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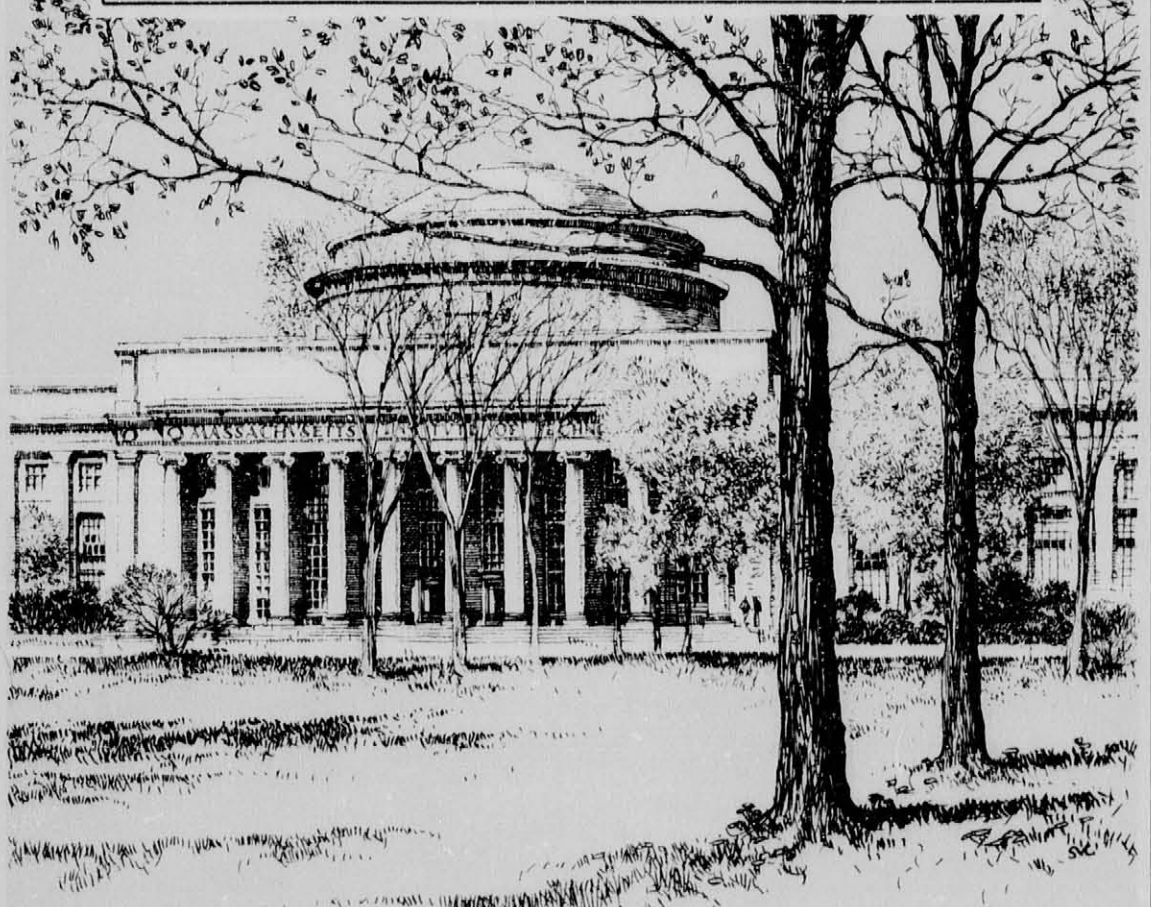

