99

MS11, MS12. Military Science. (Required in all Courses.) For students selecting Army: Drill, military organization, military policy of the United States, evolution of warfare, maps and aerial photographs, first aid and hygiene, military problems of the United States and individual weapons and marksmanship. For students selecting Air Force: Drill, world political geography.

MS21, MS22. Military Science. (Students must register for one of the following seven units.)

MS212, MS222. Corps of Engineers. Drill; history and traditions of the Corps of Engineers; characteristics of weapons; camouflage; defense against chemicals; explosives and demolitions; handtools and rigging; mines and booby traps; organization and tactics of small units; organization of the ground and field fortifications.

MS213, MS223. Signal Corps. Drill; introduction to signal communications; organization and missions of the Signal Corps; organization and signal communications practices of the Infantry, Armored and Airborne Divisions.

MS214, MS224. Ordnance Corps. Drill; the role of ordnance; automotive materiel; small arms materiel; ammunition materiel; artillery materiel; fire control materiel.

MS215, MS225. Air Science. Introduction to applied air power including aerodynamics and propulsion, aerial navigation, meteorology; applied air power including the fundamental principles of the employment of air power in military operations; drill.

MS216, MS226. Chemical Corps. Leadership, drill and the exercise of command; organization and function of Chemical Corps and Chemical Corps units; chemical agents; protection (individual); Chemical Corps materiel; field behavior of chemical agents; Chemical Corps in World War II; tactics of the rifle squad.

MS217, MS227. Army Security Agency. Drill; organization and functions of Army Security Agency; means of signal communication; basic cryptography; radio intercept and direction finding; elementary cryptanalysis; theory and application of traffic analysis; tactics of the rifle squad.

MS218, MS228. Quartermaster Corps. Drill; organization for supply in the Army; organization and functions of the Quartermaster Corps; classification of supplies; use of supply catalogs, and bases of allowances; property accountability and responsibility; research and development of supplies in the Quartermaster Corps; organization, functions, and operation of Quartermaster Units; unit and organizational supply.

MS312, MS322. Corps of Engineers, Advanced. Leadership, drill and exercise of command; bridge design and classification; engineer signal communications; engineer reconnaissance; engineer supply; military roads and runways; organizations of engineer units; organization of combat divisions; tactics of engineer units; vehicle operation and maintenance; water supply.

MS313, MS323. Signal Corps, Advanced. Leadership, drill and exercise of command; communications security; signal orders; field wire communication fundamentals; field radio communication fundamentals; applied signal communication (Division); message center and communication center procedure; signal supply and repair; career guidance program for Signal Corps officers; tactics of the rifle squad.

MS314, MS324. Ordnance Corps, Advanced. Leadership, drill and exercise of command; functional organization of the Ordnance Corps; automotive materiel; small arms materiel; ammunition materiel; ammunition supply; artillery materiel; fire control materiel; individual weapons and marksmanship; tactics of the rifle squad.

MS315, MS325. Advanced Air Science. Air operations; elementary Air Force supply procedures; military publications; leadership, drill, and exercise of command; additionally, two specialized training options are provided, as follows:

A. Air Force Communications. Wire communications, fundamentals of radio communication, application of radio communication, introduction to radar, visual and aural communications, and supply and maintenance. (Primarily for students in courses VI and VIII.)

B. General Technical. Problem solving and writing, use of technical publications, organization and mission of the United States Air Force, technical careers in the USAF, atomic theory and radiological defense, new developments.

MS316, MS326. Chemical Corps, Advanced. Leadership, drill and exercise of command; motor vehicles; tactical employment of chemicals; decontamination; protection; employment of Chemical Corps units; 4.2-inch mortar gunnery; signal communications; chemical combat intelligence; M-2 smoke generator operation.

MS317, MS327. Army Security Agency, Advanced. Leadership, drill and exercise of command; organization and functions of Army Security Agency; radio intercept and direction finding; military cryptosystems; communication security; elementary cryptanalysis.

MS318, MS328. Quartermaster Corps, Advanced. Leadership, drill and exercise of command; station supply; depot supply; storage, warehousing and materials handling; procurement, storage and distribution of petroleum products; commissary operations; garrison and field bakery operations; post and field laundry operations; salvage operation and procedures; maintenance and reclamation of quartermaster supplies; graves registration and mortuary activities; food service activities; individual weapons and marksmanship; tactics of the rifle squad.

MS412, MS422. Corps of Engineers, Advanced. Military administration; military law and boards; military teaching methods; psychological warfare; leadership, drill and exercise of command; engineer support for the Air Force; engineer support for the communication zone; engineer support for the type field army; command and staff; construction, utilities

Military Science and Air Science Continued

and job management; motor movements; river crossing operations.

MS413, MS423. Signal Corps, Advanced. Military administration; military law and boards; military teaching methods; psychological warfare; leadership, drill and exercise of command; wire communication-materiel; radio communication-materiel; higher echelon signal communication and equipment; post signal operations and administrative procedure; career guidance plan for Signal Corps officers; dark-room technique and photographic practices; command and staff; combat intelligence.

MS414, MS424. Ordnance Corps, Advanced. Military administration; military law and boards; military teaching methods; psychological warfare; leadership, drill and exercise of command; maintenance and supply; command and staff; combat intelligence; materiel specialty.

MS415, MS425. Advanced Air Science. Officer development; military administration; USAF inspection systems; military teaching methods; military law and boards; military management; career development; leadership, drill, and exercise of command; additionally, two specialized training options are provided, as follows:

A. Air Force Communications. Command and administration, communications inspections, communications training, communications centers and message handling, functional systems, organizations.

B. General Technical. World technological needs and resources, laboratory and shop management, new developments, technical specialists' functions in the USAF.

MS416, MS426. Chemical Corps, Advanced. Military administration; military law and boards; military teaching methods; psychological warfare; leadership, drill and exercise of command; Chemical Corps materiel; logistics and field service; organization and function of Chemical staff sections; duties of Chemical staff officers; protection (tactical); Chemical operations and training.

MS417, MS427. Army Security Agency, Advanced. Military administration; military law and boards; military teaching methods; psychological warfare; leadership, drill and exercise of command; command and staff, combat intelligence; elementary cryptanalysis; theory and application of traffic analysis; cryptomaterial distribution and accounting.

MS418, MS428. Quartermaster Corps, Advanced. Military administration; military law and boards; military teaching methods; psychological warfare; leadership, drill and exercise of command; fiscal procedures; procurement procedures; command and staff; combat intelligence; technical intelligence; organization and functions of the combatant arms; organization and functions of the technical services; quartermaster operations in the zone of the interior; quartermaster operations in the theater of operations.

MUSIC

Subjects Mu1 to Mu99

Mu31. Introduction to Music. Designed to familiarize students (with little or no knowledge of music) with the language of music and its universal literature. Includes contemporary music. Rudiments of harmony and ear-training, and terminology of music. Analysis of representative masterworks through lectures and demonstrations. Listening to recordings and readings.

Mu32. Western Music from the Middle Ages to the Present. Study of representative composers in their historic perspective with emphasis on outstanding examples of masterworks of Middle Ages, Renaissance, Baroque and Classic eras. Detailed analysis of compositions by Bach, Haydn, Mozart, Beethoven, and by romantic and contemporary composers. Listening to recordings and readings required.

Mu41. The Classic String Quartet. Study of the literature for string quartet in its importance as "absolute music" and as origin of the symphony. Representative quartets analyzed in detail with special emphasis on the quartets of Beethoven. Rudiments of score reading taught and practiced. Concerts, recordings, and group discussion.

Mu42. Twentieth-Century Music. Study of principal works by masters of twentieth century. Tradition and innovation as exemplified in the music of Schönberg, Stravinsky, Bartok, Hindemith, Copland, Ives, Prokofieff, Honegger, and other composers. The interrelationship of Art music, Folk music and Popular music. Concerts, recordings and group discussion.

NUCLEAR TECHNOLOGY

Subjects N1 to N99

N1–N3. Engineering Practice School at Oak Ridge (A). A twenty-two-week course at the plants of the Atomic Energy Commission in Oak Ridge, Tennessee, which are operated by Carbide and Carbon Chemicals Corporation: the Diffusion plant, the Electromagnetic plant, and the Oak Ridge National Laboratories. Work, under the direction of M. I. T. faculty residing at Oak Ridge, emphasizing the application of principles to the practical solution of engineering problems and designed to develop initiative, resourcefulness and cooperative effort under industrial conditions. Time devoted entirely to education without compensation to students. Admission is restricted to students in any department of the Graduate School who are United States citizens; they must be cleared for security by the Atomic Energy Commission. Periods: (1) late July to Christmas, (2) early February to early July. Applications for admission should be made at least four months before the start of the period to allow adequate time for clearance.

N10. Introduction to Nuclear Technology (A). Review of physical and chemical background especially important in nuclear engineering. Raw materials and processes used in the production of fissionable material, production of radioisotopes, and utilization of energy from nuclear reactions. Consideration of the design characteristics of nuclear reactors, chemical and metallurgical processes associated with them, procedures for handling radioactive materials, and isotope separation methods. Emphasis on the engineering problems

Nuclear Technology Continued

of nuclear processes and the methods developed to solve them. (Primarily for graduate and selected fourth-year students who wish a general knowledge of nuclear engineering.)

N20. Biological Effects of Nuclear Radiations (A). The interaction of nuclear radiations with matter. Effects of energy absorbed from nuclear radiations on simple and complex chemical systems, on unicellular and multicellular organisms with special reference to human beings. Theories of the action of radiations on living matter. Physical and biological factors influencing the biological response to radiation. Comparison of acute and chronic exposures. Radiation dosage and dosimetry. Biological and physical bases for safety standards. Applications to industry, biology, and medicine.

N21. Nuclear Reactor Engineering I (A). Types and functions of nuclear reactors; nuclear transformations carried out in reactors; neutron production and utilization; heat production and removal; reactor kinetics and control.

N22. Nuclear Reactor Engineering II (A). Reactor radiation and shielding; reactor hazards and their prevention; properties and production of special materials for reactors; generation of power; economics of nuclear reactors.

N90. Special Problem in Nuclear Engineering (A). Designed to meet the needs of special and graduate students who wish to carry out some minor investigation in a particular field. Subject and hours arranged to fit individual requirements.

SUBJECTS OF INSTRUCTION TABULATED

The information below is subject to change. The list of subjects actually to be given will be published with the Class Schedule prior to the beginning of each term.

The number at the left is the subject number.

The numbers following the names of subjects indicate the prerequisite subjects (those in italics may be taken simultaneously).

To the right of the prerequisites are noted the year and term and the Professional Courses in which the subjects are scheduled.

(A) following the year indicates that the subject is primarily for Graduate students. (R) means that the subject is restricted to the special groups indicated at the end of the description of the subject.

Then follows the time distribution of the subject in units (a unit representing fifteen hours work). The total units credit for a subject is obtained by adding the units allotted to Exercise (Recitation, Lecture, Laboratory, Drawing or Fieldwork), and Preparation. One unit of Recitation or Lecture credit is equivalent to one semester hour. Two units of Drawing or Laboratory credit are equivalent to one semester hour.

At the extreme right is given the name of the Instructor in charge of the subject.

CIVIL AND SANITARY ENGINEERING—1·00–1·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
1·00	Surveying	D12	2	S	I, IV-B	2	11	0	Shea
			3	S	XVII				
1·01	Survey. Fieldwork, Adv.	1·00	2	S	I, IV-B	1	5	0	Shea
1·03	Surveying, Adv.	1·01	2	1	I	2	4	4	Shea
1·04	Const. Survey. Fldwk.	1·00	3	S	XVII	2	9	0	Shea
1·05	Surveying	D12	2	1	Elective	1	2	1	Shea
1·06	Photogrammetry	1·03 or 1·05	4	2	Elective	2	2	4	Shea
1·071	Geodetic Surveying	1·01	—	S	Elective	4	10	0	Shea
1·08	Navigation	M11	3	2	Elective	2	—	4	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
1·20	Route Survey. Fldwk.	1·00	2	S	I, IV-B	1	4	0	Babcock
1·21	Route & Const. Surveys	1·20	2	2	I	2	—	4	Babcock
1·24	Transportation Planning	——	3	2	IV-B	3	—	3	Bone
			4	2	I_2				
1·271	Transportation Eng.	1·21	4	1	Elective	3	3	6	Babcock, Bone
1·272	Transportation Eng.	1·271	4	2	Elective	3	3	3	Babcock, Bone
1·28	Highways & Airports	——	4	1	Elective	3	—	3	Bone
1·30	Railway Transport., Adv.	1·272	G(A)	1	Elective	2	—	4	Babcock
1·311	High. Transport., Adv.	*1·271* or *1·28*	G(A)	1	Elective	2	—	4	Bone
1·312	High. Transport., Adv.	1·311	G(A)	2	Elective	2	—	4	Bone
1·321	Airport Planning & Admin.	1·24 or 1·28 or 1·272	G(A)	1	Elective	2	—	4	Bone
1·322	Airport Design	1·24 or 1·28 or 1·272	G(A)	2	Elective	0	6	0	Bone
1·35	Soil Mech. & Found. Eng.	2·04	4	1	$I_{1,3}$	3	3	6	Aldrich
1·351	Soil Mech. & Found. Eng.	2·04	3	1	XVII	2	2	4	D. W. Taylor
			4	1	I_2, XVII (52–53)				
1·354	Soil Engineering	1·35 or 1·351	4	2	Elective	3	—	6	Aldrich
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.	*1·35, 1·351* or *1·361*	G(A)	1	Elective	0	3	3	Aldrich
1·38	Soil Eng. Spec. Studies	*1·361*	G(A)	1 or 2	Elective		★		D. W. Taylor
1·40	Structural Analysis	2·04	3	2	I, XVII	3	—	6	Mirabelli
1·401	Structural Analysis	2·04	G	2	——	3	3	6	Mirabelli
1·41	Structural Analysis	1·40	4	1	I, XVII	3	—	6	Mirabelli
1·42	Structural Analysis	1·401 or 1·41	4	2	$I_{1,3}$,XVII	3	—	6	Norris
1·44	Structural Design, Elem.	*1·40*	3	2	I	3	6	0	Mirabelli
1·441T	Structural Design	*1·41*, 1·44	4	1	$I_{1,3}$	2	4	0	Mirabelli
1·442T	Reinforced Concrete Des.	*1·42*, 1·44	4	2	I_1	2	4	0	Holley
1·521	Structural Lab.	1·42	G(A)	1	Elective	2	3	1	Norris
1·522	Structural Lab.	1·521	G(A)	2	Elective		★		Norris
1·541	Reinf. Conc. Des., Adv.	1·42, 1·44	G(A)	1	Elective	2	4	0	Holley
1·542	Reinf. Conc. Des., Adv.	1·42, 1·44	G(A)	2	Elective	2	4	0	Holley
1·551	Structural Design, Adv.	1·42	G(A)	1	Elective	2	—	4	Wilbur
1·552	Structural Design, Adv.	1·42	G(A)	2	Elective	2	—	4	Biggs
1·561	Structural Mechanics, Adv.	1·42, M22	G(A)	1	Elective	3	—	6	Norris
1·562	Structural Mechanics, Adv.	1·42, M22	G(A)	2	Elective	3	—	6	Norris
1·571	Stat. Indet. Structures	1·42	G(A)	1	Elective	4	—	8	Fife
1·572	Stat. Indet. Structures	1·42	G(A)	2	Elective	2	—	4	Fife

★ Time specially arranged.

Civil and Sanitary Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
1·58	Elast. Stabil. of Flat Plates	M22	G(A)	2	——	3	—	6	Fife
1·601	Fluid Mechanics	2·01	3	1	I	3	—	6	Ippen, Daily
			3	2	XV-A				
1·602	Fluid Mechanics	1·601	3	2	I(1)	2	—	4	Daily
1·611	Fluid Mechanics	2·01	3	1	XVII	2	—	4	Harleman
1·612	Fluid Mechanics	2·01	G	2	XIII-A	3	—	6	Daily
1·613	Fluid Mechanics	2·01	3	2	VI-A(A)$_1$	3	—	6	Paynter
			4	1	VI$_1$				
			4	2	VI-A(B)$_1$				
1·621	Fluid Mechanics Lab.	1·601	4	1	I$_1$	0	6	0	Harleman
1·63	Applied Hydromechanics	1·602 or 1·612	G(A)	1	Elective	3	—	6	Daily
1·64	Hydraulic Machinery	1·602 or 1·613	G(A)	2	Elective	2	—	4	Daily
1·65	Free Surface Flow	1·602	G(A)	1	Elective	2	—	4	Ippen
1·66	Hydraulic Structures, Des.	1·65	G(A)	2	Elective	0	6	0	Gifford, Ippen
1·67	Hydromechanics, Seminar	1·602	G(A)	2	Elective	1	—	2	Ippen, Daily
1·681	Exp. Hydromechanics	1·602	G(A)	1	Elective	2	—	4	Ippen
1·682	Exp. Hydromechanics	1·681	G(A)	2	Elective	0	9	0	Harleman
1·683	Exp. Hydromechanics	1·63	G(A)	2	Elective	0	6	0	Paynter
1·69	Rivers & Harbors	1.65 or 1·681	G(A)	2	Elective	2	—	4	Ippen
1·70	Hydrology & Flood Control	1·601	4	1	Elective	3	3	6	Gifford
1·701	Hydrology & Flood Control	——	4	1	Elective	3	—	6	Gifford
1·71	Water Power Eng.	1·44, 1·70	4	2	Elective	3	3	3	Gifford
1·711	Water Power Eng.	1·601 or 1·613; 1·70 or 1·701	4	2	Elective	3	—	3	Gifford
1·72	Hydrol. & Water Power Eng.	1·601 or 1·613; 2·04	4	1	I$_2$	3	—	3	Paynter
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.	1·601	4	1	Elective	3	3	6	Stanley
1·76	Sewer. & Sew. Treatment	1·601	4	2	Elective	3	3	3	Stanley
1·77	Water Sup. & Sewerage	1·601	4	2	I$_2$	3	—	3	——
1·771	Sanitation	——	3	1	IV-A, IV-B	2	—	4	Stanley
1·79	Sanitary Eng. Design	1·75 or *1·76*	4	2	Elective	0	6	0	Stanley
1·811	Sanitary Eng., Adv.	*1·75*	G(A)	1	Elective	3	—	6	Eliassen
1·812	Sanitary Eng., Adv.	*1·76*	G(A)	2	Elective	3	—	6	Eliassen
1·821	Sanitary Eng. Lab.	*1·75, 1·831*	G(A)	1	Elective	2	3	4	Sawyer
1·822	Sanitary Eng. Lab.	*1·76*, 1·831	G(A)	2	Elective	2	3	4	Sawyer
1·831	Sanitary Chemistry	5·02	G	1	Elective	2	4	4	Sawyer
1·832	Chem. & Indus. Waste Treat.	1·76, 1·831	G(A)	2	Elective	2	4	4	Sawyer
1·84	San. Bacteriology I	*1·831*	G	1	Elective	2	4	4	Horwood
1·85	San. Bacteriology II	1·84	G(A)	2	Elective	2	4	4	Horwood
1·86	Pub. Health Engineering	*1·84*	G(A)	1	Elective	3	—	6	Horwood, Eliassen
1·861	Indust. Health Eng.	1·86	G(A)	2	Elective	3	—	6	H. L. Hardy
1·87	Pub. Health Statistics	1·86	G(A)	2	Elective	3	—	6	Eliassen
1·871	Pub. Health Admin.	1·86	G(A)	2	Elective	3	—	6	Horwood
1·872	Pub. Health Eng. Fldwk.	1·86	G(A)	2	Elective	2	3	4	Horwood
1·881	Sanitary Design, Adv.	*1·811*	G(A)	1	Elective	1	5	2	Stanley
1·882	Sanitary Design, Adv.	*1·812*	G(A)	2	Elective	1	5	2	Stanley
1·883	Spec. Stud. in San. Eng.	1·811, 1·812, 1·831, 1·84	G(A)	1	Elective		★		Eliassen
1·884	Spec. Stud. in San. Eng.	1·811, 1·812, 1·831, 1·84	G(A)	2	Elective		★		Eliassen
1·891	San. Eng. Seminar	*1·811* or 1·812	G(A)	1	Elective	1	—	2	Eliassen
1·892	San. Eng. Seminar	1·811 or *1·812*	G(A)	2	Elective	1	—	2	Eliassen
1·90	Conservation, Prin.	——	3	2	I(2)	3	—	6	Shea
1·91	Eng. Construction	——	3	1	I	3	—	3	Babcock
1·92	Constr. Equip. & Methods	1·91	3	2	I(3)	2	—	4	Babcock
1·94	Professional Prob.	——	4	2	I	2	—	4	Wilbur

★ Time specially arranged.

MECHANICAL ENGINEERING — 2·00–2·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2·00	Statics	8·02, M12	2	1	I, IX-B, XIII, XVI, XIX	3	—	5	Den Hartog
2·001	Applied Mechanics I	8·02, M12	2	1	II, VI	3	—	5	Crandall
2·002	Applied Mechanics II	2·001	2	2	II, VI	3	—	5	Dahl
2·003‡	Applied Mechanics III	2·002, M22	3	1	II	4	—	8	Adkins
			4	S	II-B				
2·01	Dynamics	2·00	2	2	I, IX-B, XIII, XIX	3	—	5	Den Hartog
2·011	Statics & Dynamics	8·02, M12	2	1	III, IV-A, X, XIV-A, XIV-B, XV-A, XVII, XVIII	3	—	5	Sloane
			2	2	XIII-C				
2·04	Strength of Materials	2·00 or 2·011	2	2	III, IV-A, X, XIII, XV-A, XVI, XVII	3	—	6	Dahl
			3	S	VI-A (A)				
			3	1	I, II (52–53), VI, VI-A(B), IX-B, XIII-C, XIV-A, XIV-B, XVI (52–53)				
2·046	Strength of Mat. & Dynamics	——	G	S	XIII-A	4	2	8	Dahl
2·06	Dynamics	2·01, 2·04	3	1	II-B(B) (52–53)	3	—	6	Adkins
			3	2	II(52–53), II-B(A)(52–53), XIV-A, XV-A				
2·07	Dynamics	2·04	3	2	VI (1, 4), VI-A(A)$_{1,4}$	3	—	6	Reswick
			4	S	VI-A(B)$_{1,4}$				
2·081	Strength of Materials	2·01, 2·04; or 2·002	3	1	XIII	3	—	6	Den Hartog
			4	1	II(4,5,6,8), II-B(4,5,6,8)				
			G	1	XIII-A				
2·082	Mech. Eng. Problems	2·003 or 2·06; 2.25 or 2·252; 2·42	4	2	II, II-B	3	—	6	Soderberg
2·11	Industrial Plant Eng.	2·002 or 2·04	4	2	Elective	3	—	6	Schwarz
2·121	Photoelasticity	2·002 or 2·04	4	1 or 2	Elective	1	2	3	W. M. Murray
2·122	Indust. Photoelasticity	——	—	S	Elective	No credit			W. M. Murray
2·125	Res. in Exp. Stress Anal.	2·121 or 2·126 or 2·128	G(A)	1 or 2	Elective		★		W. M. Murray
2·126	Exp. Stress Analysis	*2·081*	4	1 or 2	Elective	2	3	4	W. M. Murray
2·128	Exp. Stress Analysis	*2·081*	4	1 or 2	Elective	2	6	4	W. M. Murray
2·211	Mechanics, Adv.	2·081	G(A)	1	Elective	3	—	9	Den Hartog
2·212	Mechanics, Adv.	2·003 or 2·06	G(A)	2	Elective	3	—	9	Den Hartog
2·213	Gas Turbines	2·25 or 2·252 or 16·02	G(A)	1	Elective	3	—	9	E. S. Taylor
2·214‡	Gas Turbines	2·213	G(A)	2	Elective	3	—	9	E. S. Taylor
2·215	Numerical Analysis	M352 or M37	G(A)	2	Elective	3	—	9	Crandall
2·221	Plasticity	2·002 or 2·04	G(A)	2	Elective	3	—	9	McClintock
2·222T‡	Sem. in Plasticity	2·221	G(A)	1 or 2	Elective		★		McClintock
2·225	Phys. of Strength & Plast.	2·37, 3·11	G(A)	1	Elective	3	—	9	Orowan
2·226	Phys. of Strength & Plast.	2·225	G(A)	2	Elective	3	—	9	Orowan
2·231	Elasticity, Theory	2·081	G(A)	1	Elective	3	—	9	Adkins
2·232	Elasticity, Theory	2·231	G(A)	2	Elective	3	—	9	Adkins
2·25‡	Fluid Mechanics	2·002 or 2·01; M22	3	1	II-B(B)	4	—	8	A. H. Shapiro
			3	2	II, II-B(A)				
2·251	Fluid Mechanics	2·01, M22	3	1	II (52–53), II-B (B) (52–53), XIII, XIV-A	3	—	6	A. H. Shapiro
			3	2	II-B(A) (52–53)				
			4	1	VI$_4$, VI-A(A)$_4$				
			4	2	VI-A(B)$_4$				
2·252	Fluid Mechanics	2·251	3	2	II(52–53), XIV-A	2	—	4	A. H. Shapiro
			4	S	II-B (52–53)				
2·252T‡	Fluid Mechanics	2·25 or 2·252	4	1	II(1,2,3), II-B(1,2,3)	3	—	6	A. H. Shapiro
2·256	Fluid Mechanics	2·003 or 2·046 or 2·06; 2·40 or 2·402 or 2·403	G	1, 2	Elective	3	—	6	A. H. Shapiro
2·261	Lubrication & Friction	2·25 or 2·252	4	2	Elective	2	—	4	Rightmire
2·262	Lubrication, Research	2·261	G(A)	1 or 2	Elective		★		Rightmire
2·263	Lubrication and Friction	2·25 or 2·252	G(A)	1	Elective	3	—	6	Shaw
2·264	Lubrication Eng.	——	—	S	Elective	No credit			Rightmire
2·28	Fluid Machinery	2·491	G(A)	2	Elective	3	—	9	A. H. Shapiro
2·31	Mech. Prop. of Mat.	2·002 or 2·04; 3·11	4	1	II(5), II-B(5)	4	—	6	Orowan
2·32	Mech. Prop. of Mat.	2·31	4	2	II(5), II-B(5)	4	—	6	Orowan

‡ Not offered 1952-53.

★ Time specially arranged.

Mechanical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2·34	Mech. Prop. of Metals	2·37, 3·11	4	1 or 2	Elective	3	—	6	Lessells
2·351	Dynamic Strength of Metals	2·081, 2·34	G(A)	1	Elective	3	—	9	Lessells
2·352	Dynamic Strength of Metals	2·351	G(A)	2	Elective	3	—	9	Lessells
2·37	Mech. Behavior of Materials	2·003 or 2·04; 3·11	3	S	II-B	2	2	4	Shank
			3	1	II-B(B) (52–53)				
			3	2	II, II-B(A) (52–53)				
2·371	Test. Materials Lab.	*2·04*	3	1	I, XVII	0	2	2	Shank
			4	1	III_1, XIII (not 52–53)				
2·40	Heat Engineering	8·02, M21	3	S	$VI\text{-}A(A)_1$, XVI-B	4	—	5	Svenson
			3	1	II(52–53), $VI(1)$, $VI\text{-}A(B)_1$, IX-B, XIII, XIII-C, XIV-A, XV-A, XVI, XIX				
			3	2	XVI-B(A) (52–53)				
2·401	Heat Engineering	8·02, M21	3	1	——	4	—	5	Svenson
2·402	Heat Engineering	——	G	1	XIII-A	4	2	7	Wadleigh
2·403‡	Heat Engineering	8·02, M21	3	S	II-B	4	—	8	Keenan
			3	1	II				
2·41	Heat Engineering	8·02, M21	3	1	XVII	4	—	5	Svenson
			3	2	I(1)				
2·42	Heat Engineering	2·40 or 2·403	3	1	II-B(B)	3	—	6	Svenson
			3	2	II, II-B(A), $VI(1)$, $VI\text{-}A(A)_1$, IX-B, XIII, XIV-A, XV-A				
			4	S	$VI\text{-}A(B)_1$				
2·422	Heat Engineering	2·402	G	2	——	2	—	4	Keenan
2·43	Heat Engineering	2·25 or 2·251 or *2·256*; 2·40 or 2·403	4	1	II(1,3,9), II-B(1,3,9)	3	—	6	Kaye
2·44T	Des. Prob. in Heat Eng.	2·43	4	2	Elective	3	—	6	Kaye
2·451	Eng. Thermodyn., Adv.	2·43, *M36*	G(A)	1	Elective	3	—	9	Keenan
2·452	Eng. Thermodyn., Adv.	2·451	G(A)	2	Elective	3	—	9	Keenan
2·47	Jet Propulsion	2·003 or 2·06; 2·25 or 2·252; 2·42	4	1	II(2), II-B(2)	3	—	6	E. S. Taylor
2·48	Gas Turbines	2·42	4	1	Elective	3	—	6	Neumann
2·49	Fluid Mechanics, Adv.	2·25; *M351* or *M36*	G(A)	1	Elective	3	—	9	A. H. Shapiro
2·491	Compressible Fluid Mechanics	2·49; 2·42; *M352* or *M37*	G(A)	2	Elective	3	—	9	A. H. Shapiro
2·492	Topics in Fluid Mech., Adv.	2·49	G(A)	1 or 2	Elective		★		A. H. Shapiro
2·50	Heat Measurements	8·03	3	2	III	1	2	1	Wilkes
2·51	Heat Measurements, Adv.	8·03	G	1	——	1	4	4	Wilkes
2·521	Heat Transfer, Adv.	2·42; *M351* or *M36*	G(A)	1	Elective	3	3	6	Rohsenow
2·522	Heat Transfer, Adv.	2·42, M22	G(A)	2	Elective	3	—	9	Rohsenow
2·53	Heat Measurements	2·50	4	1 or 2	Elective		★		Wilkes
2·56	Power Plant Eng.	2·42; 2·43; 2·68 or 2·681	4	2	II(1), II-B(1)	3	3	6	Holt
2·57	Power Plants, Adv.	2·56	G(A)	1	Elective	3	—	9	Holt
2·601	Food Engineering	8·04	4	1	XX, XX-A	2	2	2	Hesselschwerdt
2·602	Food Engineering	2·601	4	2	XX, XX-A	2	2	2	Hesselschwerdt
2·621	Refrigeration	2·41 or 2·42	4	2	II(3), II-B(3)	3	—	6	Svenson
2·641	Refrigeration Eng.	2·42, 2·43	G(A)	2	Elective	3	—	6	Svenson
2·642	Low Temp. Refrigeration	2·40 or 2·403	G(A)	1 or 2	Elective	3	3	6	Collins
2·661	Heating & Ventilation	——	3	1	IV-A	2	—	4	Hesselschwerdt
2·662	Heating & Ventilation	2·661	3	2	IV-A	2	—	4	Hesselschwerdt
2·663	Air Conditioning	2·40 or 2·403 or 2·41	4	1	II(3), II-B(3)	3	—	6	Hesselschwerdt
2·664	Refrigeration, App.	2·663	4	2	Elective	2	—	4	Hesselschwerdt
2·665‡	Refrigeration, App.	2·40 or 2·403	4	2	XIII-C	2	1	5	Hesselschwerdt
2·671	Air Conditioning, Adv.	2·663	G(A)	1	Elective	3	—	9	Hesselschwerdt
2·68	Engineering Lab.	2·251; 2·40 or 2·403 or 2·41 or 10·29	4	1	II(1,2,3,5,9), II-B(1,2,3,5,9)	1	3	4	Wilson
			4	2	II(6,7,8), II-B(6,7,8)				
2·681	Engineering Lab.	2·40 or 2·403 or 2·41 or 10·29	4	1	VI_1, $VI\text{-}A(A)_1$, XIII, XIII-C	0	3	3	Wilson
			4	2	$VI\text{-}A(B)_1$				
2·693	Ref. & Air Cond. Lab.	*2·621*; 2·663; 2·68 or 2·681	4	2	Elective	0	3	6	Hesselschwerdt

‡ Not offered 1952–53.

★ Time specially arranged.