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JUNE 1949

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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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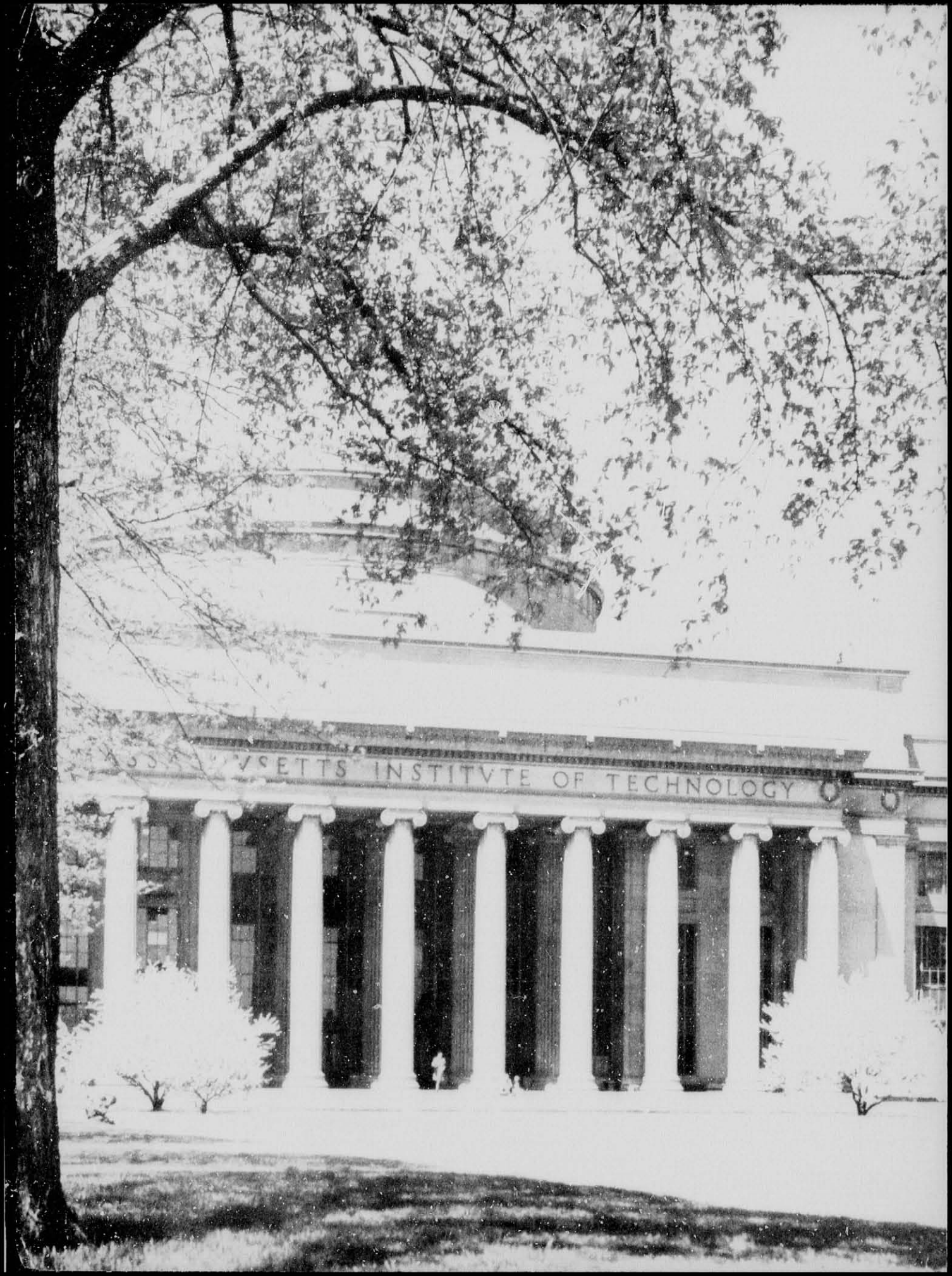
ETTS INSTITVTE OF TECHNOLOGY

The New Dormitory, on the West Campus facing the Charles River, was completed in 1949. Designed by Prof. Alvar Aalto, noted Finnish architect and member of the Faculty, it is a fresh and forward looking solution of student housing.

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CALENDAR

CALENDAR 1949-1950

FOR ACADEMIC YEAR 1949-1950

	1949	
Fall Term Begins		Sept. 19
Columbus Day (*Holiday*)		Oct. 12
Armistice Day (*Holiday*)		Nov. 11
Thanksgiving Day (*Holiday*)		Nov. 24
Christmas Vacation		Dec. 22 through Jan. 3
	1950	
Last Exercises, Fall Term		Jan. 20
Examination Period		Jan. 21 through Jan. 27
Spring Term Begins		Feb. 6
Washington's Birthday (*Holiday*)		Feb. 22
Spring Recess		March 27 through April 2
Patriots' Day (*Holiday*)		April 19
Last Exercises, Spring Term		May 25
Examination Period		May 26 through June 2
Memorial Day (*Holiday*)		May 30
Commencement Day		June 9
Summer Session 1950 Begins		June 12
Fall Term 1950 Begins		Sept. 18

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JUNE 1949

CATALOGUE ISSUE
1949-1950 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 84 NUMBER 4

PUBLISHED BY THE INSTITUTE
CAMBRIDGE, MASSACHUSETTS

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

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

Along with his professional work, the student at the Institute devotes a large amount of study to the arts of expression, both written and oral. Since a high standard of accomplishment is expected, a student planning to attend the Institute should devote special attention to this aspect

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

To vitalize its educational procedure and to fulfill its objectives, the Institute 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, or engineering 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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Term expires June, 1951
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Term expires June, 1952
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Term expires June, 1953
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[1] Address correspondence to Massachusetts Institute of Technology.

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Carle Reed Hayward, S.B. — *Professor of Process Metallurgy, Emeritus; Lecturer*
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BUSINESS AND ENGINEERING ADMINISTRATION

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

CHEMICAL ENGINEERING

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

CHEMISTRY

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, A.M.
Professor of Economics and Finance, Emeritus

ELECTRICAL ENGINEERING

DUGALD CALEB JACKSON, D.SC., D.ENG.
Professor of Electric Power Production and Distribution, Emeritus

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

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

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

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

ENGLISH AND HISTORY

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

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

GEOLOGY

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

MATHEMATICS

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

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

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

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; Lecturer

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

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

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

ADDISON FRANCIS HOLMES, S.B.
Associate Professor of Applied Mechanics, Emeritus; Lecturer

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

METALLURGY

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

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

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

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

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

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

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

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

HENRY EASTIN ROSSELL, S.M.
Professor of Naval Construction, 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., F.A.C.S.
Medical Director, Emeritus

WILLIAM NATHANAEL SEAVER, A.B.
Librarian, Emeritus

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

FACULTY COMMITTEES, 1949–50

ADMISSIONS

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

	Term Expires
S. Edgerly	1950
E. L. Gamble	1950
I. A. Getting	1951
G. T. Johnson	1951
R. D. Douglass	1952
P. M. Morse	1952

COURSE IX

	Term Expires
R. G. Hudson* (*Chairman*)	
S. C. Brown	1950
D. V. Brown	1951
E. L. Gamble	1952
J. A. Hrones	1953

GENERAL STUDIES

Dean of Humanities* (*Chairman*)

	Term Expires
W. R. Maclaurin	1950
H. R. Bartlett	1951
E. B. Millard	1952
L. B. Anderson	1953
J. H. Keenan	1954

GRADUATE SCHOOL

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

W. P. Allis	G. C. Manning
J. M. Austin	S. Ober
R. L. Bishop	B. E. Proctor
W. H. Brown	R. H. Robnett
J. P. Den Hartog	R. R. Shrock
W. M. Fife	I. W. Sizer
C. F. Floe	W. E. Stanley
M. F. Gardner	G. B. Thomas, Jr.
R. B. Greeley	W. C. Voss
E. H. Huntress	G. C. Williams

LIBRARY

Executive Board

Director of Libraries*
Librarian* (*Secretary*)

	Term Expires
V. F. Weisskopf	1950
M. J. Buerger	1951
N. J. Padelford**	1951
E. H. Huntress	1952
S. N. Caldwell**	1953
I. W. Sizer	1953

NOMINATING COMMITTEE 1949–1950

G. S. Brown (*Chairman*)
W. C. Greene
E. S. Taylor
R. H. Robnett
J. R. Zacharias

PETITIONS

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

	Term Expires
A. E. Fitzgerald	1950
H. Mueller	1951
C. L. Svenson	1952
R. H. Robnett	1953

PROVISIONAL STUDENTS AND DISCIPLINE

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

	Term Expires
C. F. Floe	1950
J. B. Rae	1951
D. L. Farnsworth	1952

UNDERGRADUATE COURSES

	Term Expires
C. E. Tucker (*Chairman*)	1951
L. F. Hamilton	1950
N. Levinson	1950
E. E. Morison	1951
W M. Murray	1952
P. A. Samuelson	1952
C. H. Blake	1953
R. D. Evans	1953

UNDERGRADUATE SCHOLARSHIPS

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

	Term Expires
J. R. Markham	1950
G. P. Wadsworth	1950
C. Kingsley, Jr.	1951
J. E. Vivian	1951
N. J. Grant	1952
R. B. Greeley	1952
J A. Beckett	1953
J. W. Daily	1953
J. E. Arnold	1954
S. C. Brown	1954