Mechanical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2·701	Machine Drawing	D12	2	1	II	0	6	0	Lent
2·73	Machine Design	2·002 or 2·01, D12	3	S	II-B	1	3	2	Sloane
			3	1	II				
2·731	Machine Design	2·002 or 2·04; 2·73; 3·11	3	1	II-B(B) (not 52–53)	2	3	4	Hrones
			3	2	II, II-B(A) (not 52–53)				
			4	S	II-B (52–53)				
2·732	Machine Design	2·731	4	1	II(6,7), II-B(6,7)	2	2	4	Arnold
2·733	Machine Design	2·732	4	2	Elective	0	9	3	Arnold
2·734	Product Design	2·731	4	1	Elective	0	6	3	Arnold
2·735	Product Design	2·734	4	2	Elective	0	6	3	Arnold
2·742	Dynamics of Machinery	2·732, M351	G(A)	2	Elective	2	3	4	Arnold
2·751	Systems Design	2·003 or 2·06 or 2·07	G(A)	1	Elective	2	4	4	Hrones
2·78	Indust. Hydraulic Mach., Des.	2·25 or 2·251	4	2	II(6), II-B(6)	2	3	4	Hrones
2·781	Hydr. Power Control, Fund.	—	—	S	Elective	No credit			Hrones
2·783	Control Prob. in Mech. Eng.	2·003 or 2·06 or 2·07; 2·403	G(A)	2	Elective	3	—	9	Hrones
2·79	Int. Comb. Eng., Elem.	2·002 or 2·04; 2·40 or 2·403 or 2·41 or 10·29	4	1	Elective	3	—	6	Rogowski
2·791	Internal Combustion Eng.	2·002 or 2·04; 2·42	4	1	II(4), II-B(4)	3	—	6	Rogowski
2·792	Internal Combustion Eng.	2·79 or 2·791	4	2	II(4), II-B(4)	3	—	6	Rogowski
2·7941	Int. Comb. Eng. Lab.	2·79 or 2·791	4	1	II(4), II-B(4)	0	2	2	Rogowski
2·7942	Int. Comb. Eng. Lab.	2·7941	4	2	II(4), II-B(4)	0	2	2	Rogowski
2·797T	Int. Comb. Eng. Adv.	2·79 or 2·791	G(A)	1	Elective	3	—	9	C. F. Taylor
2·798T	Int. Comb. Eng. Adv.	2·797T	G(A)	2	Elective	3	—	9	C. F. Taylor
2·80	Automotive Vehicles	2·79 or 2·791	4	2	Elective	3	—	6	C. F. Taylor
2·801	Spec. Prob. in Int. Comb. Eng.	2·48 or 2·79 or 2·791	G(A)	1	Elective		★		C. F. Taylor
2·802	Spec. Prob. in Int. Comb. Eng.	2·48 or 2·79 or 2·791	G(A)	2	Elective		★		C. F. Taylor, E. S. Taylor
2·85	Machine Tools, Int.	—	2	1	II	0	4	1	P. A. Smith
2·851	Machine Tool Lab.	—	2	1	XIII, XIII-C, XIV-A, XIV-B, XV-A	0	4	0	P. A. Smith
			2	2	XII-A, XII-B				
			4	1	III,				
2·853	Metal Cutting, Prin.	2·852 or 2·86	4	1	Elective	3	—	6	Shaw
2·854	Metal Cutting	2·852 or 2·86	4	1	Elective	2	—	4	Shaw
2·855	Metal Cutting, Th.	2·002 or 2·04; 3·11	G(A)	1 or 2	Elective	3	—	6	Shaw
2·856	Plasticity, Applied	2·003 or 2·04	G(A)	1 or 2	Elective	3	—	6	Yang
2·857	Metal Cutting	—	—	S	Elective	No credit			Shaw
2·86‡	Machine Tool Fund	2·002 or 2·04; 2·85; 3·11	3	2	II	0	3	2	P. A. Smith
			4	S	II-B				
2·871	Manufacturing Eng.	2·731	4	1	Elective	3	—	6	Buckingham
2·872	Prep. for Manufacturing	2·731, 2·852	4	2	Elective	3	—	6	Buckingham
2·901	Fabric Struct., Prin.	8·02	4	1	II(8), II-B(8)	3	—	6	Schwarz
2·902	Fabric Struct., Prin.	2·901	4	2	Elective	3	—	6	Schwarz
2·903	Textile Manufact., Elem.	8·02	4	1	II(8), II-B(8)	3	—	6	Schwarz
2·904	Textile Manufact., Prin.	2·903	4	2	II(8), II-B(8)	3	—	6	Schwarz
2·905	Textile Tech. Anal.	8·04	G(A)	1	Elective	3	—	6	Finch
2·906	Textile Tech. Anal.	2·905	G(A)	2	Elective	3	—	6	Finch
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, 2·93	G(A)	1	Elective	0	6	2	Finch
2·912	Textile Research Lab.	2·906, 2·911	G(A)	2	Elective	0	6	2	Finch
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
2·92	Textile Research, Prin.	—	—	S	Elective	No credit			Schwarz
2·93	Experiment Planning & Anal.	M22	G(A)	1	Elective	3	—	6	Finch
2·951	Industrial Practice	—	3	S	II-B(A)	40 h.p.w.			W. M. Murray
			4	S	II-B(B)				
2·952	Industrial Practice	—	3	1	II-B(A)	40 h.p.w.			W. M. Murray
			3	2	II-B(B)				
2·991	Mechanical Eng. Seminar	—	G(A)	1	Elective	2	—	2	Kaye
2·992	Mechanical Eng. Seminar	—	G(A)	2	Elective	2	—	2	Kaye

‡Not offered 1952–53.

★ Time specially arranged.

METALLURGY — 3·00–3·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
3·01	Metallurgical Eng. I	5·61	3	2	III	4	—	4	Schuhmann
3·02	Metallurgical Eng. II	3·01	4	1	III	3	—	6	Schuhmann
3·021	Metallurgical Eng. Lab.	3·01	4	1	III	0	4	0	Schuhmann
3·03	Metallurgical Eng. III	3·02, 3·81	4	2	III_2	2	—	4	Schuhmann, Grant
3·10	Metal. Plant Visits	—	4	S	III	0	3	1	Floe, Grant
3·11	Engineering Metals	—	2	2	II, XIV-A	4	2	4	Wulff, Backofen
			3	1	XV-A				
			4	1	XIII (not 52–53), XIV-A (52–53)				
3·12	Metal Processing	3·11 or *3·32*	3	2	III(1)	2	2	4	H. F. Taylor
3·13	Foundry Engineering I	3·12	4	2	Elective	2	—	4	H. F. Taylor
3·15	Welding Engineering	3·12	4	2	Elective	2	—	4	Udin
3·16	Powder Metallurgy	3·11 or 3·32	4	1	Elective	2	—	4	Wulff
3·18	Plastic Working of Metals	*3·12*	4	1, 2	Elective	2	—	4	Shaler, Backofen
3·20	Metal. Thermodynamics	5·62	4	1	III	4	—	4	Bever, Wagner
3·21	Steelmaking, Prin.	3·20	G(A)	2	Elective	3	—	6	Chipman
3·22	Thermo. of Metallic Solutions	3·20, 3·32	G(A)	2	Elective	2	—	4	Wagner
3·25	Experimental Meth. in Metal.	5·62 or 8·04	G(A)	1	Elective	1	2	0	Grant
3·30	Physical Met., Elem.	5·62 or 8·07	4	2	Elective	2	2	4	Bever
3·31	Physical Metallurgy I	5·12, 8·04	3	1	III	2	4	4	Bever
3·32	Physical Metallurgy II	3·31	3	2	III(1)	3	3	6	M. Cohen
3·33	Physical Metallurgy III	3·32	4	2	III_1	2	4	4	Floe
3·331	Industrial Phys. Met.	3·11	4	1	XV-A (52–53)	2	2	2	Floe
3·34	Physical Metal., Adv.	3·20; 3·30 or 3·32; 3·50	G(A)	1	Elective	4	—	4	M. Cohen
3·35	Physical Metal., Adv.	3·20; 3·30 or 3·32; 3·50	G(A)	2	Elective	4	—	4	Averbach
3·38	Physical Metal., Adv.	—	G	1	Elective	0	3	3	—
3·39	Physical Metal., Adv.	3·38	G	2	Elective	2	3	3	—
3·391	Properties of Metals	—	G	1	XIII-A	2	1	3	Floe
3·392	Properties of Metals	3·391	G	2	XIII-A	2	1	3	Averbach
3·396	Tech. of Nucl. React. Mat.	3·30, 3·31, 3·392	G(R)	1	—		★		Kaufmann
3·41‡	Light Alloys	3·11 or 3·31	4	1 or 2	Elective	2	—	4	—
3·42	Electrochemistry	5·62	4	1	Elective	2	—	4	Uhlig
3·43	Corrosion	5·62	G(A)	2	Elective	2	—	4	Uhlig
3·44	Behavior of Metals at Elevated Temperatures	3·32 or 3·331	G(A)	2	Elective	2	—	4	Grant
3·50	X-ray Metallurgy	3·31	4	1	III_1	2	2	4	J. T. Norton
3·51	Physics of Metals	3·50	4	2	Elective	2	—	4	J. T. Norton
3·52	Physics of Metals, Adv.	3·51	G(A)	1	Elective		★		J. T. Norton
3·53	X-ray Metallurgy, Adv.	3·50	G(A)	2	Elective		★		J. T. Norton
3·61	Magn. Prop. of Met. & Alloys	3·50, 3·51	G(A)	2	Elective	2	—	4	Kaufmann
3·62	Spec. Prob. in Metallurgy	—	G(A)	1	Elective		★		—
3·63	Spec. Prob. in Metallurgy	—	G(A)	2	Elective		★		—
3·70	Ceramics	5·02, 8·04	4	2	III_2	2	3	4	Kingery
3·71	Ceramics Seminar	3·70	G(A)	1	Elective	1	—	2	Kingery
3·72	Ceramics Seminar	3·70	G(A)	2	Elective	1	—	2	Kingery
3·73	Ceramic Processes I, Fund.	3·70, 5·62	G(A)	1	Elective	3	—	4	F. H. Norton
3·74	Ceramic Processes II, Fund.	3·73	G(A)	2	Elective	3	—	4	F. H. Norton
3·75	Spec. Prob. Ceramics	3·70	G(A)	1	Elective		★		F. H. Norton
3·76	Spec. Prob. Ceramics	3·70	G(A)	2	Elective		★		F. H. Norton
3·77	Ceramics Lab., Adv.	3·70	G(A)	1	Elective	0	5	4	Kingery
3·78	Ceramics Lab., Adv.	3·70	G(A)	2	Elective	0	5	4	F. H. Norton
3·81	Mineral Engineering I	8·04, *12·011*	3	1	III	2	2	4	Gaudin, Bell
3·82	Mineral Engineering II	3·81	3	2	III(2)	2	4	4	de Bruyn, Charles
3·83	Mineral Engineering III	3·82	4	1	III_2	2	2	4	de Bruyn
3·85	Mineragraphy	3·82	4	1 or 2	Elective	1	3	2	de Bruyn, Bell
3·86	Quantitative Mineragraphy	3·83	G(A)	1 or 2	Elective		★		de Bruyn, Bell
3·87	Ore Testing	3·83	4	1	Elective	0	10	0	Charles
3·89	Mineral Dressing Design	3·83	G(A)	1 or 2	Elective		★		Bell
3·90	Mineral Engineering, Adv.	3·83	G(A)	1 or 2	Elective	2	—	4	Overbeek
3·901	Mineral Dressing Lab., Adv.	3·83	G(A)	1 or 2	Elective		★		Gaudin, Overbeek

‡ Not offered 1952–53.

★ Time specially arranged.

ARCHITECTURE AND PLANNING — 4·00–4·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
4·031	Visual Fundamentals	——	3	1	IV-A	0	4	0	Kepes
4·032	Visual Fundamentals	4·031	3	2	IV-A	0	4	0	Kepes
4·041	Light and Color	4·032	4	2	IV-A	0	6	0	Kepes
4·042	Light and Color	4·032	4	2	Elective	0	4	0	Kepes
4·051	Graphic Presentation	4·041	5	1	IV-A	0	6	0	Kepes
4·052	Graphic Presentation	4·051	5	2	IV-A	0	6	0	Kepes
4·053	Painting	4·052	G(A)	1	Elective	0	6	0	Kepes
4·054	Painting	4·053	G(A)	2	Elective	0	6	0	Kepes
4·07	Shop	——	2	2	IV-A	0	4	0	Anderson
4·12	Urban Sociology	——	2	2	IV-A	2	—	4	Greeley
			3	2	IV-B				
			4	2	I_2				
4·13	Land Economics	4·651, 14·01	4	1	IV-B	2	—	4	Rodwin
			5	1	IV-A				
4·14	Land Economics	4·13	4	2	IV-B	3	—	6	——
4·451	Hist. of Architecture	H22	5	1	IV-A	3	—	6	Whiffen
4·452	Hist. of Architecture	4·451	5	2	IV-A	3	—	6	Whiffen
4·50	Office Practice	——	4	S	IV-B	35 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	—	5	——
4·542	Housing Seminar	4·541	G(A)	2	Elective	3	—	6	Rodwin
4·59	Govt. & Public Admin.	——	3	1	IV-B	3	—	6	C. P. Howard
			3	2	Elective				
4·60	Plan. Legis. & Admin.	4·59	4	2	IV-B	2	—	4	Kelly
4·62	Site Plan. & Constr.	4·681	4	1	IV-B	0	9	3	Lynch
4·63	Regional Planning, Prin.	——	4	1	I_2	2	—	4	Greeley
4·64	Regional Planning Seminar	4·652 or 4·63	G(A)	2	Elective	2	—	4	Greeley
4·641	City Planning, Principles	——	2	2	IV-B	2	—	4	Howard
			3	2	IV-A				
4·651	City Plan., Th. & Prac.	4·641	3	1	IV-B	3	—	6	Howard
4·652	City Plan., Th. & Prac.	4·651	3	2	IV-B	3	—	6	Howard
4·661	City Planning Research	4·683	G(A)	1	Elective	2	—	4	Greeley
4·662	City Planning Research	4·661	G(A)	2	Elective	2	—	4	Greeley
4·67	Form of the City	4·641	G(A)	2	Elective	3	—	3	Kepes, Lynch
4·681	City & Regional Planning	4·722	3	1	IV-B	0	12	6	Greeley
4·682	City & Regional Planning	4·681	3	2	IV-B	0	12	9	Greeley
4·683	City & Regional Planning	4·682	4	1	IV-B	0	9	6	Greeley
4·691	City & Reg. Plan., Adv.	4·683	G(A)	1	Elective	0	30	0	Lynch
4·692	City & Reg. Plan., Adv.	4·691	G(A)	2	Elective	0	24	0	Lynch
4·721	Architectural Design	——	2	1	IV-A, IV-B	0	9	3	Anderson
4·722	Architectural Design	4·721	2	2	IV-A, IV-B	0	9	3	Anderson
4·723	Architectural Design	——	2	1 or 2	——	0	12	6	Anderson
4·731	Architectural Design	4·722	3	1	IV-A	0	12	6	Anderson
4·732	Architectural Design	4·731	3	2	IV-A	0	12	6	Anderson
4·741	Architectural Design	4·732, 4·811, 4·812	4	1	IV-A	0	12	6	Anderson
4·742	Architectural Design	4·741	4	2	IV-A	0	12	6	Anderson
4·751	Architectural Design	4·742	5	1	IV-A	0	12	9	Anderson
4·761	Architectural Design	4·751	G(A)	1	Elective	0	30	0	Anderson
4·762	Architectural Design	4·761	G(A)	2	Elective		★		Anderson
4·78	Planning Principles	——	2	2	Elective	0	4	0	Anderson
4·811	Structural Analysis	2·04, 4·722	3	1	IV-A	2	6	0	Gelotte
4·812	Structural Analysis	4·731, 4·811	3	2	IV-A	2	6	0	Gelotte
4·91	Arch. Acoustics, Spec. Prob.	8·132	G(A)	1 or 2	Elective		★		Anderson, Bolt

CHEMISTRY — 5·00–5·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
5·00	Chemistry, Entrance	——	–	–	——	3	3	6	R. C. Young
5·01	Chemistry, General	——	1	1	All courses	4	3	4	Stephenson
5·02	Chemistry, General	5·01	1	2	All courses	4	3	4	Stephenson
5·061	Inorganic Chem., Adv.	5·13	4	1	V	2	—	4	Schumb
5·062	Inorganic Chem., Adv.	5·061	4	2	V	2	—	4	Schumb

★ Time specially arranged.

Chemistry Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
5·066	Structural Chem., Adv.	5·061	G(A)	2	Elective	2	—	4	Coryell
5·071	Spec. Topics Inorg. Chem.	5·062	G(A)	1	Elective	2	—	4	Schumb
5·08	Inorganic Lab., Adv.	5·062	G(A)	1, 2	Elective	0	6	0	R. C. Young
5·09	Radiochemistry	5·061, 5·12	G(A)	1	Elective	3	—	3	Coryell, Irvine
5·091T	Radiochemistry Lab.	5·061, 5·12	G(A)	1	Elective	0	3	2	Coryell, Irvine
5·10	Qualitative Analysis	5·02	2	1	V	3	8	3	S. G. Simpson
5·11	Qualitative Analysis	5·02	2	1	III, IX-A, IX-C, X, XII-A, XIV-C, XV-B, XX	3	4	3	S. G. Simpson
5·12	Quantitative Analysis	5·10 or 5·11	2	2	III, VII, IX-A, X, XIV-C, XV-B, XX	3	4	3	S. G. Simpson
			3	2	IX-C				
5·13	Quantitative Analysis	5·10	2	2	V	4	8	4	S. G. Simpson
5·15	Instrumental Analysis	5·42; 5·62 or 5·63	4	2	Elective	2	4	2	Hume, Rogers
5·161	Elec. Meth. in Inst. Anal.	—	G	S	Elective	No credit			Hume, Rogers
5·162	Opt. Meth. in Inst. Anal.	—	G	S	Elective	No credit			Hume, Rogers
5·163	Infrared Spec., Tech.	—	G	S	Elective	No credit			Lord
5·164	Infrared Spec., App.	—	G	S	Elective	No credit			Lord
5·192	Analytical Chem. I, Adv.	5·13	G(A)	1	Elective	2	—	4	Rogers
5·193	Analytical Chem. II, Adv.	5·13	G(A)	2	Elective	2	—	4	S. G. Simpson
5·194‡	Analytical Chem. III, Adv.	5·13	G(A)	1	Elective	2	—	4	Hume
5·41	Organic Chemistry I	5·12 or 5·13; 8·04 or 8·042	2	1	VII	4	—	4	Sheehan
			3	S	XX				
			3	1	V, X, XV-B, XX-B				
			4	1	XIV-C(not 52–53)				
5·412	Organic Preparations I	*5·41*	3	S	XX	0	10	0	Ashdown
5·414	Organic Preparations I	5·13, *5·41*	3	1	V	0	9	0	Buchi
5·416	Organic Preparations I	5·12, *5·41*	3	1	VII, X, XV-B, XX-B	0	6	0	Ashdown
5·417	Quant. Org. Anal.	5·41	4	1, 2	Elective	0	4	0	Nagy
5·42	Organic Chemistry II	5·41	3	2	V, X, XV-B, XX-B	4	—	4	Buchi
			4	2	VII-B				
5·424	Org. Prep. II & Anal.	5·414	3	2	V	0	9	0	Buchi
			4	2	VII-B				
5·426	Qual. Org. Anal.	5·416	3	2	X, XX-B	0	6	0	Ashdown
5·43	Organic Chemistry III	5·42	4	1	V	2	—	4	Swain
5·44	Organic Chemistry IV	5·43	4	2	V	2	—	4	Sheehan
5·51‡	Organic Chem.: Synth., Adv.	5·44	G(A)	1	Elective	2	—	4	Cope
5·52	Organic Chem.: Mech., Adv.	5·44	G(A)	2	Elective	2	—	4	Morton
5·54	Phys. Org. Chem., Adv.	5·43	G(A)	2	Elective	2	—	4	Swain
5·55	Org. Chem.: Natural Prod.	5·44	G(A)	1	Elective	2	—	4	Buchi
5·60	Physical Chemistry	5·02, 8·02, *M21*	2	1	VIII, XII-B	3	—	6	Beattie
			3	1	XII-A				
5·61	Physical Chem. I	5·12, 8·03, M21	3	1	III, VII, IX-A, X, XIV-C, XV-B, XX, XX-B	4	—	4	Millard
5·611	Physical Chem. Lab. I	*5·61*	3	1	VII, XX	0	4	2	Shoemaker
5·612	Physical Chem. Lab. I	*5·61*	3	1	X, XX-B	0	2	0	Shoemaker
5·62	Physical Chem. II	5·61	3	2	III, VII, IX-A, X, XIV-C, XV-B, XX, XX-B	4	—	4	Millard
5·621	Physical Chem. Lab. II	5·611, *5·62*	3	2	VII, XX	0	4	2	Shoemaker
5·622	Physical Chem. Lab. II	5·612, *5·62*	3	2	X, XX-B	0	2	0	Shoemaker
5·63	Physical Chemistry I	5·13, 8·04, M22	3	1	V	4	—	6	Stockmayer
5·631	Physical Chem. Lab. I	*5·63*	3	1	V	0	6	2	Shoemaker
5·64	Physical Chemistry II	5·63	3	2	V	4	—	6	Stockmayer
5·641	Physical Chem. Lab. II	5·631, *5·64*	3	2	V	0	6	2	Shoemaker
5·66	Surface & Colloid Chem.	5·62 or 5·64	4	2	Elective	2	—	4	Scatchard
5·67	Atomic & Molec. Struct., Int.	5·62 or 5·64	4	1	VII-B	2	—	4	Lord
			4	1	Elective				
5·68	Kin. of Chem. Reactions	5·62 or 5·64	4	2	Elective	2	—	4	Amdur
5·71	Chem. Thermodynamics I	5·62 or 5·64	G(A)	1	Elective	2	—	4	Beattie
5·72	Chem. Thermodynamics II	5·71; *M351* or *M36*	G(A)	2	Elective	3	—	6	Beattie
5·73	Chem. Thermodynamics III	5·72	G(A)	1	Elective	3	—	6	Scatchard
5·74	Statistical Mechanics	5·67 or 5·75; 5·71; M351 or M36	G(A)	2	Elective	3	—	6	Stockmayer

‡ Not offered 1952–53.

Chemistry Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
5·75	Atomic Struct. & Atomic Spectra, Int.	5·62 or 5·64; 8·04	G(A)	1	Elective	2	—	4	L. Harris
5·76	Molecular Spectra	5·75	G(A)	2	Elective	2	—	4	L. Harris
5·77	Kinetic Th. of Gases	5·71	G(A)	1	Elective	2	—	4	Amdur
5·78	Spec. of Polyatomic Molec.	5·67 or 5·75	G(A)	2	Elective	2	—	4	Lord
5·79‡	Physical Chem. of High Polymers	5·42; 5·64 or 5·71; 5·68	G(A)	1	Elective	2	—	4	Stockmayer
5·90	Spec. Prob. in Chem.	—	G(A)	1, 2	Elective		★		Amdur
5·912	Inorg. Chem. Seminar	5·062	G(A)	2	Elective	1	—	2	Schumb
5·913	Organic Chem. Seminar	5·44	G(A)	1	Elective	1	—	2	Cope
5·914	Organic Chem. Seminar	5·913	G(A)	2	Elective	1	—	2	Cope
5·915	Anal. Chem. Seminar	5·13	G(A)	1	Elective	1	—	2	Rogers
5·916	Anal. Chem. Seminar	5·13	G(A)	2	Elective	1	—	2	Rogers
5·931	Physical Chem. Seminar	*5·71*	G(A)	1	Elective	1	—	2	Scatchard
5·932	Physical Chem. Seminar	5·931	G(A)	2	Elective	1	—	2	Scatchard
5·941	Res. Conf. Inorg. Chem.	5·062	G(A)	1	Elective	1	—	2	Schumb
5·942	Res. Conf. Inorg. Chem.	5·941	G(A)	2	Elective	1	—	2	Schumb
5·951	Res. Conf. Anal. Chem.	5·13	G(A)	1	Elective	1	—	2	Rogers
5·952	Res. Conf. Anal. Chem.	5·13	G(A)	2	Elective	1	—	2	Rogers
	Research	—	G(A)	1, 2	Elective		★		Amdur
	Analytical Chemistry								Hume
	Inorganic and Nuclear Chemistry								Schumb
	Organic Chemistry								Cope
	Physical Chemistry								Scatchard

ELECTRICAL ENGINEERING — 6·00–6·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6·00T	Circuit Theory, Elem.	*8·03*	2	1	VI	4	3	5	Guillemin, Scott
			3	1	XII-B				
6·002	Trans. Response of Simple Cir.	8·03, *M22*	2	2	—	2	—	4	Guillemin
6·003	Elec. Eng., Prin.	—	3	1	—	3	—	6	Frazier
6·01	Elec. Eng., Prin. (Mag. Cir. & Trans.)	6·00 or 6·18	3	S	VI-A	3	—	6	Kingsley
			3	1	VI, XIV-B				
6·01T	Circuit Theory, Elem.	6·00T	2	2	VI	4	3	5	Guillemin, Scott
			3	2	XII-B				
6·02	Elec. Eng., Prin. (Electronic Circuits)	6·00	3	1	VI-A, VIII	4	—	5	Mason
			3	2	VI, XIV-B				
			4	2	XII-B				
6·031	Elec. Eng., Prin. (Electric Machinery)	6·01	3	2	VI, VI-A(A), XIV-B	2	1	6	Fitzgerald, Kusko
			4	S	VI-A(B)				
6·032	Elec. Eng., Prin. (Electric Machinery)	6·031	4	S	VI-A(A)	3	—	6	Kingsley
			4	1	VI, VI-A(B), XIV-B				
6·04	Elec. Eng., Prin. (Power Trans. & Dist.)	*6·032*	4	1	$VI-A(A)_1$	3	—	6	Fitzgerald
			4	2	VI_1, $VI-A(B)_1$				
6·10	Elec. Circuit Theory, Elem.	8·03, *M22*	2	2	VIII	4	—	8	Guillemin
6·16	Electricity	8·032	4	1	IV-A	3	—	6	Eager
6·17	Illumination	8·03	4	2	IV-A	2	—	4	Moon
6·18	Elec. Eng., Fund.	8·04 or 8·042	2	2	XIV-B	3	1	6	Fitzgerald, Kusko
			3	1	II, II-B(B), III, IX-C, XVI(b) (not 52–53)				
			3	2	I, II-B(A), XIII, XIII-C, XIV-C, XVI(52–53), XVI(a)(not 52–53), XVI-B(A)(52–53)				
			4	S	XVI-B(not 52–53)				
			4	1	X, X-B, XIII(52–53), XIII-C(52–53), XIV-A, XV-A(not 52–53), XVI(52–53), XVI-B(52–53), XVII(not 52–53), XX-B				
6·181	Electrical Eng.	—	G	1	XIII-A	3	1	6	Fitzgerald

Not offered 1952–53.

★ Time specially arranged.

Electrical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6·19	Industrial Electronics	6·18 or 6·40	3	2	XVI (b) (not 52–53)	3	1	6	Fitzgerald, Kusko
			4	2	XV-A (not 52–53)				
			4	2	Elective				
6·191	Electrical Eng.	6·181	G	2	XIII-A	3	1	6	Fitzgerald
6·20	Electronic Cont. & Meas.	6·02	3	2	VI-A(A)$_4$	3	—	6	Gray
			4	S	VI-A(B)$_4$				
			4	1	VI$_4$				
6·202	Electronic Cont. & Meas.	6·20	4	2	Elective	3	—	6	Gray
6·213	Ind. Feedback Control Systems	6·01 or 6·18 or 6·40; M22	4	2	Elective	3	—	6	Campbell
6·221	Elec. Power Syst.	*6·032*	4	1	Elective	3	—	6	Balsbaugh
6·222	Elec. Power Syst.	——	4	2	Elective	3	—	6	Balsbaugh
6·223	Elec. Equip. App. Eng.	6·031	4	1	Elective	3	—	6	Powel
6·224	Elec. Equip. App. Eng.	6·031	4	2	Elective	3	—	6	Powel
6·23	Electrical Implementation	6·02	4	1	VI-A(A)$_4$	3	—	6	Frazier
			4	2	VI$_4$, VI-A(B)$_4$				
6·241	Case Studies in Elec. Eng. Prac.	6·031	4	1 or 2	Elective	3	—	6	C. E. Tucker
6·26‡	Insulators & Semi-Conductors	8·04 or 8·041	4	1	Elective	3	—	6	von Hippel
6·271	Illum. Eng., Prin.	8·04 or 8·041	4	1	Elective	3	—	6	Moon
6·272	Illum. Eng., Prin.	6·271	4	2	Elective	3	—	6	Moon
6·281	Wire Com., Prin.	6·02	4	1	Elective	3	—	6	C. E. Tucker
6·291	Radar, Prin.	*6·20* or *6·311*	4	1	Elective	3	—	6	Reintjes
6·292	Radar, Prin.	6·291	4	2	Elective	3	—	6	Reintjes
6·30	Com. Network Th.	6·00, M31	3	2	VI(3), VI-A(A)$_3$	3	—	6	Guillemin
			4	S	VI-A(B)$_3$				
			4	2	XII-B				
6·311	Elec. Com., Prin.	6·02	4	1	VI$_3$, VI-A(A)$_3$	3	—	6	Radford
			4	2	VI-A(B)$_3$				
6·312	Elec. Com., Prin.	6·20 or 6·311	4	2	Elective	3	—	6	Arguimbau
6·321	Elec. Com., Prin.	8·04 or 8·041; M31 or M351	3	2	VI-A(A)$_3$	3	—	6	J. E. Thomas
			4	S	VI-A(B)$_3$				
			4	1	VI$_3$				
6·322	Elec. Com., Prin.	6·321	4	1	VI-A(A)$_3$	3	—	6	Chu
			4	2	VI$_3$, VI-A(B)$_3$				
6·331	Elec. Com. Lab.	6·02, *6·311*	4	1	VI$_3$	0	3	3	Radford
6·332	Elec. Com. Lab.	6·331	4	1	VI-A(A)$_3$	0	4	5	Radford
			4	2	VI$_3$, VI-A(B)$_3$				
6·34	Elec. Com. Lab.	——	4	1 or 2	Elective		★		Radford
6·35	Engineering Acoustics	6·00, M31	4	1	Elective	3	—	6	Beranek
6·351	Engineering Acoustics	6·191, M22	G	1	——	2	2	5	Beranek, Bolt
6·37	Television, Prin.	6·20 or 6·311	4	2	Elective	3	—	6	Arguimbau
6·40	Elec. Eng., Elem.	*8·04*	3	1	IX-B	4	—	6	Hudson
			3	2	XV-B				
6·511	Elec. Power Circuits	6·04	G(A)	1	Elective	3	—	6	Wildes
6·512	Elec. Power Circuits	6·032	G(A)	2	Elective	3	—	6	Boehne
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	6·032	G(A)	2	Elective	3	2	6	Fitzgerald
6·525	Steady-State Th. of Metadyne	6·031	G(A)	1	Elective	3	2	6	Pestarini
6·526	Metadyne Dynamics	6·032, 6·525	G(A)	2	Elective	2	1	6	Pestarini
6·535	Dig. Comp. Coding & Logic, Int.	M22	G(A)	1	Elective	3	—	6	C. W. Adams
6·536	Machine Computation	M22	G(A)	2	Elective	3	—	6	Scott
6·537	Digital Comp. App. Prac.	6·535; 6·531 or M351	G(A)	2	Elective	3	1	5	C. W. Adams
6·538	Electronic Comp. Lab.	6·02, 6·76	G(A)	2	Elective	1	3	5	Verzuh
6·54	Pulsed-Data Systems	6·56 or 6·581	G(A)	2	Elective	3	—	6	W. K. Linvill
6·56	Math. Meth. in Elec. Eng.	M31 or M36	G(A)	1	Elective	3	—	6	Guillemin
6·561	Network Theory, Adv.	6·00, M31	G(A)	1 or 2	Elective	3	—	6	Guillemin
6·562	Network Theory, Adv.	6·56, 6·561	G(A)	2	Elective	3	—	6	Guillemin
6·567T	Switching Circuits	6·00 or 6·18; M22	G(A)	1	Elective	3	1	6	S. H. Caldwell
6·568	Switching Circuits	6·567T	G(A)	2	Elective	3	1	6	S. H. Caldwell
6·571	Statistical Th. of Com.	6·561 or 6·581	G(A)	1	Elective	3	—	6	Lee
6·573	Statistical Th. of Noise & Modulation	6·30, 6·311	G(A)	1	Elective	3	—	6	Wiesner
6·574	Statistical Th. of Inform.	6·571 or 6·573	G(A)	2	Elective	3	—	6	Fano
6·581	Trans. in Linear Systems	6·00; 2·07 or 8·13; M31	G(A)	1 or 2	Elective	3	—	6	Gardner
6·582	Trans. in Linear Systems	6·581	G(A)	2	Elective	3	—	6	Gardner

‡ Not offered 1952–53.

★ Time specially arranged.