COMMITTEES ON JOINT PROJECTS, 1949–50

SOLAR ENERGY CONVERSION

H. C. Hottel (*Chairman*)
A. C. Hardy
E. H. Huntress
A. R. von Hippel
Advisory:
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
Dean of Engineering*

GAS TURBINES

C. R. Soderberg (*Chairman*)
E. L. Cochrane
N. J. Grant
H. C. Hottel
J. C. Hunsaker
E. G. Schneider
E. S. Taylor*
Dean of Engineering*

* Ex officio

** Appointed by the President

COMMITTEES ON INTERDEPARTMENTAL LABORATORIES, 1949-50

ACOUSTICS

L. B. Anderson
L. L. Beranek
R. H. Bolt
R. D. Fay
P. M. Morse
Provost*
Dean of Engineering*

ELECTRONICS

A. G. Hill (*Chairman*)
H. L. Hazen
J. C. Slater
J. B. Wiesner
Provost*

SPECTROSCOPY

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

NUCLEAR SCIENCE AND ENGINEERING

Steering Committee

J. R. Zacharias (*Chairman*)
E. R. Gilliland (*Vice-Chairman*)
J. Chipman
A. C. Cope
H. L. Hazen
J. C. Slater
W. G. Whitman
Provost*

Advisory Committee

Science

J. R. Zacharias (*Chairman*)
C. D. Coryell
R. D. Evans
I. A. Getting
B. Rossi
J. G. Trump
R. J. Van de Graaff
V. F. Weisskopf

Engineering

E. R. Gilliland (*Chairman*)
L. B. Borst
C. Goodman
J. W. Irvine, Jr.
A. R. Kaufmann

OTHER COMMITTEES AND BOARDS, 1949-50

ADVISORY COMMITTEE ON DINING AND HOUSING FACILITIES

E. M. Baker (*Chairman*)
J. W. M. Bunker
H. S. Ford
L. F. Hamilton
E. E. Morison
J. J. Snyder

ATHLETIC ADMINISTRATIVE BOARD

H. G. Stever (faculty member) (*Chairman*)
R. H. Robnett (faculty member)
W. W. Garth (alumni member)
L. T. Jester (alumni member)
R. L. Gibson (student member)
G. A. Lopez (student member)
R. G. Rorschach (student member)
Dean of Students*
Medical Director*
Athletic Director*

BEMIS FOUNDATION COMMITTEE

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

BOARD OF PUBLICATIONS

J. E. Burchard, (*Chairman*)
G. R. Harrison
E. H. Huntress
R. T. Jope
J. R. Killian, Jr.
J. R. Loofbourow

* Ex officio

BUILDING COMMITTEE

E. L. Moreland (*Chairman*)
H. S. Ford
J. A. Stratton
W. W. Wurster

CILLEY FUND

H. R. Bartlett (*Chairman*)
R. E. Booth
P. M. Chalmers

COMMENCEMENT

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

CONDUCT OF EXAMINATIONS

A. T. Gifford (*Chairman*)
S. C. Brown
E. N. Gelotte
J. A. Hrones
C. H. Norris
J. B. Rae
S. G. Simpson
A. Sloane
J. N. Thurston
G. P. Wadsworth

HOBBY SHOP

R. M. Cunningham (*Chairman*)
J. J. Rowlands
D. C. Stockbarger

LOAN BOARD

H. E. Lobdell (*Chairman*)
D. L. Rhind (*Secretary*)
E. M. Baker
H. S. Ford
T. P. Pitré
E. A. Thresher

PATENT

J. A. Stratton (*Chairman*)
J. A. Beattie
W. H. Gale
A. C. Hardy
H. L. Hazen
F. G. Keyes
J. Wulff

PATENT MANAGEMENT

J. A. Stratton (*Chairman*)
J. E. Burchard
H. S. Ford
J. R. Killian, Jr.
E. L. Moreland
N. McL. Sage
J. J. Snyder

PERMANENT ART COLLECTION

J. E. Burchard (*Chairman*)
W. W. Wurster (*Curator*)
W. C. Greene
G. Kepes
C. F. Taylor

PERSONNEL BOARD

H. S. Ford (*Chairman*)
F. L. Foster
W. A. Hokanson
H. Loomis
R. C. Maclaurin
D. L. Rhind
J. J. Snyder

SAFETY COUNCIL

E. R. Schwarz (*Chairman*)
J. W. M. Bunker
A. R. Davis
L. F. Hamilton
W. A. Hokanson
R. C. Maclaurin
C. M. F. Peterson
M. S. Stevens
R. Taylor
Medical Director*

STABILIZATION OF ENROLLMENT

E. L. Moreland (*Chairman*)
J. W. M. Bunker
J. E. Burchard
G. R. Harrison
J. C. MacKinnon
T. P. Pitré
T. K. Sherwood
J. A. Stratton
B. A. Thresher
W. W. Wurster

STAFF — ADMINISTRATION

Staff	*Administration*
F. W. Sears (*Chairman*)	E. M. Baker
J. E. Arnold	J. E. Burchard
R. L. Bishop	H. S. Ford
R. M. Cunningham	G. R. Harrison
R. D. Douglass	J. R. Killian, Jr.
J. G. Linvill	T. K. Sherwood
G. C. Williams	J. A. Stratton

STUDENT-FACULTY

J. T. Rule (*Chairman*)

Dean of Freshmen*	F. W. Sears
E. L. Cochrane	W. H. Stockmayer
M. F. Gardner	G. B. Thomas
J. Holt	W. G. Whitman
G. Putnam	

TECHNOLOGY MUSEUM

H. R. Bartlett (*Chairman*)

H. L. Beckwith	E. R. Schwarz
E. L. Cochrane	F. W. Sears
F. K. Morris	V. D. Tate
H. B. Richmond*	

UNDERGRADUATE BUDGET BOARD

E. M. Baker (*Chairman*)

T. M. Hill	M. G. Kispert
R. T. Jope	D. L. Rhind

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

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

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

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

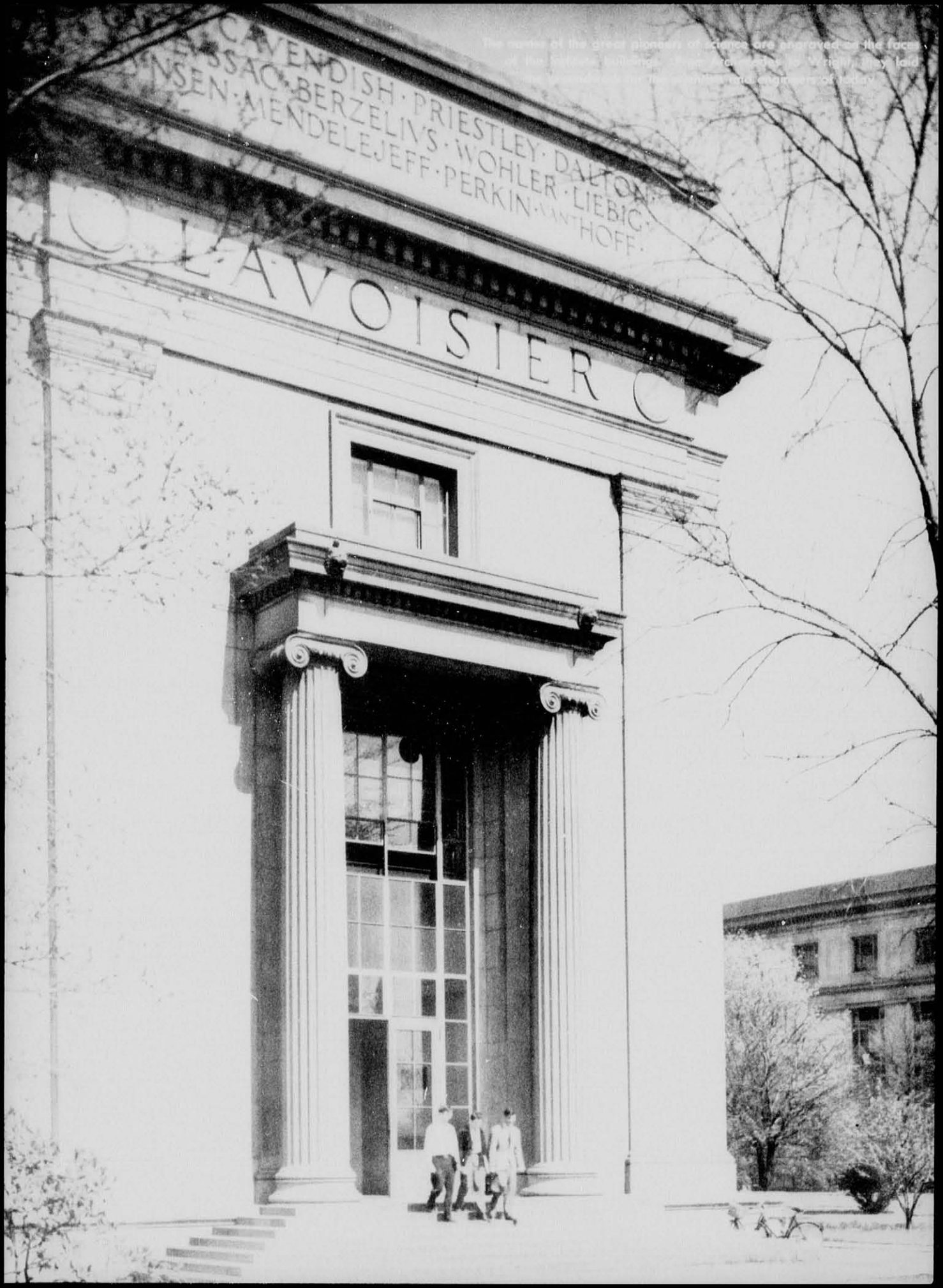
To aid the President and Treasurer there are other duly appointed officers of administration and instruction. Chief among the former are the Provost, the Deans of Engineering, Science, Architecture and Planning, Humanities, the Graduate School, and Students; the Executive Vice-President; the Bursar;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