Electrical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6·585	Int. Equa. in Elec. Eng., App.	M22	G(A)	1	Elective	3	—	6	Moon
6·586	Eng. App. of Field Theory	M22	G(A)	2	Elective	3	—	6	Moon
6·587	Two-dimensional Fields in Elec. Eng.	M31	G(A)	1	Elective	3	—	6	Moon
6·59	Communications Lab.	6·332	G(A)	1 or 2	Elective		★		Radford
6·605	Servomechanisms	6·032 or 6·213; M22	G(A)	1 or 2	Elective	3	—	6	Campbell
6·606	Servomechanisms	6·605	G(A)	2	Elective	3	3	6	Campbell
6·607	Servomechanisms Lab.	6·605	G(A)	2	Elective	0	12	0	Campbell
6·608	Servomechanisms	6·605	G(A)	2	Elective	3	—	6	Campbell
6·61	Atomic Particles & Rad.	8·031 or 8·041	G(A)	1	Elective	3	—	6	Trump
6·621	Microwave Circuits	6·322	G(A)	1	Elective	3	—	6	Adler
6·622	Antennas	6·621	G(A)	2	Elective	3	—	6	Chu
6·623	Pulse Circuits, Prin.	6·311, 6·331; or 6·20, 6·83	G(A)	1 or 2	Elective	3	—	6	Zimmermann
6·626	Freq. Modulation, Prin.	6·311	G(A)	1	Elective	3	—	6	Arguimbau
6·631	Gas. Electronics, Prin. & App.	8·071, 8·08	G(A)	1	Elective	3	—	6	J. E. Thomas
6·632	Electronics in Inst., Control, & Energy Util.	6·02	G(A)	2	Elective	3	—	6	Gray
6·633	Electronic-Circuit Theory	6·02	G(A)	1 or 2	Elective	3	—	6	Scott
6·64	Dielectric Phen. and Mat.	8·04 or 8·041	G(A)	2	Elective	3	—	6	von Hippel
6·651	Elec. Power Syst.	6·04	G(A)	1	Elective	3	—	6	Balsbaugh
6·652	Elec. Power Syst.	6·04	G(A)	2	Elective	3	—	6	Balsbaugh
6·68	Spec. Prob. in Elec. Eng.	—	G(A)	1 or 2	Elective		★		Gardner
6·691	Acoustics, Advanced	8·13	G(A)	1	Elective	3	—	6	Beranek
6·692	Acoustics, Advanced	6·35 or 8·13	G(A)	2	Elective	3	—	6	Beranek, Bolt
6·694‡	Electro-Acoustic Devices	8·13 or M31	G(A)	2	Elective	2	2	6	Fay
6·695	Spec. Prob. in Acoustics	—	G(A)	1 or 2	Elective		★		Beranek
6·73	Elec. Meas. Lab., Adv.	6·02, 6·76	G(A)	1 or 2	Elective		★		Jones
6·74	Elec. Mach. Lab., Adv.	6·04, 6·79	G(A)	1 or 2	Elective		★		Kusko
6·75	Elec. Meas. Lab.	*6·01*, 6·05	3	S	VI-A(A)	1	3	5	Jones
			3	1	VI, VI-A(B), XIV-B				
			4	1	XII-B				
6·756	Elec. Meas. Lab.	—	3	1 or 2	—		★		Jones
6·76	Eng. Electronics Lab.	*6·02*, 6·75	3	1	VI-A(B)	1	2	3	Jones
			3	2	VI, VI-A(A), XIV-B				
			4	2	XII-B				
6·78	Elec. Mach. Lab.	6·031	4	1	VI_1, $VI\text{-}A(A)_1$	1	3	4	Kusko
			4	2	$VI\text{-}A(B)_1$				
6·781	Elec. Macn. Lab.	6·031	4	1	$VI\text{-}A(A)_{3,4}$	1	2	3	Kusko
			4	2	$VI_{3,4}$, $VI\text{-}A(B)_{3,4}$				
6·79	Elec. Mach. Lab.	*6·04*, 6·78	4	1	$VI\text{-}A(A)_1$	1	2	3	Kusko
			4	2	VI_1, $VI\text{-}A(B)_1$				
6·80	Elec. Meas. Lab.	6·76	4	1 or 2	Elective		★		Jones
6·82	Elec. Meas. Lab.	6·00, *6·02*	3	1	VIII	0	3	3	Jones
6·83	Electronic Eng. Lab.	6·76	4	1	VI_4, $VI\text{-}A(A)_4$	1	2	3	Jones
			4	2	$VI\text{-}A(B)_4$				
6·84	Elec. Implement. Lab.	6·76	4	1	$VI\text{-}A(A)_4$	1	3	5	Jones
			4	2	VI_4, $VI\text{-}A(B)_4$				
6·85	Elec. Eng. Lab.	6·18 or 6·40	4	2	Elective	0	2	3	Kusko
6·86	Elec. Mach. Lab.	6·01 or 6·18 or 6·40	4	1 or 2	Elective		★		Kusko
6·89	Elec. Eng. Lab.	6·40	3 or 4	1 or 2	Elective	0	2	2	Kusko
6·901	Gen. Elec. Ind. Prac.	—	3	S	VI-A(B)	40 h.p.w.			Boehne
			3	1	VI-A(A)				
6·902	Gen. Elec. Ind. Prac.	—	3	2	VI-A(B)	40 h.p.w.			Boehne
			4	S	VI-A(A)				
6·903	Gen. Elec. Ind. Prac.	—	4	1	VI-A(B)	40 h.p.w.			Boehne
			4	2	VI-A(A)				
6·904	Gen. Elec. Ind. Prac.	—	G	S	VI-A(B)	40 h.p.w.			Boehne
			G	1	VI-A(A)				
6·911	Boston Edison Pub. Util. Prac.	—	3	S	VI-A(B)	40 h.p.w.			Boehne
			3	1	VI-A(A)				
6·912	Boston Edison Pub. Util. Prac.	—	3	2	VI-A(B)	40 h.p.w.			Boehne
			4	S	VI-A(A)				
6·913	Boston Edison Pub. Util. Prac.	—	4	1	VI-A(B)	40 h.p.w.			Boehne
			4	2	VI-A(A)				
6·914	Boston Edison Pub. Util. Prac.	—	G	S	VI-A(B)	40 h.p.w.			Boehne
			G	1	VI-A(A)				

‡ Not offered 1952–53.

★ Time specially arranged.

Electrical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6·941	Bell Telephone Lab.	——	3	S	VI-A(B)	40 h.p.w.			Boehne
			3	1	VI-A(A)				
6·942	Bell Telephone Lab.	——	3	2	VI-A(B)	40 h.p.w.			Boehne
			4	S	VI-A(A)				
6·943	Bell Telephone Lab.	——	4	1	VI-A(B)	40 h.p.w.			Boehne
			4	2	VI-A(A)				
6·944	Bell Telephone Lab.	——	G	S	VI-A(B)	40 h.p.w.			Boehne
			G	1	VI-A(A)				
6·951	General Radio Ind. Prac.	——	3	S	VI-A(B)	40 h.p.w.			Boehne
			3	1	VI-A(A)				
6·952	General Radio Ind. Prac.	——	3	2	VI-A(B)	40 h.p.w.			Boehne
			4	S	VI-A(A)				
6·953	General Radio Ind. Prac.	——	4	1	VI-A(B)	40 h.p.w.			Boehne
			4	2	VI-A(A)				
6·954	General Radio Ind. Prac.	——	G	S	VI-A(B)	40 h.p.w.			Boehne
			G	1	VI-A(A)				
6·961	Philco Corp. Ind. Prac.	——	3	S	VI-A(B)	40 h.p.w.			Boehne
			3	1	VI-A(A)				
6·962	Philco Corp. Ind. Prac.	——	3	2	VI-A(B)	40 h.p.w.			Boehne
			4	S	VI-A(A)				
6·963	Philco Corp. Ind. Prac.	——	4	1	VI-A(B)	40 h.p.w.			Boehne
			4	2	VI-A(A)				
6·964	Philco Corp. Ind. Prac.	——	G	S	VI-A(B)	40 h.p.w.			Boehne
			G	1	VI-A(A)				
6·971	Am. Gas & Elec. Serv. Corp. Prac.	——	3	S	VI-A(B)	40 h.p.w.			Boehne
			3	1	VI-A(A)				
6·972	Am. Gas & Elec. Serv. Corp. Prac.	——	3	2	VI-A(B)	40 h.p.w.			Boehne
			4	S	VI-A(A)				
6·973	Am. Gas & Elec. Serv. Corp. Prac.	——	4	1	VI-A(B)	40 h.p.w.			Boehne
			4	2	VI-A(A)				
6·974	Am. Gas & Elec. Serv. Corp. Prac.	——	G	S	VI-A(B)	40 h.p.w.			Boehne
			G	1	VI-A(A)				
6·981	Naval Ordnance Laboratory	——	3	S	VI-A(B)	40 h.p.w.			Boehne
			3	1	VI-A(A)				
6·982	Naval Ordnance Laboratory	——	3	2	VI-A(B)	40 h.p.w.			Boehne
			4	S	VI-A(A)				
6·983	Naval Ordnance Laboratory	——	4	1	VI-A(B)	40 h.p.w.			Boehne
			4	2	VI-A(A)				
6·984	Naval Ordnance Laboratory	——	G	S	VI-A(B)	40 h.p.w.			Boehne
			G	1	VI-A(A)				
6·991	Airforce Cambridge Res. Lab.	——	3	S	VI-A(B)	40 h.p.w.			Boehne
			3	1	VI-A(A)				
6·992	Airforce Cambridge Res. Lab.	——	3	2	VI-A(B)	40 h.p.w.			Boehne
			4	S	VI-A(A)				
6·993	Airforce Cambridge Res. Lab.	——	4	1	VI-A(B)	40 h.p.w.			Boehne
			4	2	VI-A(A)				
6·994	Airforce Cambridge Res. Lab.	——	G	S	VI-A(B)	40 h.p.w.			Boehne
			G	1	VI-A(A)				

BIOLOGY — 7·00–7·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
7·01	General Biology I	——	2	1	VII, IX-C, XX	3	3	4	Sanborn
7·02	General Biology II	7·01	2	2	VII, IX-C, XX	3	3	4	Sanborn
7·03	Genetics	7·02	4	2	Elective	2	—	4	Blake
7·10	Genetic Cytology	7·02	3	1	VII, IX-C	2	4	4	Bryan
7·11	Embryology	7·02	3	2	VII, IX-C	2	6	4	Bryan
7·14	Comparative Anatomy	7·02	3	1	Elective	2	6	4	Blake
7·19	General Physiology I	5·62, 7·80	4	1	VII, VII-A, VII-B	2	—	4	Waugh
7·20	General Physiology II	7·19	4	2	VII, VII-A, VII-B	2	—	4	Schmitt
7·211	Gen. Physiol. Lab. I	*7·19*	4	1	VII, VII-A, VII-B	0	4	0	Waugh
7·212	Gen. Physiol. Lab. II	7·211	4	2	VII, VII-A, VII-B	0	4	0	Sizer
7·31	Biology Seminar	7·20	G(A)	1	VII, VII-A, VII-B	1	—	2	Sizer

Biology Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
7·32	Biology Seminar	7·20	G(A)	2	VII, VII-A, VII-B	1	—	2	Sizer
7·50	Physical Chem. of Proteins	7·19	G(A)	2	VII-B	2	—	4	Waugh
7·51	Physical Chem. of Proteins Lab.	*7·50*	G(A)	2	VII-B	0	4	0	Waugh
7·80	Biochemistry	5·41	3	1	VII	2	6	4	Gould
			4	1	XX, XX-A, XX-B				
7·81	Enzymology	*7·19*	G(A)	1	VII-B, XX-A	2	—	4	Sizer
7·811	Enzymology Lab.	*7·81*	G(A)	1	VII-B	0	4	2	Sizer
7·82	Biochemistry, Adv.	*7·20*, 7·80	G(A)	2	VII-B	2	4	4	Gould
7·831	Biochem. of Microorganisms	7·80	4	1	VII-B	3	4	4	Gould
7·832	Biochem. of Microorganisms	7·831	G(A)	2	Elective	0	6	0	Gould
7·85	Biophysics I	*7·19*, 8·04	4	1	VII-A	2	2	4	Bear
7·86	Biophysics II	8·04	G(A)	2	VII-A	2	—	4	Maxfield
7·882	Biophysics Lab.	8·04	G(A)	2	VII-A	0	4	0	Maxfield
7·90	Sem. in Enzymology	7·81	G(A)	2	Elective	2	—	4	Sizer
7·91	Instrument. in Biol. I	*7·19*	G(A)	1	VII-A	3	4	6	Lion
7·92	Instrument. in Biol. II	7·91	G(A)	2	Elective	0	4	0	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
7·95	Electron Microscopy	7·85 or 8·04	G(A)	2	Elective	3	—	6	C. E. Hall
7·96	Electron Microscopy Lab.	7·95	G(A)	2	Elective	0	2	1	C. E. Hall
7·97	Tissue Ultrastructure	7·20	G(A)	1	Elective	2	—	4	Schmitt
7·98	Tissue Ultrastructure	7·97	G(A)	2	Elective	2	—	4	Schmitt

PHYSICS — 8·00–8·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
8·00	Physics, Entrance	—	—	S	—	2	—	5	—
8·001	Physics	—	—	1	—	3	—	6	—
8·002	Science Teachers Program	—	G	S	Elective	4	—	4	Sears
8·01	Physics (Mechanics)	—	1	1	All courses	4	2	5	Mueller
8·012	Physics (College Transfer)	M11	1	1	—	4	—	4	—
8·02	Physics (Mech. and Waves)	8·01	1	2	All courses	4	2	5	Mueller
8·03	Physics (Electromagnetism)	8·02, M12	2	1	All courses except IV-A, IV-B, VI, VIII, XV-A, XV-B, XVIII	4	1	5	Bitter, S. C. Brown
			G	S	XIII-A				
8·031	Physics (Electromagnetism)	8·01, M12	2	1	VI, VIII, XVIII	4	1	5	R. W. Williams
8·032	Physics (Electromagnetism)	8·01, M12	2	1	IV-A, IV-B, XV-A, XV-B	4	1	5	Bitter
8·034	Physics (College Transfer)	M11	2	2	—	4	—	4	—
8·04	Physics (Modern Physics)	8·02	2	2	All courses except IV-A, IV-B, VI, VIII, XV-A, XV-B, XVIII	4	1	5	Bitter, S. C. Brown
8·041	Physics (Electromag. & Electromag. Th. of Light)	8·031	2	2	VI, VIII, XVIII	4	1	5	R. W. Williams
8·042	Physics (Modern Physics)	8·032	2	2	IV-B, XV-A, XV-B	4	1	5	Bitter
8·05	Atomic Physics	8·04	3	1	VIII	4	—	6	Friedman
			4	1	II(9), II-B(9), VII-A				
8·06	Nuclear Physics	8·05	4	2	II(9), II-B(9), VII-A	4	—	6	M. Deutsch
8·07	Thermo. & Statist. Mech.	8·04 or 8·041	3	1	IX-A, XIX	4	—	5	Herlin
			4	1	VIII, XII-B				
8·071	Thermo. & Statist. Mech.	8·04 or 8·041	3	S	VI-A(A)$_{3,4}$	4	—	5	Sears
			3	1	VI(3,4), VI-A(B)$_{3,4}$, IX-C				
8·08	Electronics	8·041	3	2	VI(3,4), VI-A(A)$_{3,4}$, VIII, IX-A	4	—	5	Harvey
			4	S	VI-A(B)$_{3,4}$				
8·09	Experimental Physics, Tech.	8·04 or 8·041	3	1	VIII	0	3	3	Strandberg
			4	2	VII-A				
8·101	Atomic Structure Lab.	8·05	3	2	VIII	0	3	3	Frisch
8·102	Electronic Devices Lab.	6·82	3	2	VIII	0	3	3	Kraushaar
8·11	Experimental Physics	8·101, 8·102	4	1	VIII	2	6	4	Ingard
8·13	Vibration and Sound	8·04, M22	4	2	Elective	3	—	6	Ingard
8·131	Experimental Acoustics	*8·13*	4	2	Elective	0	3	4	Bolt
8·132	Architectural Acoustics	8·02	4	1	IV-A	3	2	3	Bolt

★ Time specially arranged.

Physics Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
8·135	Spec. Problems in Acoustics	8·13	G(A)	1 or 2	Elective		★		Bolt
8·15	Photography	8·04	3	2	Elective	2	—	1	Hardy
8·16	Optics	8·041	3	2	Elective	3	—	6	Hardy
8·17	Color Measurements	8·04	4	2	Elective	0	3	2	Hardy
8·18	Spec. Problems in Optics	8·16	G(A)	1 or 2	Elective		★		Hardy
8·21	Physical Electronics	8·08	G(A)	1	Elective	3	—	6	Nottingham
8·212	Physical Electronics Lab.	8·21	G(A)	2	Elective	2	3	3	Nottingham
8·231	Elec. Discharges in Gases	8·05, 8·07	G(A)	1	Elective	3	—	6	Allis
8·232	Elec. Discharges in Gases, Th.	8·231, *8·72*	G(A)	2	Elective	3	—	6	Allis
8·25	Spec. Prob. in Electronics	8·08, *8·21*	G(A)	1 or 2	Elective		★		Nottingham
8·27	X-rays & Crystal Physics	8·041, M22	4	1	Elective	3	1	6	Warren
8·28	X-ray Diffraction	8·27	G(A)	2	Elective	3	—	6	Warren
8·30	Spec. Prob. in Crystal Phys.	8·27	G(A)	1 or 2	Elective		★		Warren
8·32	Line Spectra	8·05	G(A)	2	Elective	3	—	6	Harrison
8·34	Spec. Prob. in Spectroscopy	8·32	G(A)	1 or 2	Elective		★		Harrison
8·361	Quantum Th. of Matter I	3·51 or 5·67 or 5·75 or 8·05	G(A)	1	Elective	3	—	6	Slater
8·362T	Quantum Th. of Matter II	8·361	G(A)	2	Elective	3	—	6	Slater
8·363	Select. Topics in Th. of Solids I	8·362T	G(A)	1	Elective	2	—	4	Slater
8·364	Select. Topics in Th. of Solids II	8·363	G(A)	2	Elective	2	—	4	Slater
8·38T	Sp. Prob. in Magnetism	8·05, 8·07	G(A)	1 or 2	Elective		★		Bitter
8·411‡	Statistical Thermodyn. I	*8·731*	G(A)	1	Elective	3	—	9	Tisza
8·412‡	Statistical Thermodyn. II	8·411	G(A)	2	Elective	3	—	9	Tisza
8·42	Low Temperature Physics	8·07	G(A)	2	Elective	3	—	6	Herlin
8·43	Microwave Physics	8·72	G(A)	1	Elective	3	2	6	Strandberg
8·45	Sp. Prob. in Solid State Phys.	8·362 or 8·412	G(A)	1 or 2	Elective		★		Tisza
8·511	Nuclear Physics I	8·06, *8·71*	G(A)	1	Elective	3	—	6	R. D. Evans
8·512	Nuclear Physics II	8·511	G(A)	2	Elective	3	—	6	R. D. Evans
8·513	Nuclear Physics Lab.	8·511	G(A)	2	Elective	1	3	3	M. Deutsch
8·52	Applied Nuclear Physics, Adv.	8·512	G(A)	2	Elective	3	—	6	R. D. Evans
8·541	Adv. Topics in Nuclear Phys. I	8·06	G(A)	1	Elective	2	—	4	Frisch
8·55	Nuclear Structure, Theory	8·732	G(A)	1	Elective	3	—	9	Feshbach
8·56	Cosmic Rays & High Energy Phenomena	8·71, 8·72	G(A)	2	Elective	3	—	6	Rossi
8·57	Neutron Physics	8·06	G(A)	1	Elective	3	—	6	Goodman
8·60	Sp. Problems in Nuclear Phys.	8·511	G(A)	1 or 2	Elective		★		R. D. Evans
8·71	Int. to Th. Physics I (Mechanics)	M352 or M37	G(A) except 4	VIII 1	Elective VIII	4	—	8	Weisskopf
8·72	Int. to Th. Physics II (Electromagnetic Theory)	M352 or M37	G(A) except 4	VIII 2	Elective VIII	4	—	8	Friedman
8·731	Int. to Quantum Th. I	8·71, 8·72	G(A)	1	Elective	3	—	9	Villars
8·732	Int. to Quantum Th. II	8·731	G(A)	2	Elective	3	—	9	Villars
8·791	Methods of Theoret. Phys. I	8·71, 8·72	G(A)	1	Elective	3	—	9	Morse
8·792	Methods of Theoret. Phys. II	8·791	G(A)	2	Elective	3	—	9	Morse
8·80‡	Advanced Mechanics	8·71, 8·72	G(A)	2	Elective	3	—	9	Harvey
8·86‡	Adv. Quantum Mechanics	8·732	G(A)	2	Elective	3	—	9	Feshbach
8·90	Sp. Prob. in Theoret. Phys.	8·791	G(A)	1 or 2	Elective		★		Frank

CHEMICAL ENGINEERING — 10·00–10·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
10·11	Chemical Eng.	5·02	2	1	X	1	—	1	Gilliland
10·15	Thesis Reports	——	4	1	X	0	3	0	Addoms
10·17	Industrial Chemistry	*5·41, 5·61*	3	1	X, XIV-C, XX-B	3	—	4	Addoms
10·18	Industrial Chemistry	*5·62*, 10·17	3	2	X, XIV-C	3	—	6	Satterfield
			4	1	X (52–53), X-B(52–53), XIV-C(52–53), XV-B(52–53)				
10·21	Industrial Chemistry	10·18	4	2	X, XX-B	3	—	6	Weber
10·25	Industrial Chemistry	5·42, 5·62	G(A)	1, 2	Elective	5	—	7	Meissner
10·26	Industrial Chem. Lab.	10·17	4	1	X	0	10	0	Baddour
10·27	Chemical Eng. Lab.	10·17	4	1	X	0	10	0	Mason
10·272	Chemical Eng. Lab.	10·17	4	2	Elective	0	9	0	Addoms

‡ Not offered 1952–53.

★ Time specially arranged.

Chemical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
10·28	Chemical Eng.	*5·61*	3	1	X, XIV-C	4	—	6	Sherwood
			4	1	XV-B(not 52–53)				
10·29	Chemical Eng.	10·28	3	2	X	4	—	6	Weber
			4	2	XV-B(not 52–53)				
10·30	Eng. Equipment	10·32	4	2	X-B(52–53)	0	6	0	Vivian
10·30T‡	Eng. Equipment	10·32	4	2	X-B	0	9	0	Vivian
10·31	Chemical Eng.	10·17, 10·28; or 2·41, 10·17; or *3·20*	4	1	X, X-B, XIV-C, XV-B(52–53)	4	—	6	McAdams
10·311	Heat Transfer	—	G	1	XIII-A	3	—	3	McAdams
10·32	Chemical Eng.	10·29	4	1	X-B	4	—	6	Vivian
			4	2	X, XIV-C, XV-B(52–53)				
10·33	Anal. Treat. of Chem. Eng. Processes	5·62, M22	G(A)	2	Elective	3	—	6	Mickley
10·35	Hist. of Science & Tech.	—	4	1	Elective	2	—	4	Hauser
10·40	Chem. Eng. Thermodyn.	5·62, 10·29	G(A)	1, 2	Elective	4	—	8	Weber
10·41	Distillation	10·32	G(A)	2	Elective	3	—	6	Gilliland
10·45	Distil. & Absorption	10·32	G(A)	1	Elective	4	—	8	Gilliland
10·46	Absorption & Extraction	10·32	G(A)	2	Elective	3	—	6	Addoms
10·50	Heat Transmission	10·31	G(A)	2	Elective	2	—	4	McAdams
10·52	Chemical Eng. II	10·32	G(A)	1	Elective	3	—	6	Mickley
10·53	Chem. Eng. Design	10·81, 10·82, 10·83	G(A)	—	Elective	0	12	0	Vivian
10·55	Econ. Balance in Chem. Ind.	10·32	G(A)	1 or 2	Elective	3	—	6	G. C. Williams
10·62	Thermodynamics, Adv.	10·40	G(A)	2	Elective	3	—	6	Meissner
10·63	Industrial Chemistry II	10·661	G(A)	2	Elective	3	—	6	Meissner
10·65	Catal. & High Pres. Proc.	5·62, 10·29	G(A)	1 or 2	Elective	3	—	6	Satterfield
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
10·673	Colloid Chem. Lab.	10·63 or 10·661	G(A)	1, 2	Elective	0	3	3	Hauser
10·69	Plastics and Other High Polymeric Substances	5·061 or 10·21	G(A)	2	Elective	2	—	4	Hauser
10·691	Colloid Chem. of Silicon	5·061 or 10·21	G(A)	1	Elective	2	—	4	Hauser
10·70	Combustion, Prin.	—	G(A)	1	Elective	3	—	6	Hottel
10·71	Fuel Engineering	—	G(A)	2	Elective	3	—	6	G. C. Williams
10·74	Furnace Design	10·31	G(A)	1 or 2	Elective	3	—	6	Hottel
10·81	Sch. Chem. Eng Practice (Bangor Station)	10·32	G(A)	—	Elective	0	12	0	Vivian
10·82	Sch. Chem. Eng. Practice (Parlin Station)	10·32	G(A)	—	Elective	0	12	0	Vivian
10·83	Sch. Chem. Eng. Practice (Buffalo Station)	10·32	G(A)	—	Elective	0	12	0	Vivian
10·84	Sch. Chem. Eng. Practice (Bangor Station)	10·32	4	2	X-B	0	12	0	Vivian
10·85	Sch. Chem. Eng. Practice (Parlin Station)	10·32	4	2	X-B	0	12	0	Vivian
10·86	Sch. Chem. Eng. Practice (Buffalo Station)	10·32	4	2	X-B	0	12	0	Vivian
10·90	Exp. Research Problem	—	G(A)	1, 2	Elective		★		G. C. Williams
10·991	Seminar in Chem. Eng.	10·32	G(A)	1	Elective	2	—	4	Gilliland
10·992	Seminar in Chem. Eng.	10·32	G(A)	2	Elective	2	—	4	Gilliland

GEOLOGY AND GEOPHYSICS — 12·00–12·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
12·011	Mineralogy	5·02, *12·20*	2	1	XII-A, XII-B	1	2	1	Dennen
			3	1	III				
12·012	Mineralogy	12·011	2	2	XII-A, XII-B	0	4	2	Dennen
12·04	X-ray Mineralogy	12·012, 12·20	4	2	XII-A	2	2	2	Buerger
12·05	Mineralogical Seminar	12·012, 12·24	G(A)	1	Elective	2	—	4	Buerger
12·06	Mineralogical Research	—	G(A)	2	Elective		★		Buerger
12·14	Petrology	12·012, 12·301	3	2	XII-A	2	—	4	Fairbairn
12·15T	Petrography	12·231	3	2	XII-A	0	6	0	Fairbairn
12·161	Min. Deposits & Petrol. Sem.	12·14, 12·15T, 12·40	G(A)	1	Elective	2	—	4	Fairbairn, Hurley
12·162	Min. Deposits & Petrol. Sem.	12·161	G(A)	2	Elective	2	—	4	Hurley, Fairbairn
12·17	Petrology Laboratory	12·15T	G(A)	1	Elective	0	4	2	Fairbairn

‡ Not offered 1952–53.

★ Time specially arranged.

Geology and Geophysics Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
12·20	Elem. Crystallography	M12	2	1	XII-A, XII-B	2	—	2	Buerger
			3	1	III				
12·22	Geometrical Crystallog.	12·20	G(A)	1	Elective	2	—	4	Buerger
12·231	Optical Crystallog.	*12·20*	3	1	XII-A	0	6	2	Fairbairn
12·232	Optical Crystallog., Adv.	12·231	G(A)	2	Elective	0	3	1	Fairbairn
12·24	Theoretical Crystallog.	12·20	4	1	XII-A, XII-B	2	—	4	Buerger
12·27	Crystallographic Res.	12·24	G(A)	1 or 2	Elective		★		Buerger
12·301	Physical Geology	*12·011*	2	2	XII-A, XII-B	3	4	3	Dennen
			3	2	III(2)				
12·302	Historical Geology	12·301	3	1	XII-A	3	4	3	Shrock
12·303	Geological Surveying	12·301	3	S	XII-A, XII-B	0	5	0	Parks
12·304	Field Investigations & Reports	12·301	3	S	XII-A, XII-B	0	15	0	Staff
12·306	Historical Geology	12·301	3	1	XII-B	3	2	3	Shrock
12·307	Physical Geology	*12·011*	3	2	Elective	3	—	3	Dennen
12·308	Historical Geology	12·307	4	1	Elective	3	—	3	Shrock
12·321	Engineering Geology	——	2	2	I, IV-B	2	2	4	Mead
12·322	Engineering Geology	——	G	1	Elective	2	—	4	Mead
12·40	Mineral Deposits	12·012; 12·302 or 12·306	4	1	XII-A, XII-B	2	—	4	Hurley
12·41	Mineral Deposits Lab.	*12·40*	4	1	XII-A	0	4	0	Hurley
12·432	Mineral Dep. Lab., Adv.	12·41	G(A)	2	Elective	0	4	1	Hurley
12·44	Geology of Oilfields	12·302, 12·702	3	2	XII-A, XII-B	2	—	4	W. L. Whitehead
12·45	Oilfield Reservoirs	12·44	4	2	XII-A	2	—	4	W. L. Whitehead
12·461	Geology of Petroleum & Coal	12·44	G(A)	1	Elective	3	—	6	W. L. Whitehead
12·462	Geology of Petroleum, Adv.	12·461	G(A)	2	Elective	3	—	6	W. L. Whitehead
12·51	Paleontology	12·302	4	1	Elective	1	6	2	Shrock
12·52	Paleontology, Adv.	12·51	G(A)	2	Elective		★		Shrock
12·581T	Sedimentology	12·15T, 12·301	4	1	XII-A	2	2	2	Shrock
12·582	Sedimentology, Adv.	12·15T, 12·581T	G(A)	1 or 2	Elective		★		Shrock
12·583	Sedimentology Seminar	12·581T	G(A)	1	Elective	3	—	6	Shrock
12·65	Special Problems	——	4	1 or 2	Elective		★		Staff
12·66	Special Problems	——	G(A)	1 or 2	Elective		★		Staff
12·701	Structural Elements	12·301	3	S	XII-A, XII-B	0	4	0	W. L. Whitehead
12·702	Structural Geology	12·701	3	1	XII-A	2	1	4	Mead
12·721	Tectonics Seminar	12·702	G(A)	1	XII	2	—	4	W. L. Whitehead
12·722	Tectonics Seminar	12·14, 12·15T, 12·721	G(A)	2	XII	2	—	4	Fairbairn
12·73	Regional Geology	12·302, 12·702	4	1	Elective	2	—	4	W L. Whitehead
12·80	Geochemistry	5·62, 8·04, 12·14, 12·15T	4	2	XII-A	2	—	4	Ahrens
12·81	Spectrochemical Anal.	12·40	G(A)	1 or 2	Elective	2	1	3	Ahrens
12·86	Seismology, Elements	M22	4	2	Elective	2	—	4	Leith
12·87	Geophysics, Int.	12·302	3	2	XII-A, XII-B	2	—	4	Hurley
12·881	Geophysics Seminar	12·87	G(A)	1	Elective	3	—	6	Hurley, Haskell
12·882	Geophysics Seminar	12·881	G(A)	2	Elective	3	—	6	Hurley, Haskell
12·89	Isotope Geology	8·04, 12·302	G(A)	2	Elective	2	—	4	Hurley
12·91	Mining, Elements	12·40	4	1	Elective	3	—	6	Parks
12·92	Mining Methods & Practice	12·91	4	2	Elective	3	—	6	Parks
12·94	Mineral Economics	12·40	4	1	XII-A	3	—	6	Parks
12·95	Mine Valuation	12·92	G(A)	2	Elective	3	—	6	Parks
12·96	Mineral Econ. Seminar	12·94	G(A)	1 or 2	Elective		★		Parks
12·97	Mine Valuation Seminar	12·95	G(A)	1 or 2	Elective		★		Parks

NAVAL ARCHITECTURE AND MARINE ENGINEERING — 13·00–13·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
13·01	Naval Architecture I	8·01, M21	3	1	XIII, XIII-C	3	1	5	Manning
			G	2	XIII-A				
13·02	Naval Architecture II	13·01	3	2	XIII, XIII-C	3	1	5	Manning
			G	1	XIII-A				
13·022	Ship Propulsion & Maneuver.	2·251	G(R)	2	——	2	—	4	Manning
13·03	Principles of Ship Design	13·46	G(A)	1	Elective	3	—	6	Manning
13·031	Preliminary Design of Ships	13·03	G(A)	1	Elective		★		Manning
13·032	Preliminary Design of Ships	13·031	G(A)	2	Elective		★		Manning
13·04	Ship Design, Advanced	13·03	G(A)	2	Elective	2	—	10	Manning
13·05	Hydromech. of Ship Des., Adv.	13·02	G(A)	1	Elective		★		Abkowitz

★ Time specially arranged.

Naval Architecture and Marine Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
13·12	Warship General Arrangements	13·01	G(R)	2	XIII-A	2	—	4	J. A. Brown
13·13	Warship Structure, Theory I	2·046	G(RA)	1	XIII-A	3	—	6	J. H. Evans
13·14	Warship Structure, Theory II	13·13	G(RA)	2	——	3	—	6	J. H. Evans
13·15	Warship Basic Design I	13·02, 13·12	G(RA)	1	XIII-A	3	—	6	Manning
13·16	Warship Basic Design II	13·12	G(RA)	1	XIII-A	3	—	6	J. A. Brown
13·17	History of Warships	——	G(R)	1	XIII-A	3	—	4	J. A. Brown
13·20	Ship Design, Elem.	——	G	S	XIII-A	1	4	0	J. A. Brown
13·21	Warship Form Design	13·20	G(R)	2	XIII-A	0	5	0	Robertson
13·22	Warship General Design	13·01, 13·21	G(R)	2	XIII-A	0	5	0	Robertson
13·24	Warship Structure, Design I	13·13	G(RA)	2	——	0	5	0	J. H. Evans
13·241	Warship Structure, Design	13·13	G(RA)	2	——	0	2	0	J. H. Evans
13·25	Warship Structure, Design II	13·14, 13·24	G(RA)	1	——	0	5	0	J. H. Evans
13·26	Prelim. Design of Warships	13·15	G(RA)	2	XIII-A	0	9	0	J. A. Brown
13·40	Naval Arch. & Marine Eng. I	——	2	1	XIII, XIII-C	3	—	3	Powell
13·41	Ship & Eng. Drawing	13·40	2	2	XIII, XIII-C	1	3	1	Abkowitz
13·42T	Hull Form Design	13·41	3	1	XIII	0	5	0	Robertson
			4	1	XIII-C(not 52–53)				
13·43‡	Ship Structural Drawing	13·42T, 13·45	4	1	XIII	0	3	0	J. H. Evans
13·45	Ship Structures, Design	2·062, 13·40	4	1	XIII(52–53)	3	3	3	J. H. Evans
13·45T	Ship Structures	2·081, 13·40	3	2	XIII	3	—	6	J. H. Evans
13·46	Ship Design	13·02, 13·45	4	2	XIII(52–53)	1	5	1	Manning
13·46T‡	Ship Design	13·02, 13·43, 13·53	4	2	XIII	1	8	2	Manning
13·47	Ship Design	13·021	4	2	XIII-C(52–53)	2	6	2	Robertson
13·47T‡	Ship Design	13·02, 13·42T	4	2	XIII-C	1	4	0	Robertson
13·52T	Marine Engineering I	2·40, 13·40	3	2	XIII, XIII-C	3	—	3	Burtner
13·53‡	Marine Engineering II	2·251, 2·42, 6·18, 13·52	4	1	XIII	3	—	6	Burtner
13·54	Marine Eng. Dynamics	2·01, 2·04	4	1	XIII (52–53)	2	—	4	F. M. Lewis
			4	2	XIII(not 52–53)				
			G	1	XIII-A				
13·55	Marine Engineering	2·42, 13·52	4	2	XIII(52–53)	2	—	4	Burtner
13·56†	Marine Eng. Economics	6·18, 13·02, 13·52	4	1	XIII-C	3	—	6	Powell
13·61	Marine Eng. Design	2·04, 2·40, 13·52	4	1	XIII(52–53)	1	4	1	Burtner
13·61T‡	Marine Eng. Design III	13·52T	4	1	XIII	0	3	0	Burtner
13·62	Marine Eng. Design	*13·55*, 13·61	4	2	XIII(52–53)	1	6	1	Burtner
13·62T‡	Marine Eng. Design IV	13·53, 13·61T	4	2	XIII	1	4	0	Burtner
13·70	Warship Elec. Eng.	6·20, 6·605, 6·75	G(RA)	2	——	2	2	4	Hicks
13·71	Ship Propulsion I	13·54, 13·55	G(A)	1	Elective	3	—	6	Burtner, Powell
13·711T¶	Ship Machinery Design I	13·54, 13·55	G(A)	1	Elective		★		Burtner, Powell
13·72	Ship Propulsion II	13·71	G(A)	2	Elective	2	—	4	Burtner, Powell
13·721T¶	Ship Machinery Design II	13·54, 13·55	G(A)	2	Elective		★		Burtner, Powell
13·73	Mechanical Vibration	2·01, 2·04; or 2·046	G(A)	1	Elective	3	—	6	F. M. Lewis
13·74	Mechanical Vibration	13·73	G(A)	2	Elective	3	—	6	F. M. Lewis
13·75	Warship Propulsion I	2·422, 10·311	G(RA)	1	XIII-A	3	2	6	Hicks, Powell
13·76	Warship Propulsion II	13·75	G(RA)	2	XIII-A	2	4	4	Hicks, Powell
13·78	Propeller Theory	2·251, 13·02, 13·79	G(A)	2	Elective	2	—	4	F. M. Lewis
13·79	Propeller Design	13·02	G(A)	1	Elective	2	1	2	Powell
13·791	Propeller Design	13·02	G(A)	1	Elective	2	1	5	Powell
13·81†‡	Ship Operation I	13·021, 13·52, 13·84	4	1	XIII-C	3	—	6	——
13·82†‡	Ship Operation II	13·81	4	2	XIII-C	2	—	4	——
13·83‡	Ports and Port Facilities	*13·85*	3	1	XIII-C	2	—	4	——
13·84‡	Cargo Handling and Stowage	13·01, 13·83	3	2	XIII-C	2	1	4	——
13·85	Cargoes in World Trade	——	3	1	XIII-C	3	—	6	C. H. Blake
13·86‡	Steamship Management	13·81, 13·84	4	2	XIII-C	3	—	3	——

ECONOMICS AND SOCIAL SCIENCE — 14·00–14·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
14·01	Economic Principles I	H12	2	1	XIV-A, XIV-B, XIV-C	3	—	5	Bishop
			3	1	IV-B, XV-A, XV-B				
			3, 4	1, 2	Elective (but required for graduation by I, II, II-B, III, IV-A, VI, VI-A, IX-A, IX-B, IX-C, XIII, XIII-C, XVI, XVI-B, XVII, XX, XX-A, XX-B)				

† Open only to students in Course XIII-C who have had not less than six months practical experience at sea on merchant ships.
¶ Approximately one year's practical experience with Marine Engineering Plants or design essential. Experience to be evaluated prior to acceptance of enrollment.
‡ Not offered 1952–53.

Economics and Social Science Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
14·02	Economic Principles II	14·01	2	2	XIV-A, XIV-B, XIV-C	3	—	5	E. C. Brown
			3,4	1,2	Elective				
14·03	Prices & Production	14·02	3,4	2	Elective	3	—	5	Bishop
14·09	Economic Problems Sem.	14·02	4	1	Elective	3	—	5	Samuelson
14·111	Current Economic Problems	——	G	1	Elective	3	—	6	Kindleberger
14·112	Current Economic Problems	——	G	2	Elective	3	—	6	Kindleberger
14·113	Econ. & Labor Rel., Prin.	——	G	2	Elective	4	—	8	R. E. Freeman
			G	2	XIII-A				
14·114	Econ., Finance & Statistics	——	G	S	——	4	—	9	R. E. Freeman
14·115	Econ. & Financ. Pol. II	14·114	G	1	——	3	—	6	R. E. Freeman, E. C. Brown
14·116	Econ. & Financ. Pol. III	14·115	G(A)	2	——	3	—	6	Adelman, Kindleberger
14·121	Economic Analysis	14·03	G(A)	1	Elective	3	—	6	Bishop
14·122	Economic Analysis	14·121	G(A)	2	Elective	3	—	6	Samuelson
14·132	Schools of Econ. Thought	14·121	G(A)	2	Elective	3	—	6	Bishop
14·151	Math. Approach to Econ.	14·122	G(A)	1	Elective	3	—	6	Samuelson
14·191	Economics Seminar	14·121	G(A)	1	Elective	3	—	6	R. E. Freeman
14·192	Economics Seminar	14·121	G(A)	2	Elective	3	—	6	R. E. Freeman
14·195	Read. Sem. in Econ.	14·121	G(A)	1	Elective		★		——
14·196	Read. Sem. in Econ.	14·121	G(A)	2	Elective		★		——
14·20	Building Economics	14·01	5	2	IV-A	2	—	4	Millikan
			4	2	Elective				
14·21T	Econ. of Patents & Invention	14·01	4	2	Elective	3	—	5	Maclaurin
14·271	Industrial Econ., Prob.	14·03	G(A)	1	Elective	3	—	6	Adelman
14·272	Gov. Regulation of Industry	14·271	G(A)	2	Elective	3	—	6	Adelman
14·281	Econ. of Invention & Innova.	14·03	G(A)	1	Elective	3	—	6	Maclaurin
14·282	Econ. of Invention & Innova. Sem.	14·281	G(A)	2	Elective	3	—	6	Maclaurin
14·291	Industrial Econ. Seminar	14·271	G(A)	1	Elective	3	—	6	——
14·292	Industrial Econ. Seminar	14·271	G(A)	2	Elective	3	—	6	——
14·30	Statistics, Elem.	M12	3	2	I(2)	2	—	4	H. A. Freeman, Solow
14·31	Statistics, Elem.	M12	4	1	XV-A(52–53)	3	—	6	H. A. Freeman, Solow
14·31T	Quant. Method, Int.	M12	2	1	IV-B	3	—	5	Solow, E. C. Brown
			3	1	XIV-A, XIV-B, XIV-C				
14·32	Statistical Qual. Cont.	14·30 or 14·31 or M32	4	2	Elective	3	—	6	H. A. Freeman
14·33	Econometrics	14·01; 14·371 or 14·382 or M331	4	1	Elective	3	—	6	Solow
14·371	Statistical Theory	14·30 or 14·31 or M32	4	1	Elective	3	—	6	H. A. Freeman
14·372	Statistical Theory	14·371	4	2	Elective	3	—	6	H. A. Freeman
14·382	Economic Statistics	14·01, 14·31	G(A)	2	Elective	3	—	6	Solow
14·40	Money and Income	14·02	3, 4	2	Elective	3	—	5	R. E. Freeman
14·43	Public Finance	14·02	4	1	Elective	3	—	5	E. C. Brown
14·451	National Income	14·40	G(A)	1	Elective	3	—	6	Millikan
14·461	Monetary & Banking Prob.	14·40	G(A)	1	Elective	3	—	6	R. E. Freeman
14·472	Fiscal Policy	14·451	G(A)	2	Elective	3	—	6	E. C. Brown
14·481	Business Cycles	14·451	G(A)	1	Elective	3	—	6	Samuelson
14·51	International Relations	H22	3, 4	1, 2	Elective	3	—	5	Padelford
14·52	Maj. Prob. in Cont. World Politics	14·51	3, 4	1, 2	Elective	3	—	5	Padelford
14·54T	International Trade	14·01; 14·02 or 14·51	4	2	Elective	3	—	5	Kindleberger
14·571	Major Prob. in U. S. Foreign Pol.	14·41 or 14·51	G	1	Elective	3	—	6	Padelford
14·572	International Problems	——	G	2	Elective	3	—	6	Rawlinson
14·581	International Economics	14·40	G(A)	1	Elective	3	—	6	Kindleberger
14·582	International Economics	14·581	G(A)	2	Elective	3	—	6	Kindleberger
14·60	Labor Relations	14·01	3	2	Elective	3	—	5	Shultz, Myers
14·61	Industrial Relations	14·60 or 15·30	4	1	Elective	3	—	6	D. V. Brown, Coleman
14·63	Labor Relations	H22	3	1, 2	Elective	3	—	5	Shultz, Coleman
14·64	Labor Ec. & Pub. Policy	14·63; 14·01 or 14·70	4	1, 2	Elective	3	—	5	Myers, Baldwin
14·671	Prob. in Labor Econ.	14·61	G(A)	2	Elective	3	—	6	Myers, Coleman
14·672	Public Pol. on Labor Rel.	14·61	G(A)	1	Elective	3	—	6	D. V. Brown, Shultz
14·681	Personnel Admin., Sem.	14·61	G(A)	1	Elective	3	—	6	Pigors
14·682	Personnel Admin., Sem.	14·681	G(A)	2	Elective	3	—	6	Pigors
14·691	Res. Sem. in Indust. Rel.	14·671 or 14·672	G(A)	1	Elective	3	—	6	Myers
14·692	Res. Sem. in Indust. Rel.	14·691	G(A)	2	Elective	3	—	6	Myers
14·693	Collect. Bargaining & Union-Manage. Coop.	14·61	G(A)	1	Elective	3	—	6	Scanlon

★ Time specially arranged.

Economics and Social Science Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
14·694	Sem. in Union-Manage. Coop.	14·693	G(A)	2	Elective	3	—	6	Scanlon
14·70	Introductory Psychology	—	2	2	IX-C	3	—	5	Licklider
			3	1, 2	Elective				
14·71‡	Case Method in Personnel Admin.	14·70	3	1	Elective	0	4	0	Pigors
14·72	Union-Manage. Rel.	14·70	4	1	Elective	3	—	6	Scanlon
14·73	Org. & Commun. in Groups	—	3, 4	1, 2	Elective	3	—	5	Bavelas
14·75	Experimental Psychology	14·70	3, 4	2	Elective	3	—	5	Licklider
14·761	Human Com. Networks I, Sem.	—	G(A)	1	Elective	3	—	6	Bavelas, Shepard
14·762	Human Rel. & Labor Rel.	—	G	S	—	4	—	8	Myers
14·764	Human Com. Networks II, Sem.	14·761	G(A)	2	Elective	3	—	6	Bavelas, Shepard
14·77	Psychology of Communication	14·70	4	1	Elective	3	—	5	G. A. Miller
14·771	Interpersonal Relations Sem.	—	G(A)	1	Elective	3	—	6	Shepard
14·772	Intergroup Relations Sem.	—	G(A)	2	Elective	3	—	6	Shepard
14·781	Soc. Psych. of Industry, Sem.	—	G(A)	1	Elective	3	—	6	Bavelas
14·784	Psychological Theory Sem.	—	G(A)	2	Elective	3	—	6	Bavelas
14·791	Read. Sem. in Social Science	—	G(A)	1	Elective		★		—
14·792	Read. Sem. in Social Science	—	G(A)	2	Elective		★		—
14·81	Personality & Social Structure	—	3	1	XIV-A, XIV-B, XIV-C	3	—	5	R. K. Lamb
			3	1	Elective				
14·91	Amer. Polit. System	H22	3	1, 2	Elective	3	—	5	—
14·92	Comp. Polit. & Econ. Systems	H22	3	2	Elective	3	—	5	J. H. Proctor
14·93‡	Issues in Cont. Amer. Politics	14·91 or 14·92	4	2	Elective	3	—	5	Wolfe
14·95‡	Govt. & Econ. Policy	14·02	4	1	Elective	3	—	5	Millikan
14·982	Law & Politics of Econ. Pol.	14·271	G(A)	2	Elective	3	—	6	Millikan

INDUSTRIAL MANAGEMENT AND BUSINESS AND ENGINEERING ADMINISTRATION — 15·00–15·99

GRADUATE SUBJECTS IN INDUSTRIAL MANAGEMENT
UNDERGRADUATE SUBJECTS IN BUSINESS AND ENGINEERING ADMINISTRATION

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
15·01	Indust. Manage. I, Fund	—	2	1	XV-A, XV-B	4	—	5	James
15·02	Indust. Manage. II, Fund	15·01	2	2	XV-A, XV-B	4	—	5	Summerfield
15·11	Indust. Manage., Int.	14·01	4	1, 2	Elective	3	—	6	Moore
15·14	New Enterprise Plan.	15·30, 15·50, 15·71, 15·81	4	2	Elective	3	—	6	Herrmann
15·18	Accounting, Production, & Marketing	—	G	S	—	5	—	10	Tallman
15·30	Personnel Administration	*14.01*	3	2	XV-A, XV-B	3	—	6	Pigors
15·301	Personnel Administration	—	G	2	—	3	—	5	D. V. Brown
15·41	Finance	15·50	4	1	XV-A(52–53), XV-B(52–53)	3	—	6	E. Shapiro
15·411	Finance	15·501	G	2	—	3	—	6	James
15·42	Financial Institutions	15·41	4	2	Elective	3	—	6	E. Shapiro
15·46	Fin. Adm. of Industry	15·41	G(A)	2	Elective	3	—	6	—
15·50	Accounting	*14.01*	3	1	XV-A, XV-B	3	2	4	Beckett
			3	2	I(3), XIII-C,				
			4	2	XVII(52–53)				
15·501	Accounting	—	G	1	—	3	2	4	T. M. Hill
15·51	Indust. Accounting	15·50	4	1, 2	Elective	3	2	4	Kempster
15·55	Prob. in Account. Policy	15·41	G(A)	1	Elective	3	—	6	James
15·58	Prob. in Account. Control	15·501	G(A)	2	Elective	3	—	6	Robnett
15·59	Quant. Anal. of Indust. Prob.	M21	G(A)	1	Elective	3	—	6	T. M. Hill
15·61	Business Law	*14.01*	4	2	Elective	3	—	6	Macmillan
15·64	Patent Law & Invent. Manage.	15·61	4	2	Elective	3	—	6	Berle
15·65	Labor Law	15·61	4	2	Elective	3	—	6	Jacks
15·66	Fund. Legal Principles	15·90 or 15·92	G(A)	1	Elective	3	—	6	Berman

‡ Not offered 1952–53.

★ Time specially arranged.

Industrial Management and Business and Engineering Administration Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
15·70	Production	——	4	1	II(7), II-B(7)	3	—	6	Clark
			4	2	Elective				
15·701	Production	——	G	1	——	3	—	6	Clark
15·71	Production Management	15·02 or 15·70	3	2	XV-A, XV-B	3	—	6	Ritchie
			4	1	Elective				
			4	2	II(7), II-B(7)				
15·72	Indust. Standardization	15·70 or 15·71	4	1	Elective	3	—	6	Moore
15·73	Management Lab.	15·70 or 15·71	4	1, 2	Elective	3	3	3	Goodwin
15·74	Management Lab., Adv.	15·73	4	2	Elective	3	3	3	Goodwin
15·75	Manufact. Analysis	15·71	G(A)	1	Elective	3	—	6	Ritchie
15·76	Mass Production Methods	2·851, 15·71	4	2	Elective	3	—	6	Clark
15·78	Manufact. Control Sem.	15·70	G(A)	2	Elective	3	—	6	Ritchie
15·79	Manufact. Policy Sem.	15·70	G(A)	1	Elective		★		Clark
15·81	Marketing	*14·01*	3	1	XV-A, XV-B	3	—	6	Cross
			3	2	Elective				
15·811	Marketing	——	G	1	——	3	—	6	Cross
15·82	Sales Promotion: Strategy & Methods	15·81	4	2	Elective	3	—	6	Cunningham
15·83	Marketing Research	15·81	4	1	Elective	3	—	6	Cunningham
15·851	Res. Meth. in Market. & Rel. Fields	15·81	G(A)	1	Elective	3	—	6	Cunningham
15·852	Res. Meth. in Market. & Rel. Fields	15·851	G(A)	2	Elective	3	—	6	Cunningham
15·86	New Prod. Appraisal & Development	15·81	G(A)	1	Elective	3	—	6	Cunningham, Tallman
15·88	Industrial Marketing Seminar	15·81	G(A)	2	Elective	3	—	6	Cunningham, Cross
15·90	Tech. of Exec. Control	15·30, 15·50, 15·71, 15·81	4	2	Elective	3	—	6	C. J. Brown
15·92	Industrial Problems	15·30, 15·50, 15·71, 15·81	4	2	XV-A (52–53), XV-B (52–53)	3	—	6	——
15·93	Organization	15·90 or 15·92	G(A)	1	Elective	3	—	6	C. J. Brown
15·94	Contemp. Prob. Seminar	15·90 or 15·92	G(A)	1	Elective	3	—	6	Brooks
15·951	Spec. Prob. in Management	——	G(A)	1	Elective		★		T. M. Hill
15·952	Spec. Prob. in Management	——	G(A)	2	Elective		★		T. M. Hill
15·96	Adm. Th. & Practice	15·90 or 15·92	G(A)	2	Elective	3	—	6	Schell
15·97	Public Relations Seminar	15·90 or 15·92	G(A)	1	Elective	3	—	6	C. J. Brown
15·98	Seminar in Admin.	15·18	G(A)	1	——	3	—	6	Tallman
15·99	Seminar in Admin.	15·18	G(A)	2	——	3	—	6	Tallman

AERONAUTICAL ENGINEERING — 16·00–16·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
16·00	Aeromechanics	2·00 M22	2	2	XVI	3	1	5	Halfman
16·01T	Aeromechanics	16·00	3	S	XVI-B	4	1	5	Halfman
			3	1	XVI				
16·02T	Aerodynamics	2·40, 16·01	3	1	XVI-B(B)(not 52–53)	4	2	6	Ashley
			3	2	XVI, XVI-B(A)(not 52–53)				
			4	1	XVI-B(A)(not 52–53)				
16·025	Aeronautical Mech.	16·02	4	1	Elective	3	—	6	Halfman
16·03	Aerodyn.—Non-Viscous Fluids	16·02	G(A)	1	Elective	3	—	6	Ashley
16·04	Aerodyn.—Viscous Fluids	16·02	G(A)	2	Elective	3	—	6	Bicknell
16·051	Aerodynamics — Compressible Fluids I	M351, *M352*	G(A)	2	Elective	3	—	9	Stever
16·052	Aerodynamics — Compressible Fluids II	16·051	G(A)	1	Elective	3	—	9	Stever
16·061‡	Potential Flows	16·03, 16·052	G(A)	2	Elective	3	—	9	Trilling
16·062	Unsteady Flows	16·03, 16·052, 16·91	G(A)	1	Elective	3	—	9	Ashley
16·063‡	Viscous Flows	16·04, M351, M352	G(A)	1	Elective	3	—	9	Bicknell
16·064‡	Thermal Effects	16·04, 16·051	G(A)	2	Elective	3	—	9	Finston
16·065	Waves & Shocks	16·051	G(A)	2	Elective	3	—	9	Stever

‡ Not offered 1952–53.

★ Time specially arranged.

Aeronautical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
16·066‡	Hypersonics & Superaerodynamics	16·051	G(A)	1	Elective	3	—	9	Stever, Trilling
16·10	Applied Aerodynamics	*16·01*, 16·82	3	1	XVI, XVI-B(B) (not 52–53)	4	—	8	Ober
			3	2	XVI-B(A)				
16·105	Applied Aerodynamics	16·10	G(A)	1 or 2	Elective	3	—	6	Ober
16·13	Airpl. Stab. & Control	16·10	3	2	XVI	3	—	6	Bicknell
			4	S	XVI-B(A)(52–53)				
			4	1	XVI(52–53), XVI-B(52–53)				
16·14	Airpl. Design Prob.	16·13, *16·72*	4	2	Elective	2	6	4	Koppen
16·15	Stab. & Cont. of Aircraft, Adv.	16·13	G(A)	1	Elective	3	—	6	Koppen
16·18	Guided Missiles	16·051 or 16·105; 16·13	G(A)	1	Elective	3	—	6	Stever
16·20	Structures	2·04	3	1	XVI(a)(not 52–53), XVI-B(B)(not 52–53)	3	—	6	Bisplinghoff
			3	2	XVI(52–53), XVI(b)(not 52–53), XVI-B(A)(not 52–53)				
			4	S	XVI-B(A)(52–53)				
16·21	Structures	16·20	4	1	XVI (52–53), XVI-B (52–53)	3	—	6	Bisplinghoff
16·21T‡	Structures	16·20	3	2	XVI(a)	4	—	6	Bisplinghoff
16·22	Aircraft Structures	16·21	4	2	Elective	3	3	6	Mar
16·25	Aircraft Struct., Adv.	16·21	G(A)	1	Elective	3	—	6	Bisplinghoff
16·30	Automatic Control, Prin.	16·01	4	1	XVI (not 52–53), XVI-B (not 52–53)	3	—	9	McKay
			4	1	Elective				
16·31	Inst. & Control, Prin.	2·06 or 2·07 or 6·02 or 16·02	G(A)	1	Elective	3	—	9	McKay
16·32	Inst. & Control, Prin.	16·31	G(A)	2	Elective	3	—	9	McKay
16·33	Inst. & Control Lab.	*16·31*	G(A)	1	Elective	0	3	6	Forbes
16·34	Inst. & Control Lab.	*16·32*, 16·33	G(A)	2	Elective	0	3	6	Forbes
16·35	Spec. Prob. in Inst. & Cont.	16·32	G(A)	1 or 2	Elective		★		McKay
16·36	Vibration Measurements	2·06 or 2·07 or 8·13 or 13·73 or 16·31	G(A)	2	Elective	2	3	6	Forbes
16·37	Meth. of Anal. in Cont. Syst.	16·32 or 16·42	G(A)	1	Elective	3	—	9	Laning
16·38	Control Systems Components	16·31 or 16·41	G(A)	2	Elective	3	—	6	R. K. Mueller
16·39	Vector Kin. & Gyr. Inst. Th.	*16·31* or *16·41*	G(A)	1	Elective	3	—	6	McKay
16·40	Auto. Control Equip. for Aircraft	16·13, 16·31, 16·39	G(A)	2	Elective	3	—	6	Seamans
16·41	Fire Control Prin.	—	G(RA)	1	—	4	—	8	Wrigley, Lees
16·42	Fire Control Systems	16·39, 16·41	G(RA)	2	—	3	—	9	Wrigley, Lees
16·43	Fire Cont. Instr. Lab.	*16·41*	G(RA)	1	—	1	3	5	Kendall
16·44	Fire Cont. Instr. Lab., Adv.	*16·42*, 16·43	G(RA)	2	—	1	3	5	Kendall
16·45	Fire Control Systems, Adv.	16·42	G(RA)	1	—	4	—	8	Wrigley
16·46	Fire Control Systems, Adv.	16·42	G(RA)	2	—	3	—	6	Wrigley
16·47	Rockets, Guided Missiles & Projectiles	16·13	G(RA)	1	—	3	—	9	Stever
16·48	Struct. Prob. in Weapons	2·04, 16·41	G(RA)	2	—	3	—	9	Mar
16·49	Spec. Prob. in Fire Control	16·42	G(RA)	1 or 2	—		★		Wrigler
16·50	Rotating Wing Aircraft	16·10	G(A)	1	Elective	3	—	6	Miller
16·53	Aircraft Power Plants, Prin.	2·40; 2·252 or 16·02	4	2	XVI, XVI-B	3	—	6	E. S. Taylor
16·54	Aircraft Power Plant Prob.	16·53	G(A)	2	Elective	3	—	9	E. S. Taylor
16·55	Aircraft Power Plant Prob.	16·54	G(A)	1	Elective	3	—	9	E. S. Taylor
16·56	Jet Propulsion Engines	2·213 or 2·47 or 16·53	G(A)	2	Elective	3	—	9	E. S. Taylor
16·60	Aero. Prob., Adv.	16·13 or 16·21	G(A)	1 or 2	Elective		★		Staff
16·61	Aeronautics Seminar	—	G(A)	1 or 2	—	2	—	2	—
16·62	Aerodynamic Lab.	16·01, 16·10	4	1	XVI(52–53), XVI-B (52–53)	2	2	4	Ober
16·63	Aerodynamic Lab.	16·62	4	2	Elective	2	2	5	Ober
16·65‡	Aeronautical Eng. Lab.	16·13, 16·20, *16·30*	4	1	XVI, XVI-B	3	3	6	Ober
16·70T	Aircraft Detail Des.	D12	2	1	XVI	3	6	0	Bentley
16·71T‡	Aeronautical Eng.	16·13, 16·20, 16·70T	4	1	XVI, XVI-B	0	10	0	Miller

‡ Not offered 1952–53.

★ Time specially arranged.

Aeronautical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
16·72	Airplane Design Practice	16·10, 16·13, 16·71	4	2	XVI(52–53), XVI-B(52–53)	0	9	0	Miller
16·72T‡	Aeronautical Eng.	16·30, 16·71T	4	2	XVI, XVI-B	0	12	0	Miller
16·74	Airplane Design, Adv.	16·105, 16·13, 16·72	G(A)	1	Elective	2	6	4	Miller
16·81	Aeronautics, General	1·40 or 2·06; 2·252; M21	4	1 or 2	Elective	3	—	6	Markham
16·82	Aeronautical Eng., Int.	M21	2	1	XVI	3	—	1	Markham
16·851	Industrial Practice	——	3	S	XVI-B(A)		40 h.p.w.		Markham
			4	S	XVI-B(B)				
16·852	Industrial Practice	——	3	1	XVI-B(A)		40 h.p.w.		Markham
			3	2	XVI-B(B)				
16·91	Aeroelasticity	16·02	G(A)	1	Elective	3	—	6	Ashley
16·92	Aeroelasticity, Adv.	16·91	G(A)	2	Elective	3	—	9	Ashley
16·93	Aeroelasticity Lab.	*16·91*	G(A)	1	Elective	2	2	2	Halfman
16·94	Dyn. of Aircraft Struct.	16·21, 16·91	G(A)	2	Elective	3	—	6	Bisplinghoff

BUILDING ENGINEERING AND CONSTRUCTION — 17·00–17·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
17·21	Building Construction	D12	2	1	XVII	3	3	6	Gumpertz
17·22	Building Construction	17·21	2	2	XVII	3	1	6	Gumpertz
17·31T	Building Construction	17·22	3	1	XVII	3	1	4	Gumpertz
17·40	Estimating & Job Manage.	17·31T	4	2	XVII(52–53)	2	3	4	Voss
17·40T	Job Management	17·31T	3	2	XVII	2	—	4	Voss
17·401	Job Management, Adv.	17·40	G(A)	1	Elective	3	—	6	Voss
17·41	Building Management	17·31T, 17·40	G(A)	1	Elective	3	—	6	Voss
17·42	Building Management	17·41	G(A)	2	Elective	3	—	6	Voss
17·43	Building Construction	1·91	4	2	Elective	2	3	4	Gumpertz
17·45	Construction Problems	17·31T	4	1 or 2	Elective		★		Voss
17·52T	Steel Design	2·04	3	2	XVII	4	1	7	H. Simpson
17·53	Structural Design	17·52	4	1	XVII (52–53)	3	3	6	H. Simpson
17·53T‡	Wood Design	17·52T	4	1	XVII	2	1	4	H. Simpson
17·531	Reinf. Concrete Des., Adv.	1·42 or 17·53	G(A)	1	Elective	3	—	6	H. Simpson
17·532	Reinf. Concrete Des., Adv.	17·53	G(A)	2	Elective	3	—	6	H. Simpson
17·54	Structural Design	17·53	4	2	XVII (52–53)	3	3	6	H. Simpson
17·54T‡	Concrete Design	17·53T	4	2	XVII	3	1	6	H. Simpson
17·542	Structural Steel Des., Adv.	1·42 or 17·54	G(A)	2	Elective	3	—	6	H. Simpson
17·71T	Materials — Metals	5·02, 8·02	3	1	XVII	2	—	4	Dietz
			4	1	IV-A, XVII(52–53)				
17·72	Materials — Masonry	5·02, 8·02	3	2	XVII	4	2	4	J. A. Murray
			4	2	IV-A				
17·73	Materials — Wood	5·02, 8·02	2	2	IV-A	3	—	3	Dietz
			3	2	XVII				
17·741	Eng. Prop. of Plastics	2·371, 5·02	4	1	Elective	2	—	4	Dietz
17·742	Eng. Laminates	17·741	G(A)	2	Elective	3	—	6	Dietz
17·75	Materials	5·02, 8·02	3	1	I	4	2	6	J. A. Murray
17·76	Res. in Organic Struct. Mat.	17·742	G(A)	1 or 2	Elective		★		Dietz
17·771	Cementitious Materials	17·72 or 17·75	4	1	Elective	2	—	4	J. A. Murray
17·772	Cement and Concrete	17·771	G(A)	2	Elective	3	—	6	J. A. Murray
17·78	Res. in Cementitious Mat.	17·772	G(A)	1 or 2	Elective		★		J. A. Murray
17·81	Cooperative Seminar	17·40T, 17·52T, 17·73	4	1	Elective	0	3	0	Voss
17·82	Cooperative Seminar	17·40T, 17·52T, 17·73	4	2	Elective	0	3	0	Voss

METEOROLOGY — 19·00–19·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
19·00	General Meteorology	8·02, M12	2	1	XIX	3	3	3	Malone
19·001	General Meteorology	8·02, M12	2	1	Elective	3	—	3	Malone
19·01	Descriptive Meteorol. I	19·00	3	1	XIX	3	—	6	Willett
19·012	Des. Meteorol. (Coll. Trans.)	8·02, M12	3	2	——	3	—	6	Willett

‡ Not offered 1952–53.

★ Time specially arranged.

Meteorology Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
19·02	Descriptive Meteorol. II	19·01	3	2	XIX	3	—	6	Willett
19·14	Long Range Weather Fore.	19·44	G(A)	1	Elective	3	8	6	Willett
19·21	Meteorological Observations	19·00	3	1	XIX	1	3	2	Keily
19·22	Meteorological Inst.	19·44	G(A)	2	Elective	2	4	6	Keily
19·23	Micrometeorological Inst.	19·21	G(A)	1	Elective	2	2	4	Keily
19·30	General Climatology	19·01	3	2	XIX	2	—	4	Austin
19·32	Microclimatology	19·02	G	1	Elective	2	—	4	Austin
19·33	Applied Climatology I	19·30	G(A)	S	Elective	3	—	6	Malone
19·34	Applied Climatology II	19·30	G(A)	S	Elective	3	—	6	——
19·44	Synoptic Meteorol. I	19·02, 19·51, 19·61	4	2	XIX	3	—	6	Austin
19·45	Synoptic Meteorol. II	19·44	G(A)	1	Elective	3	—	6	Austin
19·50	Meteorol. Lab., Int.	19·00	2	2	XIX	0	3	0	Malone
19·51	Synoptic Lab. I	19·02, 19·50	4	1	XIX	0	15	0	Malone
19·52	Synoptic Lab. II	19·51	4	2	Elective	0	15	0	Malone
19·53	Synoptic Lab. III	19·44, 19·51	G(A)	1 or 2	Elective	0	15	0	Austin
19·531	Synoptic Lab.	19·44, 19·51	G(A)	S	Elective	0	8	0	Austin
19·60	Thermodyn. of Atmos.	8·02, 19·01, M22	3	1	Elective	3	—	6	J. C. Johnson
			3	2	XIX				
19·601	Theor. Meteorol., Int.	8·02, M12	2	1	Elective	3	—	6	Houghton
19·61	Dynamic Meteorol. I	19·60	4	1	XIX	3	—	6	Starr
19·62	Dynamic Meteorol. II	19·61	4	2	Elective	3	—	6	Starr
19·64	Dynamic Meteorol. III	19·62	G(A)	1 or 2	Elective	3	—	9	Starr
19·65	Dynamic Meteorol. IV	19·61	G(A)	2	Elective	3	—	6	Lettau
19·651	Low-level Turb. & Diff.	19·61	G(A)	S	Elective	2	—	4	Lettau
19·70	Phys. of Atmos., Elem.	*19·01*	3	1	XIX	2	—	4	J. C. Johnson
19·71	Radar Meteorology	19·01, 19·70	G(A)	1	Elective	2	1	4	Bemis
19·72	Physical Meteorology	8·04, 19·61	G(A)	2	Elective	3	—	6	Houghton
19·83	Oceanography	*19·61*	4	1	XIX	2	—	4	Houghton
19·91	Meteorol. Seminar I	19·44, 19·62	G(A)	1	Elective	2	—	4	Houghton
19·911	Meteorol. Seminar I	19·44, 19·62	G(A)	1	Elective	1	—	2	Houghton
19·912	Meteorol. Seminar II	19·911	G(A)	2	Elective	1	—	2	Houghton
19·94	Spec. Prob. in Meteorol.	19·02	G	1 or 2	Elective		★		Staff
19·95	Spec. Prob. in Meteorol.	19·44, 19·62	G(A)	1 or 2	Elective		★		Staff

FOOD TECHNOLOGY — 20·00–20·99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
20·01T	Chem. & Tech. Food Supplies I	5·41	3	1	XX	3	4	3	Lockhart
20·02T	Chem. & Tech. Food Supplies II	20·01T	3	2	XX	3	4	3	Lockhart
20·04	Chemistry of Foods	5·12	3	2	Elective	2	4	2	R. S. Harris
20·11	Tech. Food Products	20·02T	4	1	XX, XX-A	2	4	4	B. E. Proctor
20·12	Tech. Food Products	20·11	4	2	XX, XX-A	2	4	4	B. E. Proctor
20·13	Chem. Eng. Food App.	5·61	4	1	XX, XX-A, XX-B	4	—	6	Stinchfield
20·14	Chem. Eng. Food App.	20·13	4	2	XX, XX-A, XX-B	4	—	6	Stinchfield
20·21	Flavor Evaluation	20·12, 20·32	G(A)	1	Elective	2	2	4	Lockhart
20·22	Food Acceptance	20·12, 20·32	G(A)	2	Elective	2	2	4	Lockhart
20·32	Chemistry of Nutrition	5·41, 7·80	4	2	XX, XX-A	2	—	2	R. S. Harris
20·322	Chem. of Nutrition Lab.	5·41, 7·80	4	2	XX-A	1	4	0	R. S. Harris, Sherman
20·34	Applied Nutrition	20·32	G(A)	2	Elective	2	2	4	R. S. Harris
20·36T	Nutrition, Adv.	20·32	G(A)	2	Elective	3	3	2	R.S.Harris, Sherman
20·38T	Nutr. Eval. of Food Proc.	20·12, 20·32	G(A)	1 or 2	Elective	3	—	3	R. S. Harris
20·41	Bacteriology	7·02	3	1	XX, XX-B	2	4	2	Dunn
20·42	Industrial Microbiology	20·41	3	2	XX, XX-B	2	4	4	Dunn
20·43	Ind. Microbiol., Adv.	20·42	G(A)	1	Elective	2	4	4	Dunn
20·44	Ind. Microbiol., Adv.	20·43	G(A)	2	Elective	2	4	4	Dunn
20·46	Bacteriology of Foods	20·42, 7·80	G(A)	2	Elective	2	4	2	B. E. Proctor
20·51	Food Technology, Adv.	20·12	G(A)	1	XX-A	2	6	4	B. E. Proctor
20·52	Food Technology, Adv.	20·51	G(A)	2	XX-A	2	4	4	B. E. Proctor
20·53	Food App. of Ionizing Rad.	8·04, 20·12	G(A)	1 or 2	Elective	2	2	4	B. E. Proctor, Goldblith
20·61	Food Technology Sem.	20·12	G(A)	1	XX-A	2	—	2	B. E. Proctor

★ Time specially arranged.

Food Technology Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
20·62	Food Technology Sem.	20·61	G(A)	2	XX-A	2	—	2	B. E. Proctor
20·71	Research Problems	—	G(A)	1	Elective		★		Staff
20·81	Selected Topics in Food Technology	—	G(A)	1 or 2	Elective		★		Staff
20·82	Food Technology	—	—	S	Elective	2	4	2	B. E. Proctor

ATHLETIC PROGRAM — A1–A99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
A1	Athletic Program	—	1	1	All courses	0	2	0	Geiger
A2	Athletic Program	—	1	2	All courses	0	2	0	Geiger

GRAPHICS — D1–D99

No.	Subject	Prerequisite	Year	Term	Scheduled for	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	2,3,4	1, 2	Elective	2	—	4	D. P. Adams
D32	Graphics, Adv.	D12, M12	2,3,4	1, 2	Elective	2	—	4	Coons

ENGLISH — E1–E99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
E1	English, Entrance	—	—	S	—	2	—	5	—
E25	English Composition	—	2,3,4	1 or 2	Elective		★		Woodbury
E27	Creative Writing	H22	3,4	1	Elective	3	—	5	O'Dell
E28	News Writing	—	—	2	Elective	2	2	2	Milne
E31	Books and Men	H22	3,4	1	Elective	3	—	5	Greene
E32	Books and Men	H22	3,4	2	Elective	3	—	5	Greene
E35	Reports	—	3	1	Elective	1	—	4	Ulman
E36	Seminar in Tech. Writing	—	3,4	1 or 2	Elective	2	—	4	Ulman
E37	Public Speaking	—	2	1	IV-B	3	—	3	—
E38	Public Speaking	—	2	2	Elective	3	—	3	—
E41T	Literature of Greece	E31 or E32	3,4	1	Elective	3	—	5	Greene
E42T	Non-Western Lit.	E31 or E32	3,4	2	Elective	3	—	5	Greene
E43T	Techniques of Drama	E31 or E32	3,4	1	Elective	3	—	5	Wood
E44T	Nature of Poetry	E31 or E32	3,4	2	Elective	3	—	5	Wood
E45T	Shakespeare & His Contemp.	E31 or E32	3,4	1	Elective	3	—	5	O'Dell
E46T	Imaginative Mind since 1880	E31 or E32	3,4	2	Elective	3	—	5	O'Dell
E47T	Nineteenth Century Amer. Lit.	E31 or E32	3,4	1	Elective	3	—	5	C. Collins
E48T	Twentieth Century Amer. Lit.	E31 or E32	3,4	2	Elective	3	—	5	C. Collins
E49T	Russian Lit. of the Nineteenth Cent.	E31 or E32	3,4	1	Elective	3	—	5	Morison
E50T	The Bible	E31 or E32	3,4	2	Elective	3	—	5	Morison
E57	Special Readings	E31 or E32	4, G	1	Elective	3	—	5	Staff
E58	Special Readings	E31 or E32	4, G	2	Elective	3	—	5	Staff

★ Time specially arranged.

HISTORY — H1–99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec.	Lab. Draw.	Prep.	Instructor in Charge
H11	Hum. & Soc. Sci., Int.	—	1	1	All courses	3	—	5	Wright
H12	Hum. & Soc. Sci., Int.	H11	1	2	All courses	3	—	5	Greene
H21	Hum. & Soc. Sci., Int.	H12	2	1	All courses	3	—	5	Mahoney
H22	Hum. & Soc. Sci., Int.	H21	2	2	All courses	3	—	5	Rae
H31	Topics in Amer. Civ. before 1860	H22	3,4	1	Elective	3	—	5	Edgerly
H32	Amer. Govt. & Society since 1860	H22	3,4	2	Elective	3	—	5	Rae
H33	Hist. of Amer. For. Policy	H22	3,4	1	Elective	3	—	5	Rae
H34	Rise of China & Japan	H22	3,4	2	Elective	3	—	5	Mahoney
H35	Nationalism & Growth of Nations in the West	H22	3,4	1	Elective	3	—	5	K. W. Deutsch
H36	Modern Europe	H22	3,4	2	Elective	3	—	5	—
H51‡	Intro. to Econ. Development	H22	3,4	1	Elective	3	—	5	—
H52‡	Modern Industrial Society	14·01 or H51	3,4	2	Elective	3	—	5	—
H55	History of Engineering	H22	3,4	1	Elective	3	—	5	Woodbury
H56	Technology and Society	H55	3,4	2	Elective	3	—	5	Hartley
H61	American and British Leadership	14·91 or H31 or H32	4, G	1	Elective	3	—	5	Blum
H62	History of Russia	14·92 or H35 or H36	4, G	2	Elective	3	—	5	—
H63‡	Topics in Amer. For. Policy	14·51 or H33	4, G	1	Elective	3	—	5	Mahoney
H64	Historical Studies in Innovation	14·02 or 14·63 or 14·91 or H32 or H56	4, G	2	Elective	3	—	5	Morison
H65‡	Contemp. Problems in Econ. Development	H52	4, G	1	Elective	3	—	5	Rostow
H67	Technology & Soc. in U. S.	14·02 or H31 or H32 or H56	4, G	1	Elective	3	—	5	Bryant
H71	Basic Ideas of West. Politics & Ethics, 500 B.C.–1500 A.D.	H22	3,4	1	Elective	3	—	5	K. W. Deutsch
H72	Rise of Mod. Pol. & Soc. Science, 1500–1914	H35 or H36 or H71	3,4	2	Elective	3	—	5	K. W. Deutsch
H73	Science & Phil. from Greeks to Copernicus	H22	3,4	1	Elective	3	—	5	de Santillana
H74	Science & Phil. from Galileo to Present	H71 or H73	3,4	2	Elective	3	—	5	de Santillana
H77	Amer. Intellectual Hist. to 1865	H22	3,4	1	Elective	3	—	5	Wright
H78	Amer. Intellectual Hist. from 1865 to the Present	H22	3,4	2	Elective	3	—	5	Wright
H81	Contemp. Ideas on Pol. & Econ. Dev.	Any two 14 or H subjects above H22	4, G	1	Elective	3	—	5	K. W. Deutsch
H82	Nationalism & National Dev.	Any two 14 or H subjects above H22	4, G	2	Elective	3	—	5	K. W. Deutsch
H83	Phil. of Science	Any two 14 or H subjects above H22	4, G	1	Elective	3	—	5	de Santillana
H84	Topics in Hist. of Science	Any two 14 or H subjects above H22	4, G	2	Elective	3	—	5	de Santillana
H91	Spec. Topics in History	H22	4, G	1	Elective	3	—	5	Staff
H92	Spec. Topics in History	H22	4, G	2	Elective	3	—	5	Staff
H93	Prob. in Amer. Pol. Econ.	—	G	1	Elective	3	—	6	Blum

MODERN LANGUAGES — L1–L99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec.	Lab. Draw.	Prep.	Instructor in Charge
L11	German, Elem.	—	2,3,4	1	Elective	3	—	5	Condoyannis
L12	German, Elem.	L11	2,3,4	2	Elective	3	—	5	Steinmetz
L13	German, Int.	L12, or Elem. Entrance German	2,3,4	1	Elective	3	—	5	Steinmetz
L14	German, Int.	L13	2,3,4	2	Elective	3	—	5	Steinmetz
L15T	German Lit. 1919–1933	L14 (see page 164)	3,4	1	Elective	3	—	5	Bodmer
L16T	Lit. of Postwar Germany	L14 (see page 164)	3,4	2	Elective	3	—	5	Bodmer
L17	Scientific German	—	G	1	Elective	3	—	6	Condoyannis

‡Not offered 1952–53.

Modern Languages Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
L20	Great Books & Authors in Ger. Lit.	L14 (see page 164)	3,4	2	Elective	3	—	5	Koch
L51	French, Elem.	—	2,3,4	1	Elective	3	—	5	Condoyannis
L52	French, Elem.	L51	2,3,4	2	Elective	3	—	5	Condoyannis
L53	French, Int.	L52 or Elem. Entrance French	2,3,4	1	Elective	3	—	5	Koch
L54	French, Int.	L53	2,3,4	2	Elective	3	—	5	Koch
L55T	Contemp. French Lit.	L53 (see page 164)	3,4	2	Elective	3	—	5	Locke
L56T‡	French Lit. of Third Repub.	L54 (see page 164)	3,4	2	Elective	3	—	5	Locke
L57	Scientific French	—	G	2	Elective	3	—	6	Locke
L59‡	Great Books & Authors in Fr. Lit.	L54 (see page 164)	3,4	1	Elective	3	—	5	Locke
L75	Language & Society	—	4, G	1	Elective	3	—	5	Bodmer
L76	Applied Semantics	—	4, G	2	Elective	3	—	5	Bodmer
L81	Spanish, Elem.	—	—	1	Elective	3	—	5	Koch
L82	Spanish, Elem.	L81	—	2	Elective	3	—	5	Koch
L83‡	Spanish, Int.	—	—	1	Elective	3	—	5	Koch
L84‡	Spanish, Int.	L83	—	2	Elective	3	—	5	Koch
L91	Russian, Elem.	—	—	1	Elective	3	—	5	Znamensky
L92	Russian, Elem.	L91	—	2	Elective	3	—	5	Znamensky
L93‡	Russian, Int.	—	—	1	Elective	3	—	5	Znamensky
L94‡	Russian, Int.	L93	—	2	Elective	3	—	5	Znamensky
L97	Scientific Russian	—	G	2	Elective	3	—	6	Znamensky

MATHEMATICS — M1–M99

No.	Subject	Prerequisite	Year	Term	Scheduled for	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	——
M10‡	Calculus	—	—	1	—	3	—	6	——
M11	Calculus	Entrance Algebra, Solid Geometry, Trigonometry	1	1	All courses	3	—	6	Douglass
M12	Calculus	M11	1	2	All courses	3	—	6	Douglass
M21	Calculus	M12	2	1	All courses except IV-B	3	—	6	Zeldin
M22	Diff. Equations	*M21*	2	2	All courses except IV-A, IV-B	3	—	6	Zeldin
M31	Diff. Equations	M22	3	1	VI	2	—	4	Franklin
M32	Statistics, Elementary	M21	2	2	XVIII, XIX	3	—	6	Wadsworth
			3	1	XII-B				
			3	2	IX-C, XII-A				
M331‡	App. Statistical Methods	M32	3	1	Elective	3	—	6	Wadsworth
M333‡	App. Statistics Seminar	M342; or M331 & *M341*	4	1	Elective	2	—	2	Wadsworth
M334‡	App. Statistics Seminar	M333	4	2	Elective	2	—	2	Wadsworth
M341‡	Modern Statistical Th.	M22, M32	4	1	Elective	3	—	6	Wadsworth
M342‡	Modern Statistical Th.	M341	4	2	Elective	3	—	6	Wadsworth
M351	Adv. Calculus for Engineers	M22	G(A)	1	XIII-A	3	—	6	Hildebrand
			3	1	VIII, XII-B, XVIII				
			3	2	VI-A(B)				
			4	2	VI-A(A)				
M352	Adv. Calculus for Engineers	M351	G(A)	2	XIII-A	3	—	6	Hildebrand
			G	S	VI-A(B)				
			3	2	VIII, XII-B, XVIII				
M36‡	Advanced Calculus	M22	G(A)	1	Elective	3	—	6	Douglass
			3	1	IX-A				
M37‡	Advanced Calculus	M36	G(A)	2	Elective	3	—	6	Douglass
			3	2	IX-A				
M371	Operations Research	M32; M351 or M831	G	2	Elective	3	—	6	Wadsworth
M372	Operations Research	M371	G	2	Elective	3	—	6	Wadsworth

‡ Not offered 1952–53.

Mathematics Continued

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
M381	Theory of Functions	M352, M831	G(A)	1	Elective	3	—	9	I. S. Cohen
M382	Theory of Functions	M381	G(A)	2	Elective	3	—	9	I. S. Cohen
M39T	Methods of App. Mathematics	M351	G(A)	1	Elective	3	—	9	Hildebrand
M411	Numerical Analysis	M351	G(A)	1	Elective	3	—	6	Hildebrand
			(except XVIII)						
			4	1	XVIII Elective				
M42‡	Hydromechanics, Int.	M351	4	2	Elective	3	—	6	Lin
M421	Theoretical Hydromechanics	M352 or M381	G(A)	1	Elective	3	—	9	Lin
M422	Theoretical Hydromechanics	M421	G(A)	2	Elective	3	—	9	Lin
M441‡	Projective Geometry	M21, *M62*	4	1	Elective	3	—	6	——
M442	Diff. Geometry, Elem.	M22	4	2	Elective	3	—	6	——
M451	Fourier Series & Integrals	M381 or M831	G(A)	2	Elective	3	—	9	Wiener
M452	Fourier Series & Integrals	M451	G(A)	2	Elective	3	—	9	Wiener
M461	Seminar in Math.	M352 or M381 or M832	G(A)	2	Elective		★		Staff
M481	Topology	M62; M381 or M831	G(A)	1	Elective	3	—	9	G. W. Whitehead
M482	Topology	M481	G(A)	2	Elective	3	—	9	G. W. Whitehead
M483‡	Advanced Topology	M482	G(A)	2	Elective	3	—	9	Hurewicz
M491‡	Geometry of Manifolds	*M381, M481;* M833	G(A)	1	Elective	3	—	9	Ambrose
M492‡	Geometry of Manifolds	M491	G(A)	2	Elective	3	—	9	Ambrose
M52‡	Topics in the Th. of Numbers	M381	G(A)	1	Elective	3	—	9	Salem
M54	Mathematical Lab.	M22	3	2	Elective	3	—	6	Douglass
M551	Funct. of Real Variable	M381 or M831	G(A)	2	Elective	3	—	9	——
M552‡	Funct. of Real Variable	M551	G(A)	1	Elective	3	—	9	——
M561	Functions of a Complex Var.	M382, M481	G(A)	1	Elective	3	—	9	Salem
M562	Functions of a Complex Var.	M382	G(A)	2	Elective	3	—	9	Martin
M571	Diff. Equations	M381, M62	G(A)	1	Elective	3	—	9	Levinson
M572	Diff. Equations	M571	G(A)	2	Elective	3	—	9	Levinson
M581‡	Continuous Groups	*M481,* M551	G(A)	1	Elective	3	—	9	——
M582‡	Continuous Groups	M581	G(A)	2	Elective	3	—	9	——
M591	Partial Differential Equations	M351 or M381 or M831	G(A)	1	Elective	3	—	9	——
M592	Partial Differential Equations	M591	G(A)	2	Elective	3	—	9	——
M61	Math. Logic	M381 or M62	G(A)	1	Elective	3	—	9	Nash
M62	Modern Algebra	M22	3	1	XVIII	3	—	6	Hurewicz
			3	2	Elective				
M63	Algebra	M62	G(A)	2	Elective	3	—	9	——
M631	Integral Equations	M22	G(A)	2	Elective	3	—	9	Crout
M633	Abstract Algebra	M62 or M63	G(A)	1	Elective	3	—	9	——
M634‡	Topics in Algebra	M63 or M633	G(A)	2	Elective	3	—	9	I. S. Cohen
M635‡	Topological Algebra	M62, *M833*	G(A)	1	Elective	3	—	9	——
M636‡	Topological Algebra	M635	G(A)	2	Elective	3	—	9	——
M641	Tensor Calculus	M62	G(A)	2	Elective	3	—	9	——
M642‡	Tensor Calculus	M641	G(A)	2	Elective	3	—	9	——
M651‡	Analytical Mechanics	M22	G(A)	1	Elective	3	—	9	Franklin
M652‡	Analytical Mechanics	M651	G(A)	2	Elective	3	—	9	Franklin
M66‡	Foundations of Probability	M551 or M61 or M63	G(A)	2	Elective	3	—	9	——
M67‡	Algebraic Curves	M63	G(A)	1	Elective	3	—	9	I. S. Cohen
M681‡	Calculus of Variations	M381 or M831	G(A)	2	Elective	3	—	9	——
M691	Charact. Value Prob.	M351 or M381 or M831	G(A)	1	Elective	3	—	9	Franklin
M692	Charact. Value Prob.	M691	G(A)	2	Elective	3	—	9	Franklin
M73	Review of Mathematics	——	G	S	XIII-A	20	—	0	Douglass
M76	Th. of Probability	M351	G(A)	1	Elective	3	—	9	G. B. Thomas
M78	Th. of Elasticity, Int.	M351	4	1	Elective	3	—	6	Reissner
M791‡	Th. & App. Elasticity	M351 or M381 or M831	G(A)	1	Elective	3	—	9	Reissner
M792‡	Th. & App. Elasticity	M791	G(A)	2	Elective	3	—	9	Reissner
M831	Analysis	M22	4	1	XVIII	3	—	9	Martin
M832	Analysis	M831	4	2	XVIII	3	—	9	Martin
M833	Analysis	M831	4	1	Elective	3	—	6	Martin
M84	Complex Variables & App., Int.	M351 or M831	4	2	Elective	3	—	6	Lin
M90	Math. Reading	——	G(A)	1 or 2	Elective		★		Martin

‡ Not offered 1952–53.

★ Time specially arranged.

MILITARY SCIENCE AND AIR SCIENCE—MS1-MS99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
MS11	Military Science	—	1	1	All courses	2	1	0	W. Anderson
MS12	Military Science	—	1	2	All courses	2	1	0	W. Anderson
MS21	Military Science								
	Students must register for one of the following seven units:								
MS212	Corps of Engineers	MS11, MS12	2	1	All courses	2	1	0	Shapland
MS213	Signal Corps	MS11, MS12	2	1	All courses	2	1	0	Haynes
MS214	Ordnance Corps	MS11, MS12	2	1	All courses	2	1	0	S. L. Hall
MS215	Air Science	MS11, MS12	2	1	All courses	2	1	0	Gricius
MS216	Chemical Corps	MS11, MS12	2	1	All courses	2	1	0	Reagan
MS217	Army Security Agency	MS11, MS12	2	1	All courses	2	1	0	J. P. Cox
MS218	Quartermaster Corps	MS11, MS12	2	1	All courses	2	1	0	Fragala
MS22	Military Science								
	Students must register for one of the following seven units:								
MS222	Corps of Engineers	MS212	2	2	All courses	2	1	0	Shapland
MS223	Signal Corps	MS213	2	2	All courses	2	1	0	Haynes
MS224	Ordnance Corps	MS214	2	2	All courses	2	1	0	S. L. Hall
MS225	Air Science	MS215	2	2	All courses	2	1	0	Gricius
MS226	Chemical Corps	MS216	2	2	All courses	2	1	0	Reagan
MS227	Army Security Agency	MS217	2	2	All courses	2	1	0	J. P. Cox
MS228	Quartermaster Corps	MS218	2	2	All courses	2	1	0	Fragala
MS312	Corps of Engineers, Adv.	MS222	3	1	All courses	3	—	1	Shapland
MS313	Signal Corps, Adv.	MS223	3	1	All courses	3	—	1	Haynes
MS314	Ordnance Corps, Adv.	MS224	3	1	All courses	3	—	1	S. L. Hall
MS315	Air Science, Adv.	MS225	3	1	All courses	3	—	1	Gricius
MS316	Chemical Corps, Adv.	MS226	3	1	All courses	3	—	1	Reagan
MS317	Army Security Agency, Adv.	MS227	3	1	All courses	3	—	1	J. P. Cox
MS318	Quartermaster Corps, Adv.	MS228	3	1	All courses	3	—	1	Fragala
MS322	Corps of Engineers, Adv.	MS312	3	2	All courses	3	—	1	Shapland
MS323	Signal Corps, Adv.	MS313	3	2	All courses	3	—	1	Haynes
MS324	Ordnance Corps, Adv.	MS314	3	2	All courses	3	—	1	S. L. Hall
MS325	Air Science, Adv.	MS315	3	2	All courses	3	—	1	Gricius
MS326	Chemical Corps, Adv.	MS316	3	2	All courses	3	—	1	Reagan
MS327	Army Security Agency, Adv.	MS317	3	2	All courses	3	—	1	J. P. Cox
MS328	Quartermaster Corps, Adv.	MS318	3	2	All courses	3	—	1	Fragala
MS412	Corps of Engineers, Adv.	MS322	4	1	All courses	3	—	1	Shapland
MS413	Signal Corps, Adv.	MS323	4	1	All courses	3	—	1	Haynes
MS414	Ordnance Corps, Adv.	MS324	4	1	All courses	3	—	1	S. L. Hall
MS415	Air Science, Adv.	MS325	4	1	All courses	3	—	1	Gricius
MS416	Chemical Corps, Adv.	MS326	4	1	All courses	3	—	1	Reagan
MS417	Army Security Agency, Adv.	MS327	4	1	All courses	3	—	1	J. P. Cox
MS418	Quartermaster Corps, Adv.	MS328	4	1	All courses	3	—	1	Fragala
MS422	Corps of Engineers, Adv.	MS412	4	2	All courses	3	—	1	Shapland
MS423	Signal Corps, Adv.	MS413	4	2	All courses	3	—	1	Haynes
MS424	Ordnance Corps, Adv.	MS414	4	2	All courses	3	—	1	S. L. Hall
MS425	Air Science, Adv.	MS415	4	2	All courses	3	—	1	Gricius
MS426	Chemical Corps, Adv.	MS416	4	2	All courses	3	—	1	Reagan
MS427	Army Security Agency, Adv.	MS417	4	2	All courses	3	—	1	J. P. Cox
MS428	Quartermaster Corps, Adv.	MS418	4	2	All courses	3	—	1	Fragala

MUSIC—Mu1—Mu99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
Mu31	Introduction to Music	H22	3,4	1	Elective	3	—	5	Liepmann, G. Tucker
Mu32	Western Music from Middle Ages to Present	Mu31	3,4	2	Elective	3	—	5	Liepmann, G. Tucker
Mu41	Classic String Quartet	Mu32	4	1	Elective	3	—	5	Liepmann
Mu42	Twentieth Century Music	Mu32	4	2	Elective	3	—	5	G. Tucker

NUCLEAR TECHNOLOGY — N1–N99

No.	Subject	Prerequisite	Year	Term	Scheduled for	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
N1	Eng. Prac. School at Oak Ridge	——	G(A)	1 or 2	Elective	0	12	0	Vivian
N2	Eng. Prac. School at Oak Ridge	N1	G(A)	1 or 2	Elective	0	12	0	Vivian
N3	Eng. Prac. School at Oak Ridge	N2	G(A)	1 or 2	Elective	0	12	0	Vivian
N10	Nuclear Technology, Int.	M22	G(A)	2	Elective	4	—	8	Benedict
N20	Biol. Effects of Nucl. Rad.	8·06	G(A)	2	Elective	3	—	6	R. D. Evans
N21	Nucl. Reactor Eng. I	8·06; M31 or M352	G(A)	1	Elective	3	—	6	Benedict
N22	Nucl. Reactor Eng. II	N21	G(A)	2	Elective	3	—	6	Benedict
N90	Spec. Prob. in Nuclear Eng.	——	G(A)	1 or 2	Elective		★		Benedict

★ Time specially arranged.

APPENDIX A

STUDENT AID AND PRIZES

RESOURCES for financial aid include: Freshman scholarships open to students entering from secondary schools; undergraduate scholarship aid to upper classmen; The Technology Loan Fund and other loan funds for undergraduate and graduate students; fellowships and graduate scholarships, and full- and part-time Assistantships to aid students pursuing work leading to the Master's or Doctor's degree; and prizes.

FRESHMAN SCHOLARSHIPS

There are available a wide range of scholarship grants carrying stipends from one hundred dollars per year to full tuition. Some awards 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 comes from a particular locality, a graduate of a particular school, etc. However, the William Barton Rogers Scholarships, the Development Fund Scholarships — four-year scholarships — are open to all incoming candidates without restrictions. Limited to nineteen large metropolitan areas throughout the United States are the Alumni Regional Scholarships carrying grants of full tuition for the freshman year. Approximately 200 Freshman Competitive Scholarships with stipends varying from $100 to $600 for the first year are awarded annually to entering freshmen who do not qualify for the William Barton Rogers or Alumni Regional Scholarships. The Freshman Competitive Scholarships have no geographical limitations.

Consideration for a freshman award is confined to students who make application to the Dean of Freshmen before February 14 in advance of matriculation. Also, all freshman scholarships are limited to students entering the Institute directly from secondary schools. Selection is based, to a large degree, upon the candidate's entrance record, C. E. E. B. scores, 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 cooperate 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.

The figures in parentheses are the dates of establishment of the scholarship or fund.

ALUMNI REGIONAL (1926). As a means of cooperating with Alumni in various Technology centers in attracting to the Institute students of exceptional ability and promise from all parts of the United States, several Regional Scholarships, carrying an award 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., Rochester, N. Y., San Francisco, St. Louis, Seattle, Schenectady, Southern Ohio, and Westchester County, New York. These are open to American citizens of good character and health whose standing in their preparatory school studies has been high and who have satisfied with high standing all entrance requirements.

ARMY AND NAVY (1930). Sons of regular Army, Navy, Air Force, Marine Corps and Coast Guard Officers, who are admitted as undergraduate students to the Institute, will 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 Dean of Freshmen 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 Dean of Freshmen.

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 satisfactory 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 C. E. E. B. scores and general admission record.

CLASS OF 1895 SCHOLARSHIP MEMORIAL FUND (1945). Gift of the Class of 1895 on its Fiftieth Anniversary "the income annually to be used to provide scholarships for suitably qualified descendents of members of the Class of 1895. If in any year the total income is not required for this purpose, the balance shall be added to the Technology Loan Fund."

CLASS OF 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."

CLASS OF '22 FUND (1942). Established at the twentieth reunion of the Class of 1922, the "income and principal . . . to be used to assist students entering the Institute as freshmen from secondary schools, with preference being given to sons (or daughters) of members of the Class." Beneficiaries "are expected to issue notes agreeing to repay the face value, without interest, of amounts received."

CLASS OF 1938 SCHOLARSHIP FUND (1938). Gifts from the Class of 1938, "the income for scholarships."

WILLIAM A. CONANT (1943). Bequest of $150,000 "for the purpose of establishing a permanent fund to be known as the W. A. Conant Scholarship Fund, the income therefrom to be used for the education of native born American Protestant boys of New England of American Protestant parents, who are graduates of some high or preparatory school, public or private in New England, preference to be given to the graduates of the public schools of Brookline, Massachusetts, but without limitation thereto, and whose parents are financially unable to send them to the Institute and whose own means are insufficient to allow them to attend the Institute." One scholarship, carrying an annual stipend of $900 per year for each of the four undergraduate years, is annually offered to an entering freshman. Application should be made to the Dean of Freshmen.

DEVELOPMENT FUND SCHOLARSHIPS (1950). Scholarships provided by gifts to the M. I. T. Development Fund with four-year grants to students who maintain academic ranking in the top quarter of the class and demonstrate continued need for financial assistance. A number of these awards will be for full tuition, others for three-quarters tuition, and some for half tuition. They are open to all candidates from secondary schools. For consideration for an award the College Entrance Examination Board tests will be required. Application for renewal of these awards for each succeeding year should be made to the Student Aid Committee.

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 with the Dean of Freshmen. Selection will be based on C. E. E. B. scores and general admission record.

FRANCIS MORGAN FRASHER, JR. MEMORIAL SCHOLARSHIP (1951). Established by his parents for a graduate entering directly after acquiring his entire high school education in the secondary schools of San Antonio, Alamo Heights, or Bexar County, Texas. This applicant, if admitted to the Institute, must pursue work for a degree in science. The award covers tuition for the freshman year only. Selection will be made by the Student Aid Committee at the Institute.

FRESHMAN COMPETITIVE SCHOLARSHIPS (1932). Prize awards covering part tuition for the first year. There are no geographical restrictions of eligibility, and any candidate for admission to the freshman class directly from secondary school may apply. Competition is based upon academic records and evidences of non-academic merit of the competitors and no special examinations are required.

CHARLES HAYDEN MEMORIAL (1939). Established through a grant from the Charles Hayden Foundation, the Institute offers a number of scholarship awards in memory of the late Charles Hayden, a graduate of the English High School Class of 1886 and of the M. I. T. Class of 1890: "To aid deserving 'Boston and New York boys' — high school graduates whose parents are unable to finance the entire cost of their education — to enroll as members of the first-year class at Technology." Full particulars concerning these awards may be obtained from the Dean of Freshmen.

JAKOBSON SCHOLARSHIP (1951). Established by Jakobson Shipyard Incorporated, an annual freshman scholarship carrying a grant of $1,000. First preference to a son of an employee of Jakobson Shipyard Inc. and second preference to graduates of the following high schools: Glen Cove, Huntington, Manhasset, Oyster Bay, Port Washington, Roslyn, Sea Cliff.

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."

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."

JACOB AND JENNIE LICHTER FUND (1949). "To be used for the aid of students who shall satisfy all entrance requirements of the Institute and be endorsed as to character and personality."

CHARLES E. LOCKE MEMORIAL FUND (1923). Established by the Class of 1896 to found a scholarship. Preference in making awards will be given to descendants of members of the Class of 1896, including freshmen.

WALDO A. MARTIN SCHOLARSHIP FUND (1950). Established by Eleanor P. Martin in memory of her brother, Waldo A. Martin, M. I. T. 1890. First preference until 1975 to friends or relatives of Waldo A. Martin and the donor. Second preference to graduates of Milton High School, Milton Academy, or a resident of Milton for the freshman year only on the basis of character, integrity and ability.

M. I. T. CLUB OF CHICAGO SCHOLARSHIP FUND (1944). Gift of $6,000 from Harold B. Harvey of the Class of 1905 "to establish scholarships to be known as the Technology Club of Chicago Scholarship Fund," the awards to be made by a committee composed of the Honorary Secretaries of the Chicago area and the Dean of Freshmen, and restricted "to boys who reside in the area of the club membership."

GEORGE H. MAY (1914). Gift of $5,000 from George H. May of the Class of 1892 to provide a scholarship "to assist graduates of the Newton High Schools who are students at M. I. T. and who have been recommended as eligible by the Superintendent and Head Master of the Newton High Schools." Beneficiaries under this fund are expected to issue notes agreeing to repay the face value, without interest, of amounts received.

MILTON HIGH SCHOOL FUND (1885). Founded by the Institute in recognition of contributions from residents of Milton. This scholarship is conferred upon such former pupils of the Milton High School in good standing at the Institute as the Master of that school and the School Committee of the town may select.

WILLIS WARD REEVES, JR. FUND (1945). Established by Mr. and Mrs. Willis Ward Reeves of Hazard, Kentucky, "as a memorial to their son, Willis Ward Reeves, Jr. of the Class of 1946, late Lieutenant, U. S. Army Air Forces, killed in action over France during World War II . . . the income to be used for scholarship aid to deserving undergraduate students, with preference to those from Kentucky."

WILLIAM BARTON ROGERS SCHOLARSHIP (1947). A limited number of four-year grants established in honor of William Barton Rogers, founder of the Institute, to enable young men of superior ability and future promise but of limited financial means to pursue an education in either Engineering, Science, or Architecture. A stipend of $1,200 (full tuition plus $300) will be granted for the first year. Successful applicants who maintain honor standing will continue to hold full tuition awards for their undergraduate course and will be eligible to apply to borrow up to $900 annually from the Technology Loan Fund. These scholarships are open to all freshmen candidates with no restrictions of geographical location. All applicants will be required to establish scores in the College Entrance Examination Board tests.

FRANK ARNOLD SHERMAN SCHOLARSHIP FUND (1947). Bequest of Frank Arnold Sherman, '03, "the income to be used first and preferentially for a scholarship to some boy graduate of Westerly High School, Westerly, R. I., or if no suitable candidate, preferentially to a boy graduate of some other Rhode Island high school."

G. H. MILLER SMITH FUND (1945). Established by Mr. and Mrs. George Blackwell Smith of Lookout Mountain, Tennessee, "as a memorial to their son, G. H. Miller Smith of the Class of 1943, late Lieutenant, U. S. Army, killed in action in France during World War II . . . the income to be used for scholarship aid to deserving undergraduate students, with preference to those from Tennessee."

TAU BETA PI MEMORIAL SCHOLARSHIP FUND (1947). Gift from members of Tau Beta Pi, Massachusetts Beta Chapter, on their twenty-fifth anniversary. An annual award of $500 for freshmen to be selected by M. I. T. Scholarship Committee. There is to be no restriction of geographical area and candidates will be selected on high scholastic standing, character and future promise.

VERMONT (1924). Gift of $40,000 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 Student Aid 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 7-133.

The scholarships or funds described are arranged in the alphabetical order of their names, the figures in parentheses being the dates of establishment:

AMERICAN BRAKE SHOE COMPANY SCHOLARSHIP (1948). Established by the American Brake Shoe Company to assist worthy students studying in the general field of Metallurgy, particularly in the fields of foundry engineering, metal processing and physical metallurgy. A full tuition grant plus $1,000 per year open to a third or fourth year student, to be selected by the head of the Department of Metallurgy subject to the approval of the Committee on Student Aid and final approval by the American Brake Shoe Company.

AMERICAN SMELTING AND REFINING COMPANY (1946). Gift of the Company to establish scholarships of $500 each to Course III students. Recipients are to be selected by the Head of the Course in Metallurgy subject to approval by the Faculty Committee on Student Aid. Preference will be given to third or fourth year students in Metallurgy.

ANONYMOUS (1952). A gift of $20,000 to the Institute for scholarships or some alternate form of student aid.

LOUIE G. APPLEBEE (1942). Bequest "to be expended in assisting deserving students."

ELISHA ATKINS (1894). Founded by Mrs. Mary E. Atkins of Boston with a gift of $5,000.

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."

HUSE TEMPLETON BLANCHARD FUND (1946). Bequest of Huse T. Blanchard, of the Class of 1901, for "the benefit of worthy boys of the State of New Hampshire."

LEVI BOLES (1915). Bequest of $10,000 from Frank W. Boles in memory of his father, Levi Boles, the "net income thereof to be applied annually to the assistance of needy and deserving students."

JONATHAN BOURNE (1915). Bequest of $10,000 from Hannah B. Abbe to constitute a fund "known as the Jonathan Bourne Scholarship Fund, the income only to be used in aid of deserving students."

ALBERT G. BOYDEN (1931). Bequest of $40,000 from Elizabeth R. Stevens as a permanent fund, to be known as the Albert G. Boyden Fund, "income only to be awarded as scholarships to assist worthy and needy students, preference to be given to young men or women residents of the town of Swansea or the city of Fall River."

BERTRAM BREWER SCHOLARSHIPS (1952). Bequest under the will of Bertram Brewer. "Income . . . to be used to provide annual scholarships for deserving undergraduates of good character and ability. . . ."

HARRIET L. BROWN FUND (1932). Bequest of Harriet L. Brown "to be held in trust as a scholarship . . . the income to be given to such needy and deserving young women desiring to become students at M. I. T., as would otherwise be unable to attend; and in case of two or more applicants of equal merit, preference shall be given to a native of either Massachusetts or New Hampshire."

BRUMBERGER SCHOLARSHIP (1952). Gift of the Brumberger Foundations, Inc. A $500 scholarship open to a senior in Mechanical Engineering. Candidate must show promise in the field of mechanical engineering and design and be an American citizen. First preference will be for a student residing in New York State, New Jersey, or Connecticut. Selection will be made by the Faculty Committee on Student Aid.

GODFREY L. CABOT (1950). Established by gift for scholarships . . . with preference to students of Chemistry or Chemical Engineering.

MABEL BLAKE CASE (1920). Bequest of $25,000 from Caroline S. Freeman to be "known as Mabel Blake Case Fund, income to be used to aid deserving students (preferably women) who are in need of assistance."

NINO TESHER CATLIN (1926). Gift from Maria T. Catlin to establish a fund in memory of her son, Nino T. Catlin of the Class of 1918, the income "to be awarded to needy and deserving students."

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."

A. V. CLARKE (1950). Gift of Mr. Clarke. "Proceeds to be used for student aid at the discretion of the Faculty Committee on Student Aid."

FRED L. AND FLORENCE L. COBURN (1932). Bequest of $5,000 from Fred L. Coburn, the income of which "shall be expended by said Trustees in giving aid and assistance to students of M. I. T. . . . preference being given by said Trustees to students residing in Somerville, Massachusetts."

COFFIN MEMORIAL (1929). This gift from the executors of the estate of Charles A. Coffin — a bequest — carried out the wishes of Mr. Coffin. The fund is to be used for loans or other aid to students as determined by the Executive Committee.

COLLEGE OF WILLIAM AND MARY (1904). Established by the Institute in commemoration of the early association of President William Barton Rogers with the College of William and Mary. Stipend $400 per year; granted to a student nominated by the faculty of the College of William and Mary.

ALBERT CONRO SCHOLARSHIP FUND (1943). Bequest of Mary T. Conro, sister of Emma O. Conro, of the Class of 1884, in memory of their uncle, "for the purpose of establishing and maintaining a scholarship in . . . mining engineering . . . to be known as the Albert Conro Scholarship."

THE GEORGE R. COOKE FUND (1939). Established by gift of $3,000, "the income to be awarded to a student, preferably in the Course in Civil Engineering, or in some related field of study giving preparation for Public Service and Government. Prior to matriculation, the recipient, who need not necessarily be a candidate for a degree, must have acquired practical experience and earned his living by working in some field, preferably for one year or more. Candidates are to be judged upon their evidences of character, sincerity of purpose and need for assistance."

JOHN G. CRANE SCHOLARSHIPS (1951). Gift of J. G. Crane, 1890, for undergraduate awards.

LUCRETIA CROCKER (1916). By the will of Matilda H. Crocker, the Institute was made the residuary legatee of her estate "for the establishment of one or more scholarships for women in memory of my sister, Lucretia Crocker . . . the income to aid one or more young women in need of pecuniary assistance in obtaining instruction at said Institute."

EUNICE McLELLAN CRUFT FUND (1949). Bequest of Eunice McLellan Cruft "to assist young men whose means are inadequate to pay their expenses at the Institute."

ISAAC W. DANFORTH (1903). Bequest of $5,000 from James H. Danforth for scholarship purposes as a memorial to his brother, Isaac Warren Danforth.

ARTHUR DAVIS DEAN FUND (1952). Through the bequest of Arthur Davis Dean '95, the Institute has established a number of grants to cover a portion of the rental of rooms in the undergraduate houses so that young men of limited means may live on the Institute campus. Grants will be made by the Faculty Committee on Student Aid to undergraduates (including entering freshmen) who have demonstrated need for financial assistance through application to the Committee on Student Aid and/or the Technology Loan Fund Board.

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."

CLARA AND JOSEPH F. FORD SCHOLARSHIP (1951). Established by Mr. and Mrs. Joseph F. Ford, "income to be awarded to worthy and well-qualified students who have demonstrated a democratic and tolerant spirit and who are well-disposed toward people of all creeds and races."

FOUNDRY EDUCATIONAL FOUNDATION SCHOLARSHIPS (1947). Established by the Foundry Educational Foundation which represents the American Foundrymen's Association, the Gray Iron Founders' Society and the Malleable Founders' Society, and the Foundry Equipment Manufacturers Association. Full tuition awards open to third and fourth year students in Business and Engineering Administration, Mechanical Engineering, and Metallurgy.

PHILIP JACOB FRIEDLANDER (1945). Gift of Israel Friedlander "in appreciation of the opportunity my son, Philip Jacob Friedlander, had of spending a little more than a year at M. I. T. before enlisting in the United States Naval Reserve . . . . the income to be used with the income from other such funds for the purpose of helping qualified students at M. I. T. regardless of race, creed, or color, or geographical origin, who may be in need of financial assistance . . ."

NORMAN H. GEORGE (1919). Bequest of Norman H. George "to be used for the assistance of needy and worthy students in obtaining an education in M. I. T."

ARTHUR B. GILMORE (1941). Bequest of $10,000 from Arthur B. Gilmore ". . . for the purpose of assisting needy students who shall be members of the Beta Theta Pi Fraternity . . . said net income to be divided among not more than two students in any one year."

BARNETT D. GORDON FUND (1942). Gift of $5,000 from Barnett D. Gordon of the Class of 1916, "the income as scholarships for deserving students at M. I. T."

LUCIA G. HALL (1945). Bequest of Louise K. Gunn to "be known as 'The Lucia G. Hall Scholarships' . . . the income only therefrom to be used for the aid of worthy students."

HALL-MERCER SCHOLARSHIP FUND (1940). Bequest of Alexander G. Mercer ". . . . income only . . . for the benefit of such poor students as have passed through some of the Public Schools with the best reputation for character and ability."

JAMES H. HASTE (1930). Bequest of James H. Haste of the Class of 1396, "for the aid of deserving students . . . of insufficient means, said fund, together with any other sums which said institution may receive under this will, to be known as the James H. Haste Fund."

GEORGE HOLLINGSWORTH (1916). Bequest of $5,000 from Rose Hollingsworth to found the George Hollingsworth Scholarship.

LOREN C. HOLM SCHOLARSHIP FUND (1950). Established by Marie Holm in memory of her father, for worthy and needy students.

ELIAS HOWE, JR. SCHOLARSHIPS (1949). Established under the will of Julia Howe Stockwell Smith. "The income from this fund shall be available for aiding such students and in such amounts as shall be recommended by the Faculty."

SAMUEL P. HUNT (1945). Gift of Samuel P. Hunt of the Class of 1895 for scholarship purposes.

T. STERRY HUNT (1894). Bequest of $3,000 from T. Sterry Hunt, for seven years Professor of Geology at Technology, to found a scholarship in his name. Restricted to students of Chemistry and preference is given to those in the higher years.

WILLIAM F. HUNTINGTON (1892). From Susan E. Covell, the Institute received a gift of $5,000 to constitute a fund in memory of William F. Huntington of the Class of 1875, the "income to apply to payments of tuition of needy and deserving students . . . preference to be given to students in Civil Engineering."

DAVID L. JEWELL (1928). Bequest of $25,000 from Colonel David L. Jewell "to be known as the David L. Jewell Fund, the income therefrom to be used to pay the tuition charges of five young men who may be selected by the President or Board of Trustees of the Institute as worthy of assistance, and who, were it not for such assistance, might be unable to pursue their studies at such Institute."

EDWARD A. JONES SCHOLARSHIP FUND (1947). Bequest of $25,000 from Edward A. Jones "to be used for the establishment and maintenance of one or more scholarships."

JOY (1886). Established by the gift of Nabby Joy and created pursuant to a decree of the Supreme Judicial Court of Massachusetts for the benefit of "one or more women studying Natural Science at M. I. T."

KULJIAN PRIZE SCHOLARSHIPS (1951). Gift of Harry A. Kuljian, '19, to establish two prize awards for outstanding seniors in engineering departments. Candidates will be nominated by the Departments to the Dean of Humanities and Social Studies as young men of outstanding professional promise and aware of the significance of the humanities in their professional education. Winners will be expected to complete two elective humanities subjects — in addition to the required humanities program — in either the junior or senior year. Selection will be made by the Faculty Committee on Student Aid.

KURRELMEYER FUND (1947). Raised by contributions "for undergraduate scholarship award to a needy student."

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 Director of Student Aid.

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 Co-operative Course in Electrical Engineering."

MARGARET A. MATTHEWS FUND (1947). Bequest from Margaret A. Matthews "the income for the benefit of such of the women students at M. I. T. who intend to become teachers."

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. . . ."

NATIONAL ASSOCIATION OF ENGINE AND BOAT MANUFACTURERS, INC. Scholarship of $600 to be awarded to a student in Naval Architecture and Marine Engineering and who is particularly interested in small boat design.

NICHOLS (1895). Bequest of $5,000 from Mrs. Betsy F. W. Nichols to constitute The Nichols Scholarship in memory of her son William Ripley Nichols of the Class of 1869, for sixteen years Professor of General Chemistry at the Institute. Preference is given to students in the Course in Chemistry.

CHARLES C. NICHOLS (1904). Bequest of $5,000 from Charles C. Nichols to constitute a scholarship.

WILLIAM E. NICKERSON SCHOLARSHIP FUND (1949). Established by the Nickerson Trust, the income to be used for a scholarship for a worthy student.

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."

LOUISE KNIGHT AND CHARLES PARKS FUND (1952). Bequest of the Estate of Jessica A. L. Knight, "as a memorial to Louise Parks Knight, and her father, Charles F. Parks, of the Class of 1875 . . . for the aid of poor but worthy students, who have already entered upon a course of study, but are unable to finish owing to a lack of funds."

GEORGE L. PARMELEE (1921). Bequest from George L. Parmelee of "one third of my property and estate, interest thereof to be used for tuition of worthy students, either special or regular, according to the direction of the Faculty."

FRANK STETSON PECKER FUND (1947). Established by the wills of Frank Stetson Pecker and Annie J. Pecker for scholarship.

RICHARD PERKINS (1887). Bequest of $100,000 from Richard Perkins, the income from half of which is available for the "support of free scholarships in said Institute."

CHARLES H. AND HELEN BARTLETT PRAY FUND (1950). Established under the wills of Charles H. and Helen Bartlett Pray "for scholarships for needy young men."

FLORENCE E. PRINCE FUND (1943). Bequest of Florence E. Prince "for the aid of worthy students who may need assistance in the matter of maintenance and living expenses while pursuing their studies."

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 P. RYAN MEMORIAL (1935). Established by friends of the late Professor William P. Ryan of the Class of 1918, the income to be used for scholarship aid (graduate or undergraduate) in Chemical Engineering, the award to be made on recommendation of the Head of the Department of Chemical Engineering.

JOHN P. SCHENKL (1922). Bequest of $20,000 from Johanna Pauline Schenkl "to be held in trust to establish one or more scholarships in the Department of Mechanical Engineering" in memory of her father, John P. Schenkl.

PAUL D. SEGHERS, JR. SCHOLARSHIP (1948). Established by the estate of May Towles Kirk Seghers in memory of Second Lieutenant Paul Dotrenge Seghers, Jr., U. S. Army Corps of Engineers, M. I. T. Class of 1945, who was killed in action in the Asiatic area on July 11, 1945, to aid worthy and needy students in the discretion of the Institute.

THOMAS SHERWIN (1871). Founded with a gift of $5,000 from the English High School Association in memory of Thomas Sherwin. Holders must be graduates of the English High School of Boston and must be pursuing a regular course at the Institute.

SKIDMORE, OWINGS AND MERRILL TRAVELLING FELLOWSHIP (1950). An award to a student graduating in the Department of Architecture, for foreign travel. Gift from the firm of Skidmore, Owings and Merrill for scholarship grants to students in the Department of Architecture.

CLIFTON BECKERT SMITH SCHOLARSHIP (1952). Donated by the Transparent Package Company Foundation. Half tuition grants to a junior and to a senior in chemical engineering who have shown good promise and achievement and are in need of financial assistance. Selections will be made by the Faculty Committee on Student Aid.

H. HILLIARD SMITH FUND (1950). Bequest of Grace J. F. Smith in memory of her husband, H. Hilliard Smith '96, for the purpose of assisting young men in Architecture.

HORACE T. SMITH (1931). Bequest from Horace T. Smith of the Class of 1898, to provide scholarships to worthy students, preference to be given to graduates of the East Bridgewater (Massachusetts) and Bridgeport (Connecticut) High Schools.

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 Architecture and Marine Engineering. Applications should be made directly to the Head of the Department of Naval Architecture and Marine Engineering.

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 $40,000 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."

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."

LOAN FUNDS

Since its establishment in 1930 over 3,100 M. I. T. students have borrowed more than $2,250,000 from the Technology Loan Fund.

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 $2,700 during his undergraduate period, or $3,600 during his undergraduate and graduate periods.

To receive favorable consideration an applicant must:

1. Be endorsed as to character and personality by: (*a*) an alumnus of the Institute from the community in which he has resided, or by some other citizen of standing in that community; (*b*) the Principal or Head Master of the high school or preparatory school, or the President or Dean of the college or university he has previously attended, (*c*) his Registration Officer or the Head of his Course.

2. Have passed, with a standing satisfactory to the Board, the physical examination required annually of all Institute students.

3. Submit a statement of his financial needs and such other information as the Board may deem necessary, on the application form supplied by the Board, such application to have the approval of his parent or guardian.

4. Be prepared to furnish such life insurance as collateral as may be required by the Board.

A recipient of a loan will be required to sign promissory notes in $50 units up to the amount of his loan, each note carrying interest at one per cent per annum from the date of its issue to a date not exceeding two years after he leaves the Institute, and at five per cent per annum thereafter. Interest is to be paid semi-annually. Each note shall have a definite maturity, such maturities to be spaced at intervals of six months, beginning on or before the December thirty-first following the recipient's expected date of graduation, but payments may be anticipated.

Upon signing notes, the student will be supplied with copies thereof. After leaving the Institute he will be required to advise the Board annually, or at more frequent intervals, as to his whereabouts, the character of the work in which he is engaged, the remuneration he is receiving and his plans for the repayment of his obligations to this Fund.

ETHEL I. FRYER SCHOLARSHIP LOAN FUND (1951). Gift of H. Fryer 1911 to establish a loan scholarship for deserving students from the States of Washington, Oregon, and California. Limited to grants of $600 per student and repayable within five years of graduation.

NATHAN R. GEORGE LOAN FUND (1943). Bequest of $29,000 from Professor Nathan R. George of the Department of Mathematics, the "income to be loaned to undergraduates of M. I. T. who are either citizens or who intend to become citizens" and who are members of the third or fourth year classes.

JOHN A. GRIMMONS (1930). In memory of John A. Grimmons of the Class of 1921 through a deed of trust executed by the late C. Lillian Moore, the Institute received a sum of money to be "used in making loans to undergraduates who are preparing to make Electrical Engineering their life work; such loans to be known as given from the John A. Grimmons Perpetual Loan Scholarship; such loans are not to exceed six hundred (600) dollars to any one student in any one year and are to be made on condition that the loans shall bear interest at five per cent, and shall be repaid within ten years, and that repaid loans shall be treated as income to revert into the Perpetual Loan Fund and to be reloaned from time to time; such loans are to be protected by life insurance. . . . Loans are to be awarded to male, white, native born citizens of the United States, who are loyal to the State and Nation, are of sound physical body and show steadiness of purpose and zeal in educational acquirements."

LAMSON-VIRGIN LOAN FUND (1946). Bequest of $5,000 from Elizabeth H. Lamson, the income to be used in aiding a worthy student of excellent character who "must have shown not only respect for his parents but also proper consideration for the rights of others." Students thus aided shall repay if and when they find themselves able to do so.

GEORGE J. MEAD FUND (1951). Bequest of George J. Mead '16 for loans to students in Aeronautical and Mechanical Engineering.

PRIZES

AMERICAN SOCIETY OF TOOL ENGINEERS (1945). Gift of the Boston Chapter of the Society. A monetary prize of $100 offered annually for the best graduation thesis on a subject related to the professional field of tool engineering.

ROBERT A. BOIT (1921). Bequest of $5,000 from Robert A. Boit, to provide annual prizes "to stimulate the interest in the best use of the English language." Awards are made to undergraduates on the basis of essays written on topics approved by the Department of English and History.

KARL TAYLOR COMPTON PRIZE FUND (1951). Gifts from members and friends of the Boston Stein Club Income for prizes and grants in recognition and encouragement of outstanding contributions in promoting high standards of performance and good citizenship within the Institute community.

ELLEN KING PRIZE. Established in 1950, the prize, a collection of books valued at approximately $50, is awarded for the best essay written by a freshman upon any topic suitable for treatment in literary form. Papers submitted in a regular subject, as well as extra-curricular compositions, will be eligible for the prize. Specific topics must be registered and approved at the headquarters of the Department of English and History.

GEORGE J. MEAD PRIZE (1951). Bequest of George J. Mead '16 "to stimulate all students at M. I. T. in the aeronautical field to their best effort through suitable prizes. . . ." To be administered by a special committee appointed by the President.

JAMES MEANS MEMORIAL (1925). A medal and monetary prize of $100 offered annually to the senior showing the highest professional promise in Aeronautical Engineering.

SILENT HOIST AND CRANE COMPANY MATERIALS HANDLING AWARD (1950). Gift of the Wunsch Foundation, Inc., to provide annual prizes for the best papers or theses submitted on subjects in the fields of production, materials handling, or machine design related to materials handling equipment. Prizes totaling $200 will be awarded on the basis of a competition held each year.

STRATTON (1930). Established by the late President Samuel W. Stratton. Awards of $100, $50, $20, and three $10 prizes 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 Department of Architecture who has shown an ability for leadership, performed willing service for his school and department, and given promise of real professional merit through his attitude and personality.

CHAMBERLIN (1913). Gift of Boston Society of Architects. Prize of $25 to a student in the graduate class in Architecture. Awarded in alternate years.

F. W. CHANDLER (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. A prize awarded to a student in the third-year class in Architecture for a sketch problem.

WILLIAM EMERSON (1940). Gift of the Alumni and Staff. Five prizes of $10 each awarded in the first, second, third, fourth and fifth years of Course IV-A, and one prize of $10 awarded in Course IV-B.

ROTCH (1895). Gift of Arthur Rotch. Two prizes awarded at the end of the fifth year to the regular and the special student having the best general records. The special student must have spent at least two years in residence to be eligible.

STUDENT MEDAL OF THE AMERICAN INSTITUTE OF ARCHITECTS (1914). Awarded on the recommendation of the Department to the member of the fifth-year class whose record for the Course is the best.

BOSTON SOCIETY OF ARCHITECTS (1923). Gift of the Society. Prizes totalling $50 for week-end conjunctive problems with Harvard and the Boston Architectural Club.

WILLIAM R. WARE (1923). Given by M. I. T. in memory of the founder of the School, prizes totalling $50 for week-end conjunctive problems with Harvard.

H. LANGFORD WARREN (1923). Given by Harvard in memory of Professor Warren, prizes totalling $50 for week-end conjunctive problems with Harvard.

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.

GRADUATE SCHOLARSHIPS AND FELLOWSHIPS

A FELLOWSHIP is an award of a cash stipend, with or without a credit against tuition fees, based on academic performance and promise of professional competence to aid the recipient in his pursuit of advanced study and research. This award recognizes the recipient as having demonstrated the promise of unusual attainments in science or engineering.

A SCHOLARSHIP is an award of a financial credit toward tuition fees, made to a graduate student of academic promise, to aid and encourage his graduate study toward an advanced degree.

Fellowships and Scholarships are awarded by the Committee on Graduate School Policy only to graduate students who are not also staff members. Tuition credits to whole-time or part-time staff appointees are arranged by the departments recommending staff appointments from funds other than those designated for graduate students.

GRADUATE STUDENT FELLOWSHIPS are available to certain graduate students proceeding toward advanced degrees: ADVANCED RESEARCH FELLOWSHIPS are available to certain holders of advanced degrees who are not enrolled as graduate students (*e.g.*, Postdoctoral Fellowships). The recipient of a Fellowship is designated as a Fellow for the period of time specified in his award. He pays full tuition, has full student status, and no services are required of him in respect to his Fellowship.

APPLICATIONS

Applications for Fellowships or Scholarships must be filed on the form "Application for Scholarship Aid" obtainable from the Admissions Office and should be returned to appropriate department officers. Applications will be acted upon by the Committee on Graduate School Policy at stated times.

For each regular academic year beginning with a Fall term, Applications for Scholarship Aid must be in hand on the previous March 1. Notices of award will be mailed on April 1, and awards not accepted by April 15 will be cancelled.

Applications received at other dates will be considered from time to time if funds are available.

Applications from students applying for admission to the Graduate School must be accompanied by full credentials required with the admission application. Only applicants with highest credentials may expect favorable consideration from the Scholarship Committee previous to at least one term of residence as a graduate student and any award to a new student will usually not exceed tuition.

Each award will be terminated following a term record of less than 3.5 unless mitigating circumstances in explanation of low grades are accepted by the Committee on Graduate School Policy.

The recipient of scholarship aid is expected to complete the period of study for which an award is made, and discontinuance of his work before the end of such period imposes upon him the obligation to refund to the Bursar all portions of the award which have been used unless a waiver is granted by the Committee on Graduate School Policy.

Correspondence concerning scholarships should be addressed to the Chairman of the appropriate Departmental Committee on Graduate Students (see page 92).

ASSISTANTSHIPS

Subfaculty academic staff appointments as teaching or research assistant are made upon recommendation of heads of departments. Request for consideration for such appointment should be addressed to the head of the appropriate department, and will be considered only when receipt of the "Application for Admission to the Graduate School" has been recorded by the Admissions Office.

An academic staff appointee may register in accord with the following schedule:

Staff Position	*Registration per Term*
Full-time	18 units
Half-time	30 units
Third-time	38 units

The above units, which include thesis units, are "normal loads." Registration Officers may permit registration up to 24 units for full-time, to 36 units for half-time, and without limit for one-third time staff appointees *when such excess registration does not interfere with staff duties.*

Graduate students, whether or not they are also on the staff, may apply for financial assistance to the Technology Loan Fund Board.

THE GOODWIN MEDAL. The Goodwin Medal together with a cash prize may be awarded in any year (but not necessarily in every year) to a graduate student who is also a member of the academic staff of the Massachusetts Institute of Technology, in recognition of conspicuously effective teaching. Candidates for this award are nominated through departmental channels or by the Student-Faculty Committee to the Dean of the Graduate School.

THE GOODWIN PREMIUM. In any year in which there is no qualified candidate for the Medal, a cash award not to exceed $500 may be granted to any graduate student in recognition of originality, ingenuity, thoroughness, and a scholarly written presentation of research embodied in a thesis of conspicuously unusual merit. As in the case of the Medal, nominations but not applications are receivable by the Dean of the Graduate School.

GRADUATE FELLOWSHIPS

The capitalized name in each case is that of the donor of funds which support the Fellowship, or the name of the person memorialized by it. All awards are for the academic year beginning September 22, 1952, unless otherwise specified.

Acoustics Laboratory

ACOUSTICAL MATERIALS ASSOCIATION, for a graduate student whose field of specialization is architectural acoustics, primarily in last year of work for an advanced degree, tuition plus $1,200 single, $1,800 married.

Aeronautical Engineering

AVIATION WEEK, for a male U. S. citizen enrolled for an advanced degree, renewable as long as satisfactory academic rating is maintained, $1,800.

DOUGLAS AIRCRAFT COMPANY, for a highly recommended graduate student, $1,500.

RICHARD C. DU PONT, memorial fellowship in aeronautical engineering, for a graduate student in any year of his work toward an advanced degree, tuition plus $1,200 single, $1,800 married. (Two available for 1952–53.)

GOODYEAR TIRE AND RUBBER COMPANY, for a graduate student, tuition plus $1,200.

SPERRY GYROSCOPE COMPANY, for a graduate student, tuition plus $1,700.

Architecture

GRUNSFELD EUROPEAN, for travel and study in Europe for a recipient of the B.Arch. or M.Arch. degree from M. I. T. during the calendar year 1952, $1,000.

Chemical Engineering

ALLIED CHEMICAL AND DYE CORPORATION, for a U. S. citizen in final year of graduate study, tuition plus $1,500.

AMERICAN CYANAMID COMPANY, for a graduate student during his final academic year of residence in work toward an advanced degree, tuition plus $1,500.

R. S. CRAWFORD GRADUATE RESEARCH, for a graduate student whose work is in the field of elastic colloids, tuition plus $1,200 single, $1,800 married.

DOW CHEMICAL COMPANY, for a graduate student whose research is in the field of high pressure chemical reactions, for two terms plus a regular summer session, tuition plus $1,200 single, $1,800 married.

E. I. DU PONT DE NEMOURS AND COMPANY, for a graduate student in any year of his work toward a Doctorate, tuition plus $1,400 single, $2,100 married.

GENERAL MOTORS CORPORATION (Research Laboratories Division), for a graduate student, renewable; tuition plus $1,200 single, $1,800 married.

HUMBLE OIL AND REFINING COMPANY, for a student enrolled for the S.M. or a Doctorate, tuition plus $1,250.

KIMBERLY-CLARK CORPORATION, for a graduate student whose research is in a subject of interest to the paper and pulp industry, $2,000.

ARTHUR D. LITTLE, memorial fellowship for a candidate for a Doctorate, $2,000.

PAN AMERICAN REFINING CORPORATION, for a graduate student in his last year of predoctoral study, tuition plus $1,200.

PITTSBURGH CONSOLIDATION COAL COMPANY, for a graduate student, candidate for a Doctorate, for three terms, tuition plus $1,440.

PROCTER AND GAMBLE COMPANY, for a graduate student in his last year of work toward the S.M., or in any year of his work toward a Doctorate, for three terms, tuition plus $1,800.

STANDARD OIL COMPANY (INDIANA), for a graduate student whose thesis subject is in the field of basic research in Chemical Engineering, tuition plus $1,200.

VISKING, for 1952–53, for a graduate student in the final year of his graduate work for the Doctorate in Chemical Engineering, tuition plus $1,500.

Chemistry

ALLIED CHEMICAL AND DYE CORPORATION, for a U. S. citizen in final year of graduate study, tuition plus $1,500.

E. I. DU PONT DE NEMOURS AND COMPANY, for a graduate student in any year of his work toward the S.M. or a Doctorate, tuition plus $1,400 single, $2,100 married.

EASTMAN KODAK, for a student in his last year of research study for the Ph.D., tuition plus $1,400.

ARTHUR D. LITTLE, memorial fellowship for a candidate for a Doctorate in Chemistry, $2 000.

FORRIS JEWETT MOORE MEMORIAL, for a graduate of the Institute for further study in residence or elsewhere, preference being given to the field of Organic Chemistry, $1,800.

JAMES FLACK NORRIS MEMORIAL, for a candidate for a Doctorate, $2,400.

UNION CARBIDE AND CARBON, for a graduate student in his final year of predoctoral study, tuition plus $1,400 single, $2,100 married.

UNITED STATES RUBBER COMPANY, for a candidate for a Doctorate, tuition plus $1,400 single, $2,100 married.

City Planning

F. W. CHANDLER, awarded upon recommendation of Head of Department to a candidate for the M.C.P., $1,200.

Economics

GOODYEAR TIRE AND RUBBER COMPANY, for a graduate student in the field of industrial economics or industrial relations, $2,500.

CLARENCE J. HICKS MEMORIAL, for a graduate of not more than 5 years (exclusive of military service) since his Baccalaureate from a college or university in the U. S. or Canada, who is a candidate for a Doctorate at M. I. T. in the field of Industrial Relations, up to $1,500.

INDUSTRIAL ECONOMICS AND INDUSTRIAL RELATIONS, for candidates for the Doctorate in these fields, several, up to $1,500.

WESTINGHOUSE FELLOWSHIP IN INDUSTRIAL RELATIONS, for a graduate student in this field, $2,500.

Research Laboratory of Electronics

INDUSTRIAL FELLOWSHIPS IN ELECTRONICS, for graduate students conducting thesis research in this Laboratory, several in various amounts. Sponsored jointly by INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION, RADIO CORPORATION OF AMERICA, WESTINGHOUSE, GENERAL RADIO, SOCONY-VACUUM LABORATORIES, and SPERRY GYROSCOPE COMPANY.

Food Technology

BRUCE'S JUICES, INC., for a male U. S. citizen, veteran of World War II, a graduate student, not to exceed $1,850.

PROCTER AND GAMBLE COMPANY, for a graduate student enrolled for the Ph.D. in the field of fat metabolism and approved by the Department of Food Technology, tuition plus $1,200.

QUAKER OATS COMPANY, for a graduate student, up to $1,500.

Industrial Management

SCHOOL OF INDUSTRIAL MANAGEMENT, for advanced study and research in Industrial Management, for college graduates whose major studies have been in science, engineering, and engineering administration. Awards may be continued for second year of study if performance justifies. A number of fellowships, tuition plus up to $1,400 single, up to $2,100 married.

SLOAN, for training in executive development, for industrial executives of some experience who are nominated by their employers, a twelve months' program with grants up to $3,700. (14 available for 1952–53.)

Mathematics

MATHEMATICS, for graduate students who are studying in the Department of Mathematics for careers of research or teaching in the various fields, tuition plus $800.

Mechanical Engineering

E. I. DU PONT DE NEMOURS AND COMPANY, for a graduate student in any year of his work toward a Doctorate, tuition plus $1,400 single, $2,100 married.

ETHYL CORPORATION, for a graduate student, preferably a candidate for the Sc.D., in the field of internal combustion in reciprocating engines, tuition plus $1,400 single, $2,100 married.

SHELL, for a graduate student, candidate for the S.M. or Sc.D., preference to be given to doctoral candidate; renewable, tuition plus $1,500.

Metallurgy

ALLEGHENY-LUDLUM FELLOWSHIP. Two fellowships for graduate students whose thesis research is on topics of interest to the alloy steel industry, tuition plus $1,800–$2,400.

ALUMINUM COMPANY OF AMERICA, three fellowships for graduate students whose thesis research is on topics of interest to the aluminum industry, tuition plus $1,200 to $1,800.

AMERICAN BRAKE SHOE COMPANY, for a graduate student, tuition plus $1,000.

AMERICAN SMELTING AND REFINING COMPANY, two fellowships for graduate students whose thesis research is in the field of physical chemistry of copper smelting, tuition plus $1,800 to $2,400.

ARMOUR AND COMPANY (AMMONIA DIVISION), for a graduate student whose thesis research pertains to the field of carbonitriding in the Department of Metallurgy, tuition plus $1,200 to $1,800.

ARMOUR AND COMPANY, for graduate students whose thesis research is in the field of flotation in the Department of Metallurgy. Several available for 1952–53, tuition plus $1,200 to $1,800.

REPUBLIC STEEL CORPORATION, for graduate students, in any department, whose thesis research, in a field ancillary to the production or uses of steel, is approved by the Department of Metallurgy. A Fellowship is renewable upon basis of satis-

factory progress. Several available for 1952–53, tuition plus $1,200 to $2,400.

REVERE COPPER AND BRASS COMPANY, for a graduate student, tuition plus $1,200.

TIMKEN ROLLER BEARING COMPANY, for graduate students in the Department of Metallurgy or Department of Mechanical Engineering whose thesis topic is in the general field of the grinding of metals, tuition plus $1,200 to $1,800.

UNION CARBIDE AND CARBON, for a graduate student for research in the metallurgical field, tuition plus $1,200.

WEIRTON STEEL COMPANY, for advanced research (postdoctoral) in fundamental corrosion studies, for 12 months, $5,000.

S. K. WELLMAN COMPANY, fellowship in Powder Metallurgy, for a graduate student in the Department of Metallurgy whose thesis research is in the field of Powder Metallurgy, tuition plus $1,200 for 12 months.

WYMAN-GORDON FELLOWSHIP. One fellowship for graduate student in the field of Metallurgy whose thesis work is concerned with the general fundamentals of the hot deformation of metals, tuition plus $1,200–$1,800.

Meteorology

RICHARD C. DU PONT MEMORIAL (All American Aviation, Inc., donor), for a graduate student in the Department of Meteorology. Renewable upon satisfactory progress. Preference to qualified employees of airlines and aviation companies who are granted leave of absence for such study, not to exceed $1,200.

Physics

E. I. DU PONT DE NEMOURS AND COMPANY, for a graduate student in any year of his work toward a Doctorate, tuition plus $1,400 single, $2,100 married.

GULF OIL CORPORATION, for a graduate student whose major work is in the field of petroleum physics in the Department of Physics. $1,500.

SHELL, for a graduate student, candidate for the S.M. or Sc.D. preference to be given to doctoral candidate; renewable, tuition plus $1,500.

Textile Technology

CLARK THREAD COMPANY, for graduate students in a field of textile technology whose thesis research is in that Division, three for 1952–53, tuition plus $1,000

LOWELL TEXTILE SCHOOL FELLOWSHIP, (Proprietors of the Locks and Canals on the Merrimac River, donors), for a graduate of the Lowell Textile School whose work is for an advanced degree in the Division of Textile Technology, two for 1952–53, $750.

NEW ENGLAND TEXTILE FOUNDATION, for a graduate student whose major field is in Textile Technology, recipient to be a graduate of Lowell Textile Institute, or any other textile school in New England, who is qualified for entrance in the above field, tuition plus $1,000.

TEXTRON, for a male graduate student, citizen of the U. S., in any year of his work toward the S.M. or a Doctorate, who is studying in the Division of Textile Technology; renewable. For 1952–53, tuition plus $1,800.

Unrestricted

(In any department)

BOLLES, for graduate work, $1,200.

GOTTESMAN FOUNDATION, for a graduate student in engineering for research in the pulp and paper field, tuition plus $1,200.

INTERNATIONAL BUSINESS MACHINES CORPORATION, for a graduate student in the field of electronics, tuition plus $1,400 single, $2,100 married.

INTERNATIONAL BUSINESS MACHINES CORPORATION, for a graduate student in the field of automatic control systems, tuition plus $1,400 single, $2,100 married.

WILLIAM S. KNUDSEN, for a graduate student in any field of science or engineering, tuition plus $1,200 single, $1,800 married.

ARTHUR D. LITTLE FELLOWSHIP FOR ADVANCED STUDY, for a postdoctoral student in any department, $3,500.

GERARD SWOPE FELLOWSHIPS, for predoctoral students graduates in an Honors Group or equivalent from M. I. T. or elsewhere for study at M. I. T., for study in residence or elsewhere. Reserved for students of exceptional ability and promise. Among equally well qualified candidates, preference to be given to (*a*) residents of St. Louis, Mo., (*b*) residents of Highland Park or New Brunswick, N. J., (*c*) employees of General Electric Company or their children. This award is a mark of highest distinction. Several for 1952–53, $1,000.

GRADUATE SCHOLARSHIPS

Unrestricted

AUSTIN and WHITNEY FUNDS	$25,000
COLLAMORE and ROGERS FUNDS (for women)	2,800
SALTONSTALL FUND	400
SAVAGE FUND	800
SWETT FUND	400

In Specified Fields

DALTON FUND, for advanced chemical study and research, preference given to chemical research especially applicable to textile industries. $400.

HOBBS FUND, in Architecture. $500.

WILFRED LEWIS FUND, in Mechanical Engineering. $400.

THORP FUND, for a member of previous year's graduating class of M. I. T., studying for an advanced degree in Chemical Engineering. $600.

VERGES FUND, for a graduate student whose research is related to sugar chemistry. $800.

Regional Awards

HEBREW INSTITUTE OF TECHNOLOGY, Haifa, Israel, for a staff member, tuition; in conjunction with an award by The Boston Stein Club.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, London, England, tuition.

M. I. T. CLUBS OF MEXICO, for a graduate student nominated by the Alumni of M. I. T. Clubs of Mexico City and Monterrey, tuition for 1952–53.

THEODORE B. PARKER MEMORIAL for graduates of colleges of the Tennessee Valley States, tuition.

VERMONT SCHOLARSHIP. Open to a native of Vermont or a graduate of Middlebury College or Norwich University. Undergraduate applications have preference, tuition.

OTHER AWARDS
NOT ADMINISTERED BY THE GRADUATE SCHOOL

Housing

ALBERT FARWELL BEMIS FOUNDATION FELLOWSHIP, to aid a student in his research on any significant aspect of housing, from broad studies of needs and requirements to specific problems in management, design, procurement, production and marketing. May lead to a master's or a doctor's degree in an appropriate Institute course, or may be undertaken without reference to a degree. Up to $2,500. Apply to Director, Bemis Foundation, M. I. T.

APPENDIX B

STUDENT HOUSING

Including Men's Residences, Women's Residence, and Residences for Married Students

(All rentals and information apply to the school year 1952–53 and are subject to change.)

THE UNDERGRADUATE HOUSES

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 extracurricular activities which properly supplement scholastic work. A Faculty Resident occupies quarters in each of the three residential centers. Chosen for their understanding of students and student questions, these men welcome informal friendly discussions with their fellow residents.

The Institute believes that it is to the great advantage of all students who do not live at home to live in Institute Houses or in fraternities. Such residence is required for all freshmen unless other special arrangements are approved by the Associate Dean of Students. The Institute has no specific regulations, however, as to the place where upperclassmen must live, and they are free to make whatever living arrangements they choose.

Government

The undergraduate houses are administered as a part of the general plan of student self-government at the Massachusetts Institute of Technology, with the co-operation of an Advisory Committee, appointed by the President. The Student Dormitory Committee organizes and supervises all student activities, athletic and social, and co-operates with recognized undergraduate activities at the Institute.

The success of student self-government depends upon the willingness of every resident to co-operate and contribute, and therefore upon the responsibility which the group as a whole is willing to assume. Those who are unable or unwilling to live under student government and support its principles in the strictest sense, whether on or off the Institute grounds, are undesirable tenants, and are so recognized by the Student Dormitory Committee and the Advisory Committee. The privilege of residence in the undergraduate houses will therefore be denied to those who do not accept this responsibility.

A House Tax included in rental is turned over to the Student Dormitory Committee for social and athletic activities.

The Everett Moore Baker House
(West Campus)

Located on the river front at 362 Memorial Drive, Cambridge, west of Massachusetts Avenue, Baker House was completed and occupied during the academic year 1949–50. The House, which accommodates some 350 students in single, double, or triple rooms, offers many distinctive features. All private rooms in it receive direct sunlight during most of the day, and nearly all have spectacular views across the Charles River Basin. On the north are living rooms with large window areas looking out on the Institute's playing fields. Generous lounge space is provided on each of the floors, with a main lounge adjoining the entrance. On the ground floor is a community area including music, recreation, and social rooms. Baker House has its own dining facilities, where residents are expected to take commons meals. (See Page 211.)

The Alfred Edgar Burton House
(West Campus)

This House is also on the river front at 410–420 Memorial Drive, Cambridge, west of the Baker House. Formerly an apartment hotel, it has been converted into a residence house and completely refurnished and redecorated. It consists of five units accommodating 600 students. There are some single and double rooms but most of the accommodations are suites of rooms designed for congenial groups. Units 1 and 2 of the 410 section of this house are operated on the co-operative plan and residents accept responsibility for the care of their own rooms.

Residents of the House who choose to do so may include commons meals with the rental and will be served in one of the campus dining rooms. The building has a number of lounge and game rooms, and a bicycle room. A completely modern snack bar on the ground floor has just been opened to accommodate those students who live on West Campus. Open from 7:30 in the morning to 12:00 midnight, seven days a week, this provides a very pleasant place to meet friends and relax.

Units 3, 4, and 5 of the 420 section are not on a co-operative basis and the rooms are cared for by Institute personnel.

The Faculty Houses
Ware, Atkinson, Runkle, Holman, Nichols, and Crafts
(East Campus)

These six houses, located on Memorial Drive, east of Walker Memorial and adjacent to the President's House, accommodate about 225 students.

Most of the first floor rooms in all the houses except Crafts and Ware are designed for single occupancy. On the upper floors most of the quarters are suites, composed of a living room, a dressing room, with lavatory, and a sleeping room arranged for two students.

The Alumni Houses
Munroe, Hayden, Wood, Goodale, Bemis, Walcott
(East Campus)

Situated on the main campus near Walker Memorial, these six houses have accommodations for 430 men. Most of the rooms are designed for single occupancy — with a limited number of double and triple suites. There are lavatory installations in all these rooms, supplemented by adequate toilets and showers on each floor of every house.

Dining facilities for residents of the East Campus Houses are in the Walker Memorial Building. This includes a large cafeteria where both commons meals and à la carte service are provided. A modern social room and soda bar, where light refreshments are served, is located in Pritchett Lounge on the second floor. This room is open to residents of the house and their guests during the evening hours, and is equipped with a dance floor and other facilities for entertainment.

Application

Applications for rooms should be sent to the Associate Dean of Students, Massachusetts Institute of Technology, Cambridge 39, Massachusetts. Each Freshman and college transfer student will receive with his notice of admission a form for use in requesting up-to-date information about dormitory accommodations, including an application.

Assignment of Rooms

Current Residents: Priority in the assignment of rooms for the year 1952–53, except those especially reserved for entering first-year students, is granted to students in residence.

Application forms for the next regular year will be distributed to residents prior to the end of the spring term and must be returned to the Associate Dean of Students. Assignments will be made to these applicants immediately and a definite reservation made. The right is reserved to reject any application for sufficient reason.

FRESHMEN: The number of rooms reserved for Freshmen in the undergraduate houses varies from year to year but is arranged to accommodate all first-year students who do not live at home or who are not affiliated with a recognized fraternity and live in the fraternity house. All applications received on or before August 15 will be subject to a drawing and applicants will be notified of an assignment in the undergraduate houses.

OTHER NEW STUDENTS: Students transferring from other colleges with upper-class status are urged to file application promptly after admission for assignment to rooms not reserved for freshmen.

OCCUPANCY

The period of occupancy for an academic year extends from the Wednesday preceding Registration Day (see Calendar in Catalogue) through the Tuesday following the last day of the scheduled final examination period. All accommodations are for the full academic year, except as indicated below in the sections on "Fraternity Affiliation" and "Fees — Refunds."

On arrival in Cambridge, a student should report to the desk in the lobby of the house to which he has been assigned. At this time he will complete his dormitory registration and obtain a key. Every effort will be made to accommodate students who find it impossible to arrive during the normal business hours; in the event of difficulty in locating the proper dormitory unit, inquire at the Institute's Information Office in the Rogers Lobby at 77 Massachusetts Avenue, which is attended at all times.

A student is not allowed to sublet or transfer his room or his share in a room to any person without the prior approval of the Associate Dean of Students. Changes from room to room within the Houses, for cause, may be made if approved by the Associate Dean of Students.

COMMONS MEALS

All freshmen living in the Dormitories are required to take commons meals, provided in Walker Memorial for residents of East Campus and in Baker House or in one of the other dining halls for residents of Burton House. Three meals are served each day Monday through Friday, except during stated vacation periods; on Saturdays and Sundays, and during vacations, the dining facilities of the Institute are available on a cash basis. The fee for commons meals, at the rate of $10.75 per week, is payable for the full term in advance with the tuition. The commons meal fee for the fall term, 1952–53, will be $182.75. Arrangements for deferred payment may be made through the Bursar before payment is due.

Upperclassmen are invited to take commons meals on the same basis by making arrangements with the Dining Service.

FRATERNITY AFFILIATION

The "recognized list" of fraternities at the Massachusetts Institute of Technology includes twenty-six chapters situated on private property in Cambridge, Boston, and Brookline. Residence in the undergraduate houses or fraternities provides a more intimate contact with Technology life and activities. Approximately ninety per cent of the fraternity Freshmen are pledged early in the Fall term, and in order that they may assume residence at the fraternity houses of their choice immediately and thereby release accommodations to those who prefer residence in the undergraduate houses, the privilege of cancellation of reservations is extended to those who make a decision on or before Registration Day. Parents who anticipate fraternity affiliation for their sons should, if possible, encourage them to participate in Rush Week and grant them permission to act on their own initiative. The satisfactory and permanent housing of a large group of entering students can be accomplished best through the co-operation of parents, students, and fraternity and Institute housing representatives in making early and prompt decisions so that temporary housing is reduced to a minimum. Freshmen and other new students are therefore requested to withdraw applications for residence promptly if they are certain that such accommodations will not be required.

FEES — REFUNDS

Rental rates for accommodations in the dormitories vary from $120 to $190 each person each term. Though less than rated occupancy of any suite is not encouraged, where space is available one man may apply to occupy a double, two men a triple, or three men a four-man suite at an additional charge of $50 each term each man. In the Co-operative Unit of the Burton House, or any House for which there is a waiting list, this privilege will not be possible. The following rates apply to the academic year, 1952–53:

EAST CAMPUS: $165 each student each term, except for: Bemis double rooms 112, 212, 312, 412, and 512; Atkinson single rooms 204A, 304A, 404A, and 204B, 304B, and 404B; and Runkle single rooms 206A, 306A, 406A, 501, 502, 505, 601, 602, 603, 604, 604A, 605, and 605A — all of which are $130 each term each man.

BAKER HOUSE: $190 each student each term.

BURTON HOUSE: $120 each student each term in the Co-operative Section; see accompanying floor plan for rates in the 420 section of this House.

Rent for the full term is payable with tuition to D. L. Rhind, Bursar, except when prior arrangements are made with the Bursar for deferred payments. Each student assigned a room in the dormitories will be expected to meet his obligation in full except as provided under "Fraternity Affiliation" unless notice of cancellation is given to the Associate Dean of Students three weeks prior to Registration Day.

Rooms are engaged for the full academic year. Reservations are automatically cancelled and a proportionate refund is allowed upon withdrawal of a student from the Institute or transfer to a co-operative course, or in the event of a leave of absence for military service. Freshmen or other new students resident in the undergraduate houses who desire to move to recognized fraternities after Registration Day and prior to the end of the third week of the Fall term and whose transfer is requested by authorized representatives of the fraternity will be refunded the rental fee less a charge for occupancy at the weekly rate.

EQUIPMENT AND SERVICE

All rooms in the undergraduate houses are fully equipped for occupancy, all single rooms having a special bed or couch, all-hair inner-spring mattress, pillow, blankets, mirror, chiffonier or wardrobe, desk and chair, study chair, bookcase, wastebasket, light bulbs, and extra electrical outlets. Inter-dormitory telephone service is provided. Double and triple suites are furnished in a manner similar to the single rooms. Each occupant is expected to complete an equipment inventory acknowledgment at the opening of the fall term, indicating the condition of the room and the furnishings. A student will be held responsible for losses or for unusual damage occurring during his occupancy.

Bed linen is furnished in all houses. Except for the Co-operative Section of Burton House, the beds are made up with clean linen once a week by Institute personnel and the rooms are cleaned daily, but not on week ends and holidays. In the Co-operative section of Burton House, each occupant is responsible for the cleaning and care of his own room, drawing fresh bed linen once a week from the supply room. Students in all houses provide their own towels and soap.

For maintenance and safety, rooms are inspected regularly during the normal working hours by responsible Institute personnel.

GENERAL INFORMATION

VISITORS. Since the Houses are the residences of men students, ladies are not permitted in other than the public rooms except on special occasions as recommended by the Dormitory Committee with the approval of the Associate Dean of Students. Violation of this regulation will result in the cancellation of residence.

KEY DEPOSITS. A deposit of $1 is required for a room key, subject to refund in full upon return of the key.

ELECTRICAL APPLIANCES. Since they impose hazards to the safety of residents, electrical appliances other than clocks, radios, razors, and refrigerators may not be used in the Houses. Applications for installation of refrigerators must be obtained from the Associate Dean of Students; a fee of $2.50 per term or part of a term during which a refrigerator is in use is to be paid at the Cashier's Office. Short-wave transmitters and television sets are subject to special arrangements with the Dean's Office.

PARKING AND AUTOMOBILE REGULATIONS. Because of the acute shortage of on-campus parking space students who bring automobiles to Cambridge must be prepared to make their own arrangements for parking.

Operators of motor vehicles should consult the Office of the Dean of Students or the Massachusetts Registry of Motor Vehicles, regarding regulations and insurance of out-of-state

motor vehicles. The registration and operating licenses of certain states are not honored in Massachusetts after thirty days.

STORAGE. Space is available in the basement for trunks and baggage during the academic year only and at the owner's risk. The Institute assumes no liability, and articles must be removed when occupancy is terminated. No packing cases or trunks are permitted in the rooms.

MAIL, PARCEL POST, AND EXPRESS SERVICE. Each room or suite has a separate combination lock mail box, located in the house office. In addressing mail or packages to a student in the Houses, please specify the house (e.g. East Campus, 3 Ames Street, or Burton House, 420 Memorial Drive, or Baker House, 362 Memorial Drive, or the Graduate House), Massachusetts Institute of Technology, Cambridge 39, Massachusetts.

TELEPHONE SERVICE. Local and long distance calls for resident men students should be made by calling KIrkland 7-6900. An inter-dormitory telephone system provides internal service between rooms (corridors in the case of Burton House) of the various men's residence houses. Telephone pay stations for outgoing telephone calls and telegrams are conveniently located about the Houses.

LAUNDRY AND VALET SERVICE. Laundry and valet service by the Institute's authorized suppliers is available at reasonable prices to residents of the Houses for their personal laundry and cleansing on a cash basis. Laundry bags, slips, and tags are available at the office desk. Notification of return of laundry will be through the mail boxes. Laundry and valet service take four days.

DINING SERVICE. The Institute operates a complete dining service near each of the dormitory units. Baker House and the Graduate House have their own dining rooms. In addition to commons meals, a la carte service is available seven days a week, supplemented by snack bars in Walker Memorial, the Graduate House and Burton House, which are open every night until 12 p.m.

The preparation of meals or cooking of any kind in the Houses is prohibited.

OPPORTUNITIES FOR STUDENT EMPLOYMENT

As stated under "Financial Aids" on page 36 of the Catalogue, the Institute provides many opportunities for students to earn a part of their expenses. The operations of the Dormitories and the Dining Service lend themselves especially to part time work; Burton House, for example, is staffed entirely by student personnel. For information, write to Dean T. P. Pitré, Director of Student Aid, at the Institute.

WOMEN'S RESIDENCE

The Women's Dormitory, located at 120 Bay State Road, Boston (telephone CIrcle 7-8646) accommodates 17 students. It is an attractively furnished house where girls may enjoy a home-like atmosphere. A House Mother is in residence. The Dormitory is a fifteen to twenty minute walk to M. I. T. Breakfast and dinner are served to all residents during the academic year in accordance with the schedule planned in advance by the residents of the house. The girls also have the privilege of preparing their lunches with food provided by the house. During the Summer Session residents are allowed kitchen privileges. Application forms as well as further information may be obtained from the Associate Dean of Students.

THE GRADUATE HOUSE (WEST CAMPUS)

The Graduate House, with a capacity of 448 residents, is reserved exclusively for men graduate students. It is located at Memorial Drive and Massachusetts Avenue, Cambridge, directly across the avenue from the main educational buildings. The House was established in the belief that "those contacts which aid in developing qualities of leadership and co-operation would be encouraged by bringing graduate students into one group." In further justifying this new development in student life at the Institute, it was pointed out that "the most natural training comes from free social intercourse between men of different interests but of equivalent intellectual outlook."

On the first floor of the west wing of the House are the public rooms and the dining rooms. In addition to an attractive lounge, the Crafts Living Room and Library, named for James M. Crafts, President of the Institute at the turn of the century, are on the first floor at the end of the west corridor leading towards the Charles River. The Macomber Room, a small lounge, also opens from this corridor, and is used chiefly in connection with the Fabyan Dining Room. The Buttery, containing a soda bar, is located on the lower level of the west wing. The hand ball court, the ping-pong room, the photographic dark room, and a large, modern shower room are in the corresponding east wing basement.

A member of the Faculty who is familiar with the general aims and problems of graduate students is resident house master. A student house committee, acting with the advice and assistance of the House Master, has charge of the activities program.

A number of general social activities are sponsored by the Graduate House. Informal gatherings are held on Tuesday and Thursday evenings in the Buttery. Sunday afternoon teas are held during the academic year. A series of Graduate House dinners is held on Wednesday evenings from the end of October until the week of April 19, and a distinguished guest is invited on each of these occasions to make a brief address. Participation in these different functions is urged for all residents of the Graduate House.

In keeping with the widespread interest in athletics among graduate students, there are organized in the House teams in touch-football, in basketball, in bowling, in soft ball, and in rugby. To take advantage more fully of the facilities for sailing afforded by the Institute, House residents participate in the shore school held by the Nautical Association. Opportunities are available for contests in the game rooms within the House and for tennis and squash on courts maintained by the Institute.

A House Tax, included in the rental, is turned over to the Graduate House Committee for library, athletic, and social activities, and for the maintenance of the Dark Room, the Buttery Hour, and the Music Room.

THE CRAFTS LIVING ROOM is a large, comfortably furnished living room designed for the use of residents and their guests at any time from eight o'clock in the morning until midnight. The Lounge is available for similar purposes. Since the Graduate House is the residence of men students, ladies are not permitted in other than the public rooms except on special occasions as recommended by the House Committee with the approval of the Associate Dean of Students.

CRAFTS LIBRARY. There is a collection of more than two thousand volumes dealing with the history of science, engineering, architecture, economics, philosophy, and the biographies of eminent scientists, engineers, architects, and philosophers. The most useful handbooks for engineering and science together with dictionaries and encyclopaedia are provided. The library carries subscriptions to a number of leading magazines.

APPLICATIONS FOR ROOMS

Applications for rooms in the Graduate House should be made to the Associate Dean of Students, Massachusetts Institute of Technology, Cambridge 39, Massachusetts. Application forms are sent with the notice of admission to new graduate students.

If applying for double or triple suites, the applicant may indicate on the application suggestions of possible roommates. Lacking any suggestions, he will be provided an opportunity for meeting prospective roommates.

ASSIGNMENT OF ROOMS

Priority in the assignment of rooms is granted to Graduate Students already living in the House whose applications are filed in accordance with a circular issued during the Spring Term. Notices of assignments will be forwarded to these applicants as soon as possible. Acceptances must be returned as requested; otherwise, the rooms may be reassigned. The assignment of the remaining rooms by the Associate Dean will be in order of application. The right is reserved to reject any applicant for sufficient reason.

OCCUPANCY

The period of occupancy for an academic year extends from the Wednesday preceding Registration Day (see Calendar in Catalogue) through the Tuesday following the last day of the scheduled final examination period. All accommodations are for the full academic year, except as indicated below in the section on "Fees — Refunds."

Fees — Refunds

Rental rates for the Graduate House for the year 1952–53 are shown on the accompanying plans.

Rent for the full term is payable with tuition to D. L. Rhind, Bursar, except when prior arrangements are made with the Bursar for deferred payments. Each student assigned a room in the Graduate House will be expected to meet this obligation in full unless notice of cancellation is given to the Associate Dean of Students three weeks prior to Registration Day.

Rooms are engaged for the full academic year. Reservations are automatically cancelled and a proportionate refund is allowed upon withdrawal of a student from the Institute or transfer to a co-operative course, or in the event of a leave of absence for military service.

General Information

Please refer to the undergraduate section on the preceding pages for information on: Equipment and Service, Visitors, Key Deposits, Electrical Appliances, Storage, Mail, Parcel Post and Express Service, Telephone Service, Laundry and Valet Service, Dining Service, and Opportunities for Student Employment.

Parking and Automobile Regulations. As a result of the acute shortage of space only a limited number of on-campus parking permits are available for residents of the Graduate House. Students who bring automobiles to Cambridge should be prepared to make their own arrangements for parking.

Operators of motor vehicles should consult the Office of the Dean of Students or the Massachusetts Registry of Motor Vehicles, regarding regulations and insurance of out-of-state motor vehicles. The registration and operating licenses of certain states are not honored in Massachusetts after thirty days.

RESIDENCES FOR MARRIED STUDENTS

"Westgate" and "Westgate West" are housing developments on the campus designed for married students and their families. Residents must be registered as regular students and candidates for a degree at the Institute. Application may be made in advance of registration, but no assignment of a unit will be considered until the proposed tenant has submitted registration material. In general, priority for accommodations in Westgate and Westgate West is accorded first to married veterans with children, and to childless married veterans next, with due respect to their full-time or part-time status as students. Civilian graduate students are next in preference, those with children having priority if on full-time student status.

Applications for Westgate and Westgate West should be submitted to the Associate Dean of Students.

Westgate

The Westgate project consists of temporary one-story dwellings on the Institute Campus. There are 100 houses in the group, arranged in either single or duplex units. They are similar to small apartments with the privacy of a home and with the additional advantage that each house has its own plot of land.

Fifty of the homes, which are reserved for couples without children, consist of a living room, kitchenette closed off by doors, bath, one bedroom, and closet space. The larger 50 have in addition an extra bedroom and a separate kitchen.

Both the small and large units in Westgate are unfurnished except for a refrigerator, stove, and kitchen cabinet, all in one compact unit. All of the units have thermostatically controlled gas heaters and hot water units.

Tenants occupying Westgate units are required to sign a lease under which the rent is $51 and $63 per month for the one-bedroom and two-bedroom units, respectively, including electricity and water. The cost of gas for cooking, heating, and hot water is not included in the monthly rental given above and is estimated to be approximately $10 a month over the calendar year.

Westgate West

Westgate West, with 170 apartments, is adjacent to Westgate. Each two-story building contains 10 apartments; each of these has its own private entrance, and consists of two bedrooms, a living room, kitchen, bath and storage space. Some of the apartments are partially furnished, but tenants are responsible for providing their own furniture. The apartments are equipped with an ice box, gas stove, and thermostatically controlled gas heater and hot water unit. Gas refrigerators are not permitted in either Westgate or Westgate West, but tenants may install their own electric refrigerators in Westgate West.

Tenants occupying Westgate West units are required to sign a lease under which the rental is $37 per month, including water, but not electricity or gas. It is estimated that $15 per month should cover the cost of gas and ice, over and above the rental quoted. Electricity is metered, and the cost subject to the amount used. Telephone connections are available to residents of both Westgate and Westgate West on application to the telephone company.

Off-highway play areas are provided for the children and a nursery school is available to all Westgate and Westgate West children from the ages of two to five. The nursery school is in operation at stated hours, by age groups, on school days (except Institute holidays) and is in the charge of a trained nursery school teacher who is assisted by two or three apprentice teachers. The school has grown out of the efforts of the Westgate Council, a governing body formed within the project, and is subsidized in part by the Technology Christian Association. A Well Baby Clinic is held once a month. A recreation room has been provided for the Westgate Council meetings and special parties. For the convenience of Westgate and Westgate West wives, a community laundry (also a project of the Technology Christian Association) is located on the premises and is easily accessible to the tenants. Limited parking space is available adjacent to the houses for residents.

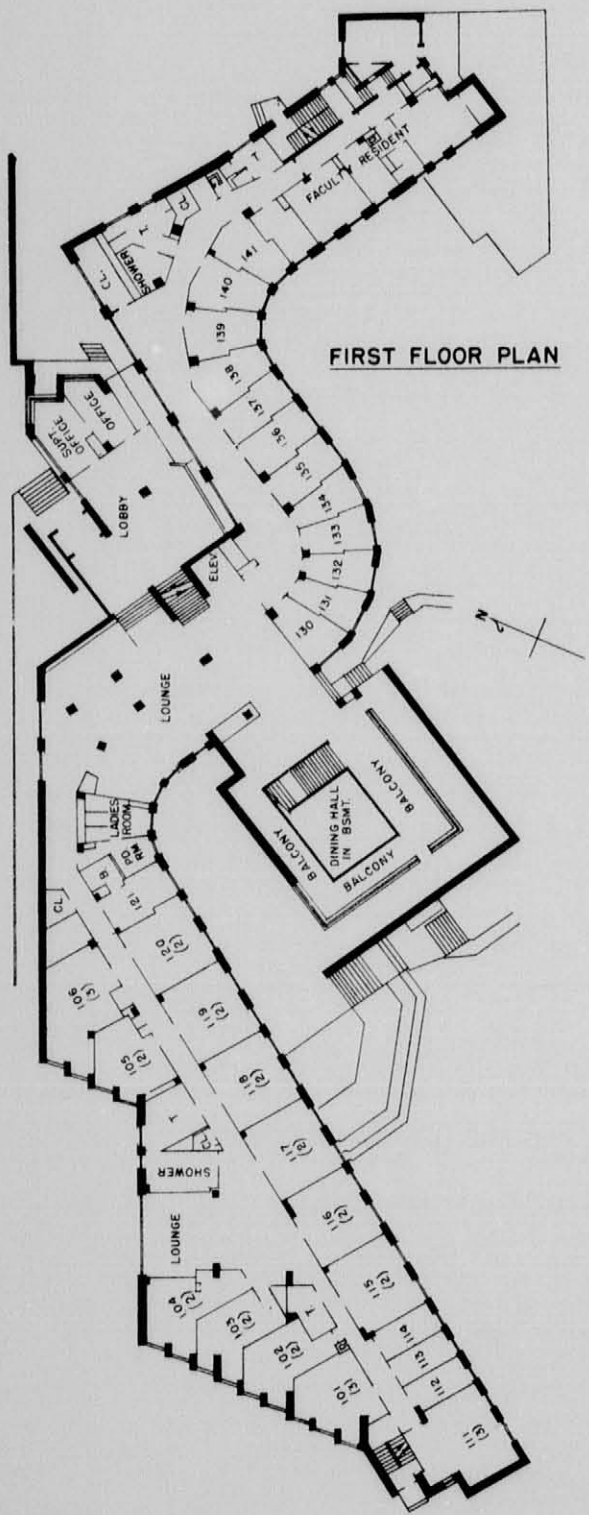
Technology Lane

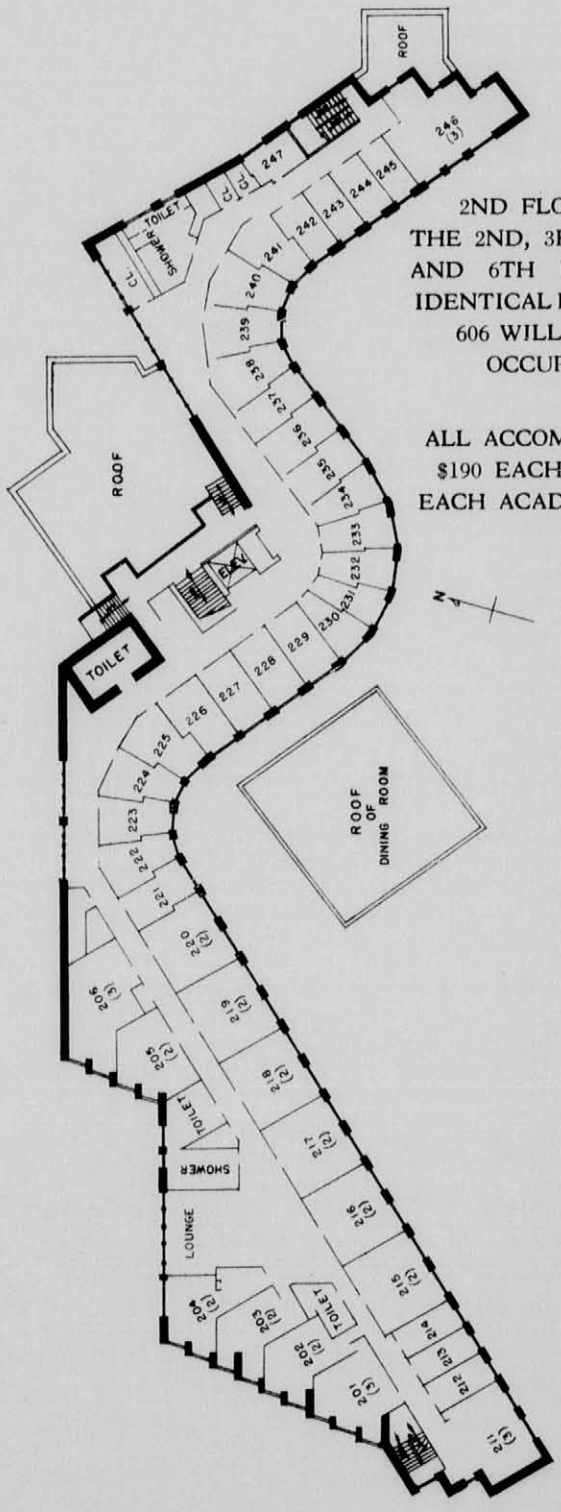
The Institute has also provided a small plot of land between Westgate and Westgate West on which ten trailers may be parked. Technology Lane is also reserved for Institute students and is operated co-operatively by the residents of the ten trailers. The Associate Dean of Students maintains a waiting list for the trailer spaces and application may be made in the same manner as for Westgate and Westgate West.

Married students who cannot be accommodated in Westgate or Westgate West should refer to the Housing Bureau of the Technology Christian Association, Walker Memorial, Massachusetts Institute of Technology, Cambridge 39, for local real estate listings.

UNDERGRADUATE HOUSES

The Baker House (West Campus)





2ND FLOOR PLAN
THE 2ND, 3RD, 4TH, 5TH. AND 6TH FLOORS ARE IDENTICAL EXCEPT ROOM 606 WILL BE FOR 2 OCCUPANTS.

ALL ACCOMMODATIONS $190 EACH OCCUPANT EACH ACADEMIC TERM.

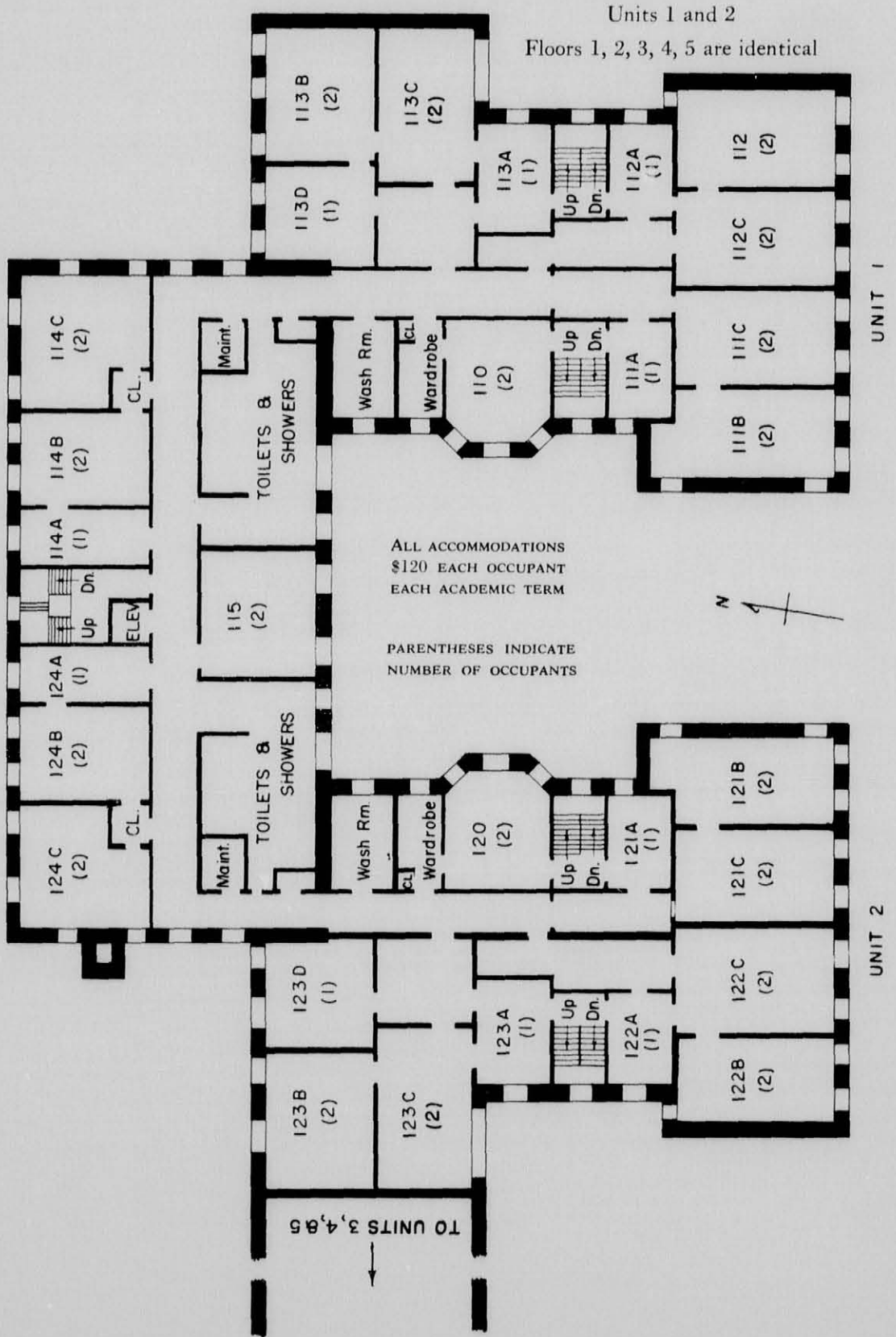
UNDERGRADUATE HOUSES

The Burton House (West Campus)

420 Memorial Drive

Units 1 and 2

Floors 1, 2, 3, 4, 5 are identical



UNDERGRADUATE HOUSES

The Burton House (West Campus)

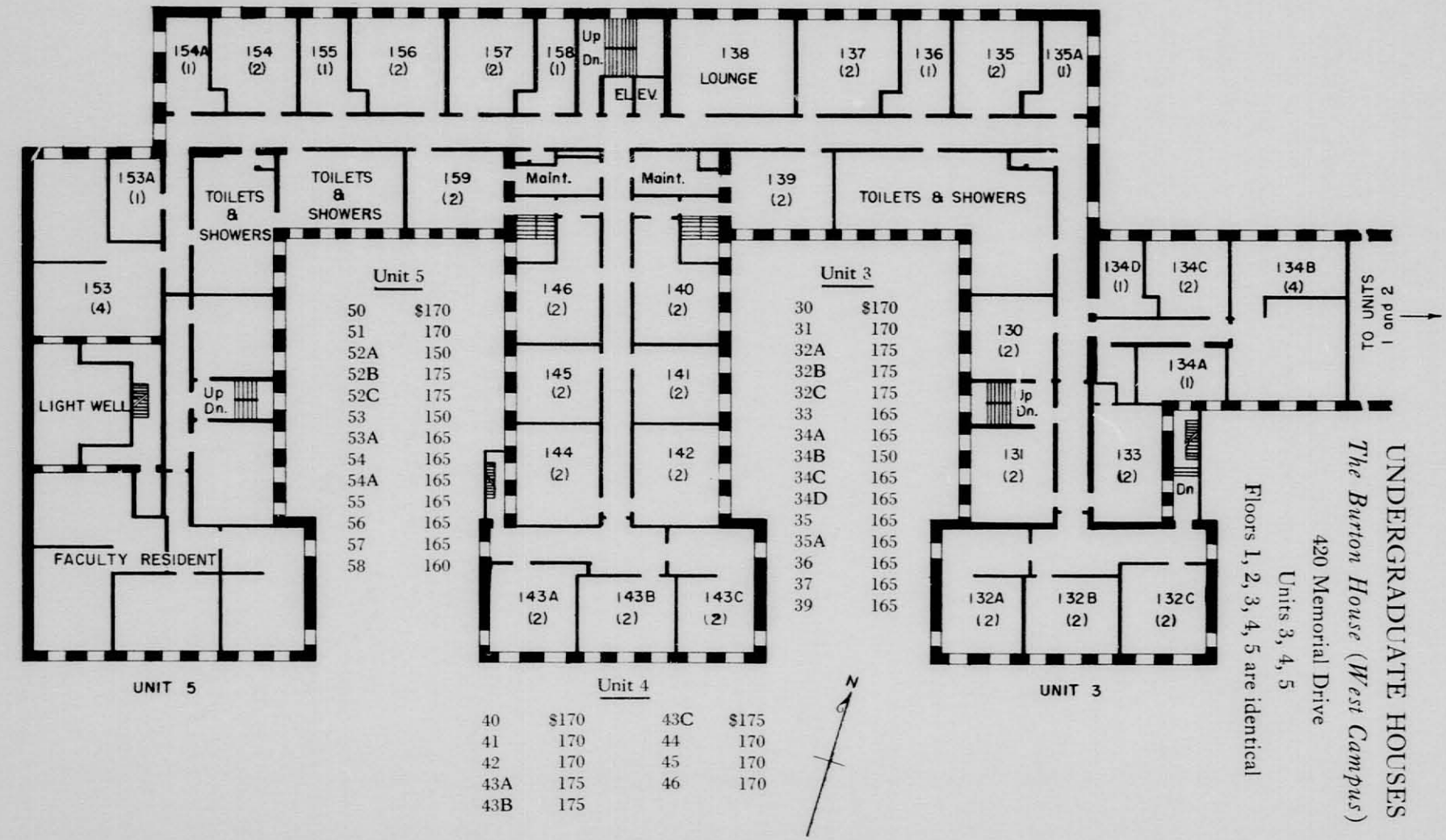
420 Memorial Drive

Units 3, 4, 5

Floors 1, 2, 3, 4, 5 are identical

Rates for Floors 1, 2, 3, 4, 5

Prices listed are for each occupant each academic term
Parentheses indicate number of occupants



Unit 5

50	$170
51	170
52A	150
52B	175
52C	175
53	150
53A	165
54	165
54A	165
55	165
56	165
57	165
58	160

Unit 3

30	$170
31	170
32A	175
32B	175
32C	175
33	165
34A	165
34B	150
34C	165
34D	165
35	165
35A	165
36	165
37	165
39	165

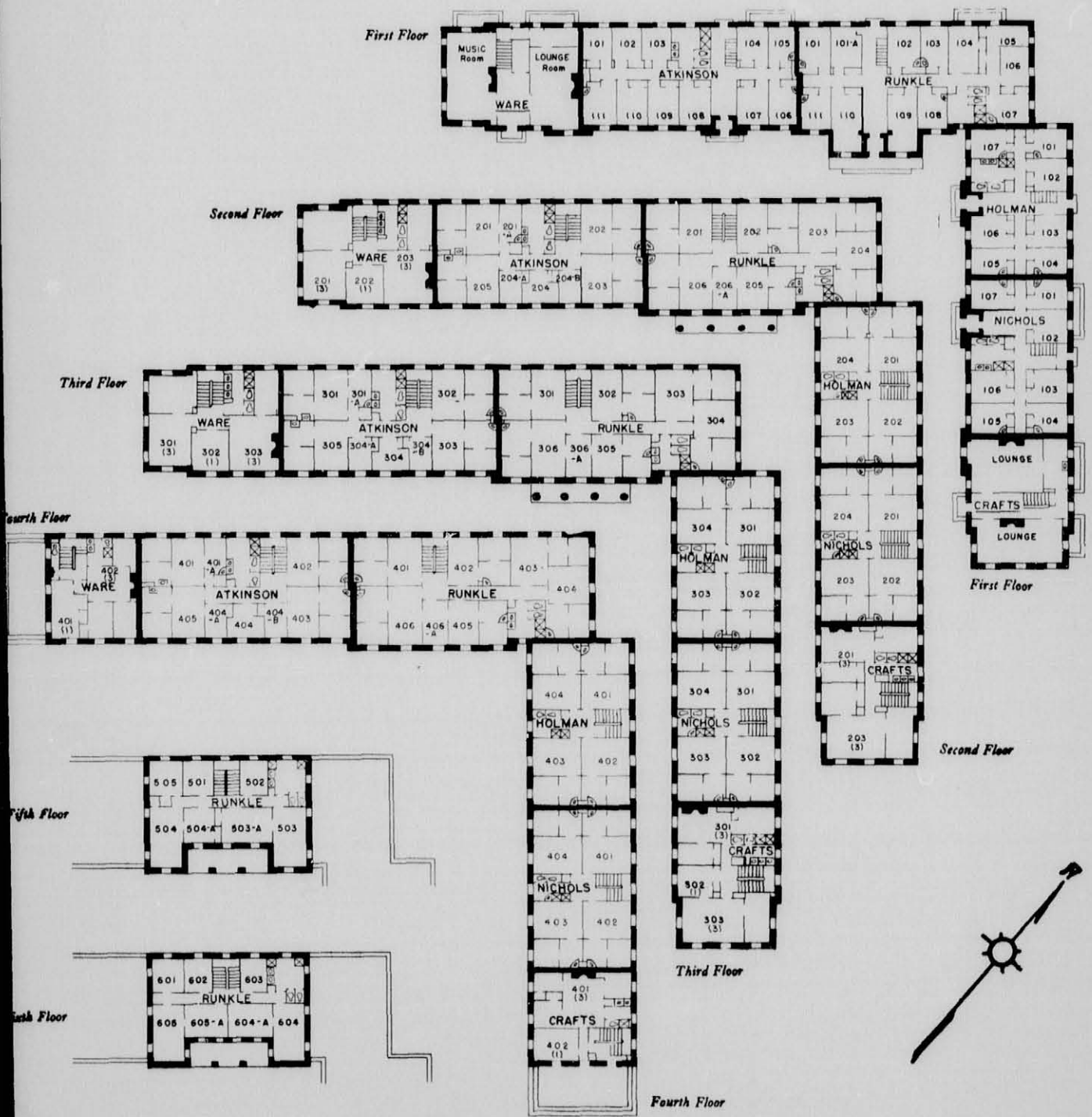
Unit 4

40	$170	43C	$175
41	170	44	170
42	170	45	170
43A	175	46	170
43B	175		

UNDERGRADUATE HOUSES

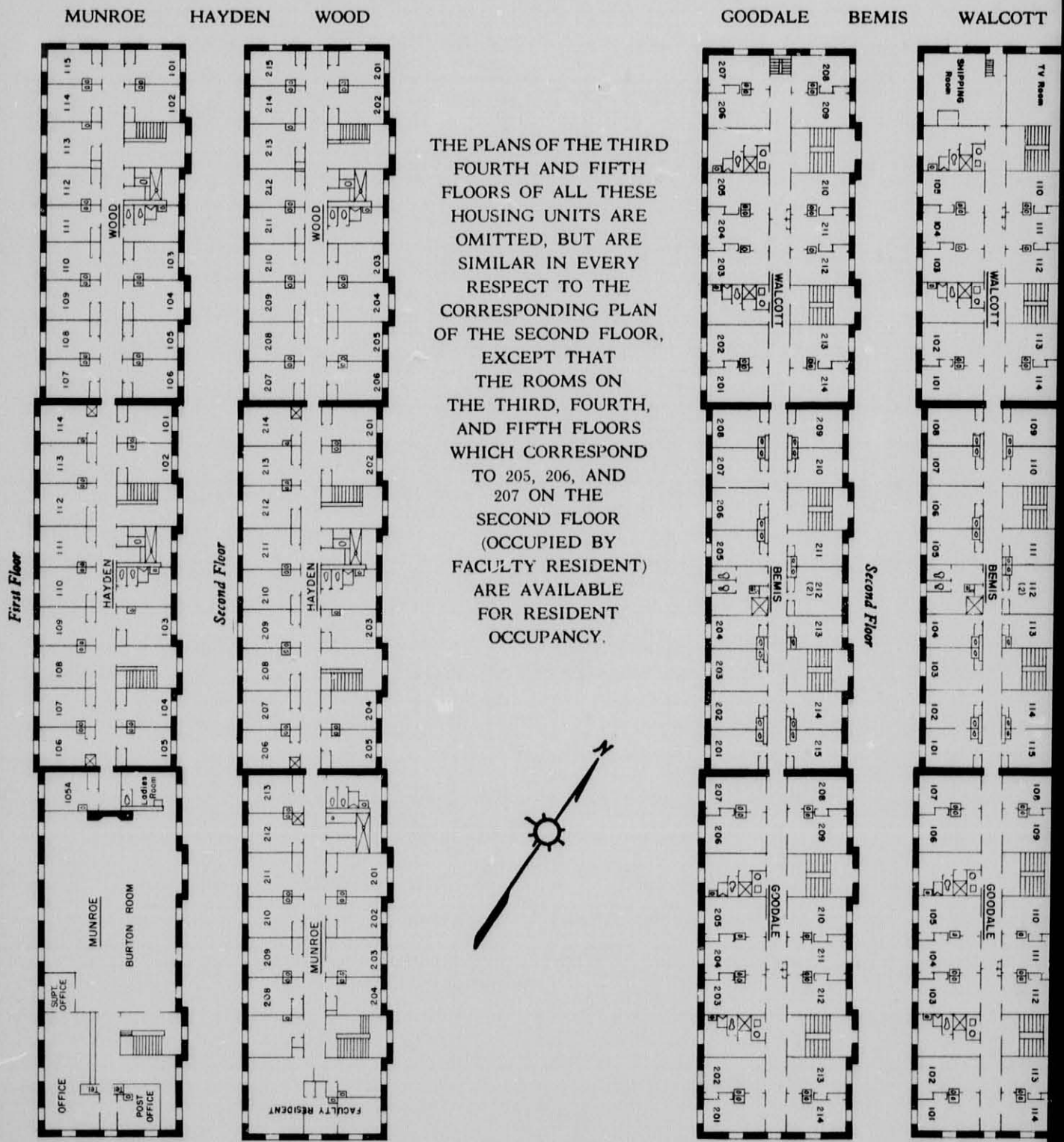
The Faculty Houses (East Campus)

WARE ATKINSON RUNKLE
HOLMAN NICHOLS CRAFTS



UNDERGRADUATE HOUSES

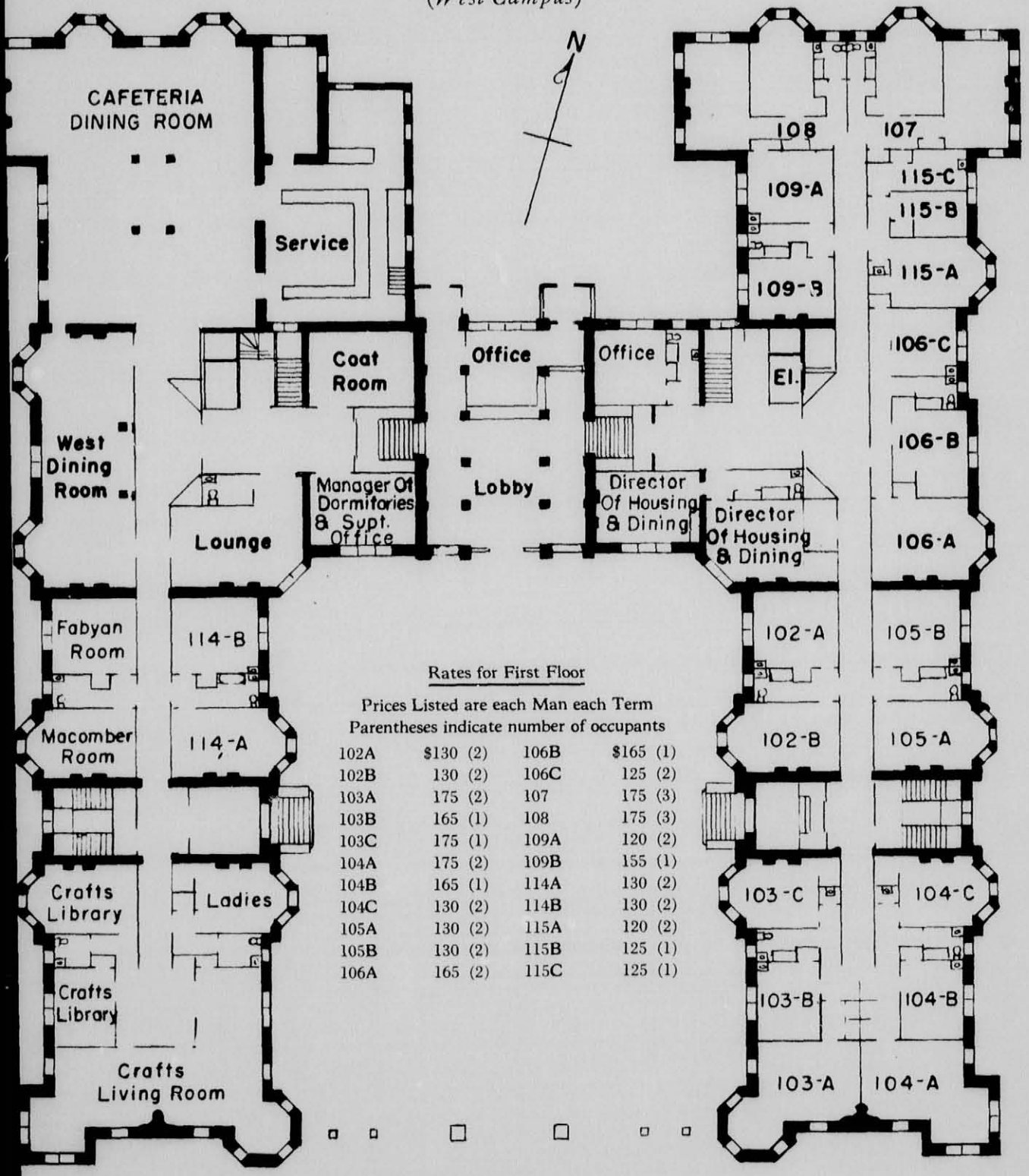
The Alumni Houses (East Campus)



THE PLANS OF THE THIRD FOURTH AND FIFTH FLOORS OF ALL THESE HOUSING UNITS ARE OMITTED, BUT ARE SIMILAR IN EVERY RESPECT TO THE CORRESPONDING PLAN OF THE SECOND FLOOR, EXCEPT THAT THE ROOMS ON THE THIRD, FOURTH, AND FIFTH FLOORS WHICH CORRESPOND TO 205, 206, AND 207 ON THE SECOND FLOOR (OCCUPIED BY FACULTY RESIDENT) ARE AVAILABLE FOR RESIDENT OCCUPANCY.

THE GRADUATE HOUSE

(West Campus)



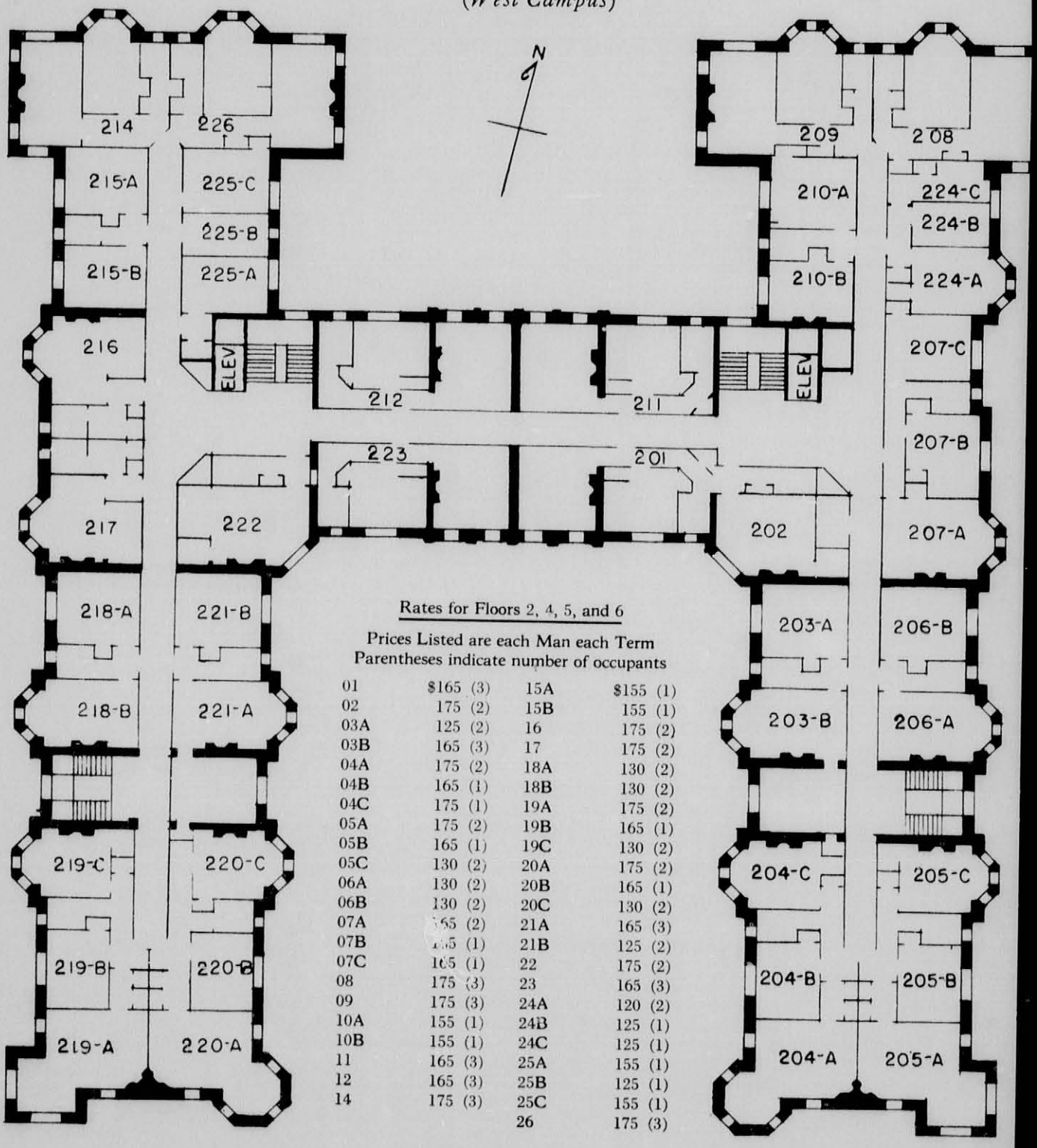
Rates for First Floor

Prices Listed are each Man each Term
Parentheses indicate number of occupants

102A	$130 (2)	106B	$165 (1)
102B	130 (2)	106C	125 (2)
103A	175 (2)	107	175 (3)
103B	165 (1)	108	175 (3)
103C	175 (1)	109A	120 (2)
104A	175 (2)	109B	155 (1)
104B	165 (1)	114A	130 (2)
104C	130 (2)	114B	130 (2)
105A	130 (2)	115A	120 (2)
105B	130 (2)	115B	125 (1)
106A	165 (2)	115C	125 (1)

THE GRADUATE HOUSE

(West Campus)



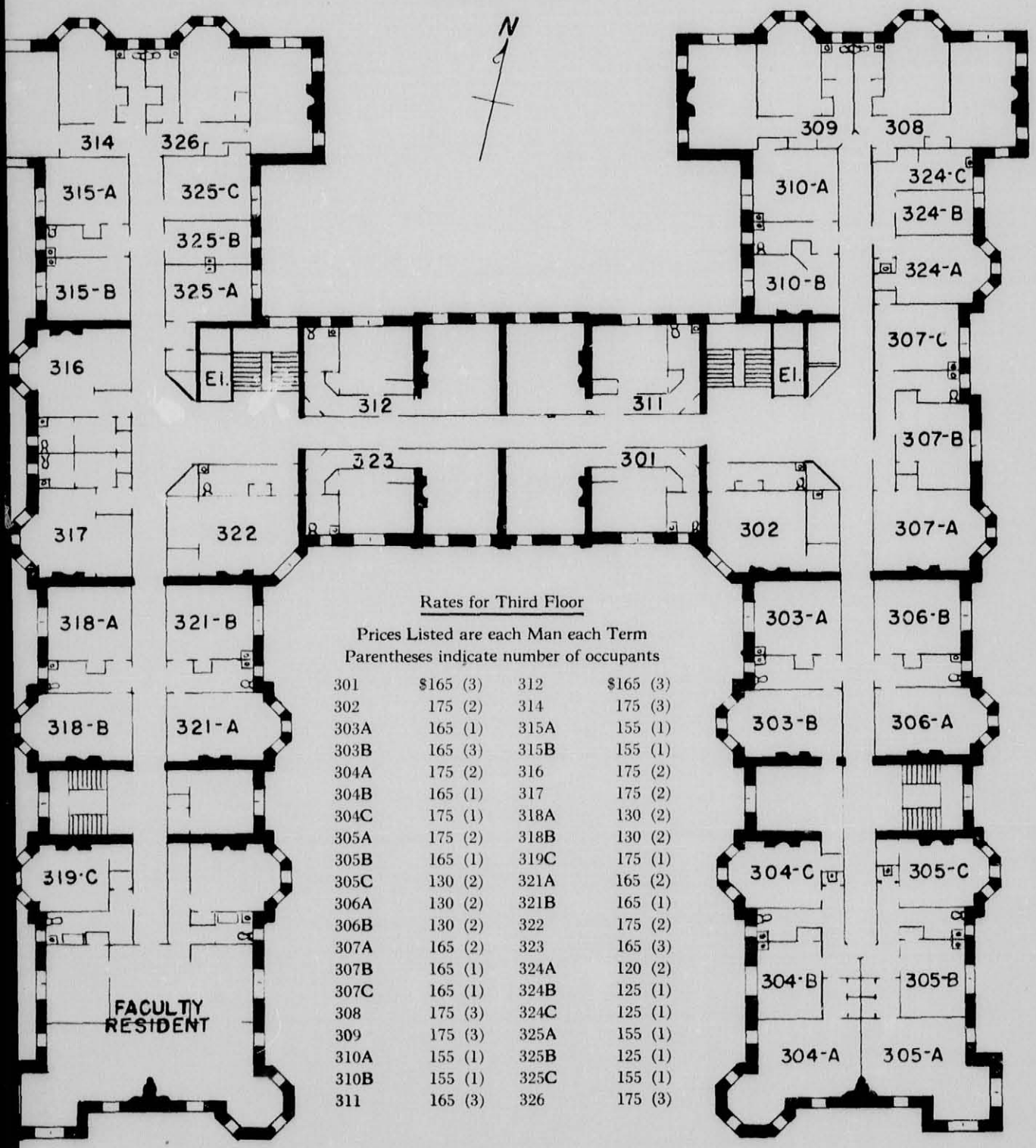
Rates for Floors 2, 4, 5, and 6

Prices Listed are each Man each Term
Parentheses indicate number of occupants

01	$165 (3)	15A	$155 (1)
02	175 (2)	15B	155 (1)
03A	125 (2)	16	175 (2)
03B	165 (3)	17	175 (2)
04A	175 (2)	18A	130 (2)
04B	165 (1)	18B	130 (2)
04C	175 (1)	19A	175 (2)
05A	175 (2)	19B	165 (1)
05B	165 (1)	19C	130 (2)
05C	130 (2)	20A	175 (2)
06A	130 (2)	20B	165 (1)
06B	130 (2)	20C	130 (2)
07A	165 (2)	21A	165 (3)
07B	165 (1)	21B	125 (2)
07C	165 (1)	22	175 (2)
08	175 (3)	23	165 (3)
09	175 (3)	24A	120 (2)
10A	155 (1)	24B	125 (1)
10B	155 (1)	24C	125 (1)
11	165 (3)	25A	155 (1)
12	165 (3)	25B	125 (1)
14	175 (3)	25C	155 (1)
		26	175 (3)

THE GRADUATE HOUSE

(West Campus)



Rates for Third Floor

Prices Listed are each Man each Term
Parentheses indicate number of occupants

301	$165 (3)	312	$165 (3)
302	175 (2)	314	175 (3)
303A	165 (1)	315A	155 (1)
303B	165 (3)	315B	155 (1)
304A	175 (2)	316	175 (2)
304B	165 (1)	317	175 (2)
304C	175 (1)	318A	130 (2)
305A	175 (2)	318B	130 (2)
305B	165 (1)	319C	175 (1)
305C	130 (2)	321A	165 (2)
306A	130 (2)	321B	165 (1)
306B	130 (2)	322	175 (2)
307A	165 (2)	323	165 (3)
307B	165 (1)	324A	120 (2)
307C	165 (1)	324B	125 (1)
308	175 (3)	324C	125 (1)
309	175 (3)	325A	155 (1)
310A	155 (1)	325B	125 (1)
310B	155 (1)	325C	155 (1)
311	165 (3)	326	175 (3)

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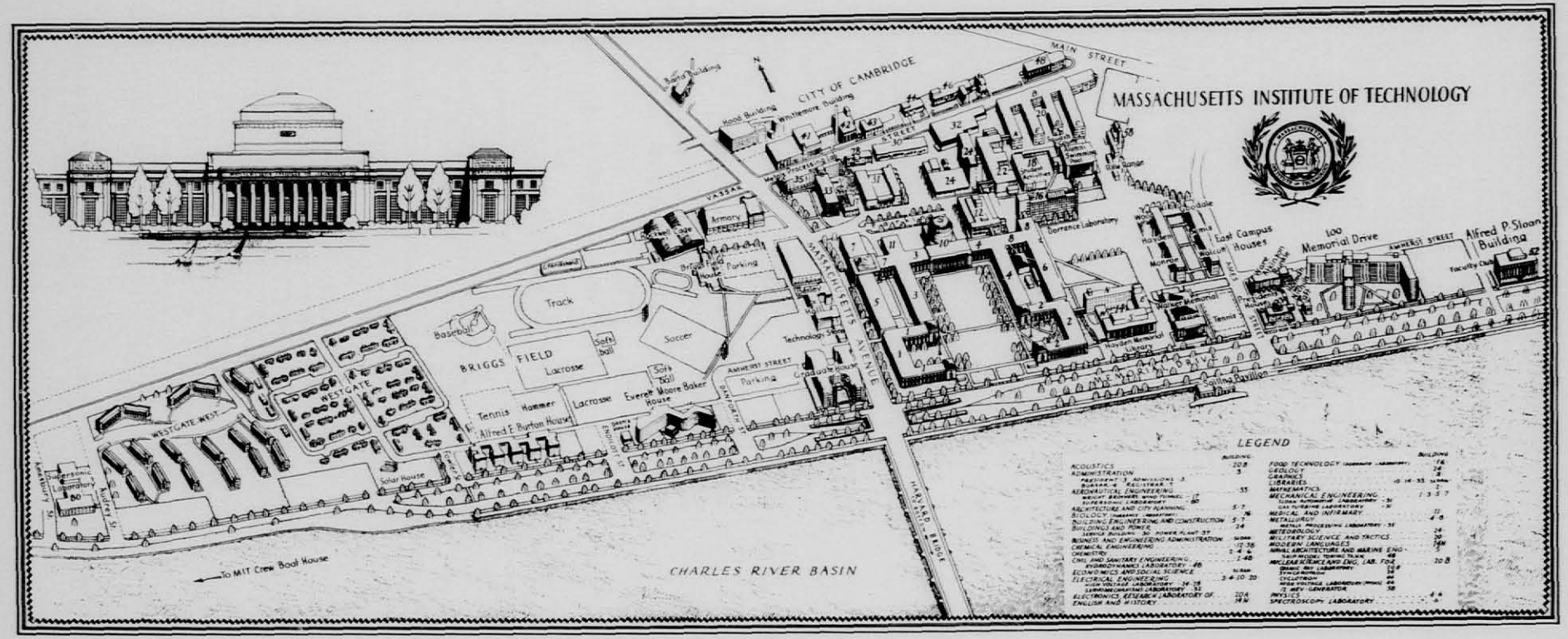
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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CITY OF CAMBRIDGE
MAIN STREET
CHARLES RIVER BASIN
To M.I.T. Crew Boat House
BRIGGS FIELD
Track
Soccer
Baseball
Lacrosse
Tennis
Hammer
Alfred E. Burton House
Everett Moore Baker House
Solar House
WESTGATE WEST
WESTGATE
Armory
Parking
Graduate House
Dormitory
Parking
Dorrance Laboratory
East Campus Houses
Memorial Drive
Alfred P. Sloan Building
Faculty Club
Swimming Pool
Tennis
Sloan Laboratory
Sloan Automotive Laboratory
Gas Turbine Laboratory
Metallurgy
Meteorology
Military Science and Tactics
Modern Languages
Naval Architecture and Marine Eng.
Nuclear Science and Eng. Lab. (NSEL)
Physics
Spectroscopy Laboratory
Acoustics
Administration
Aeronautical Engineering
Architecture and City Planning
Biology
Building Engineering and Construction
Business and Engineering Administration
Chemical Engineering
Chemistry
Civil and Sanitary Engineering
Economics and Social Science
Electrical Engineering
Electronics Research Laboratory of
English and History
Food Technology
Geology
Graphics
Libraries
Mathematics
Mechanical Engineering
Medical and Infirmary
LEGEND