The Academic Council consists of the President as Chairman, the Provost as Vice-Chairman, the Executive Vice-President, the Deans of Engineering, Science, Architecture, Humanities, 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, Executive Vice-President, Provost, Deans, Registrar, Assistant Registrar, 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, and the Laboratory for Nuclear Science and Engineering. For its government the Faculty has adopted a set of "Rules and Regulations" which set forth the duties and powers of its Chairman, Secretary, and Assistant Secretary, and of its standing committees which include those on the Graduate School, Undergraduate Courses, Admissions, Petitions, Provisional Students and Discipline, Undergraduate Scholarships, the Courses in General Science and General Engineering, General Studies, the Library, and on First-, Second-, Third-, and Fourth-Year Students. These "Rules and Regulations" also provide for a 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.

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

In the Schools of Architecture and Planning, Engineering, and Science are grouped those departments of study which lead to degrees and which embody the primary educational objective of the


CAVENDISH · PRIESTLEY · DALTON ·
GAY-LUSSAC · BERZELIUS · WOHLER · LIEBIG ·
ARRHENIUS · MENDELEJEFF · PERKIN · VAN'T HOFF ·
LAVOISIER

A. Graduate House
B. Main Educational Buildings
C. Dormitories
D. Student Center

the Massachusetts Institute of Technology opened
for professional education in science, engineering
Fifty-one years later the Institute moved
location on the Charles River
undergraduate
engineering, architecture,
student body drawn

The Great Court in winter takes on a new aspect when covered with a blanket of snow. New England provides unparalleled opportunity for the enjoyment of all winter sports.

Institute. In the Division of Humanities are grouped the studies through which students may supplement the cultural values inherent in their scientific and engineering subjects with the broadening discipline of the humanities. The Graduate School coordinates the work leading to advanced degrees in all the departments. In the Division of Industrial Cooperation are centered the organized activities of departments and individual members of the staff which are devoted wholly or in part to the assistance of industry in the solution of its problems or development of new products and methods.

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

DEGREES GRANTED

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

Many prospective students of engineering, science, architecture, or city planning wish to attend a liberal arts college before undertaking their professional training. Two years are generally required to qualify for the S.B. degree in engineering or the Bachelor in City Planning (B.C.P.) at M. I. T. after graduation from a liberal arts college. For architecture, three 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 to facilitate the combination of a liberal arts course with education in science, engineering, architecture, or city planning, 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, a student of high standing may pursue a combined five-years' program in which the first three years are spent at the college and the last two (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.

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
Miami University, Oxford, Ohio
Middlebury College, Middlebury, Vermont
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 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, Biology, and Geology and Mineralogy.

THE LIBRARY. The Institute Library, one of the leading collections in science and engineering in the United States, includes the Central Library and a number of strong branch libraries, containing all together approximately 400,000 volumes. A comprehensive collection of periodicals and society publications, remarkably complete in subjects within the scope of the Institute's programs of study and research, is maintained by the current receipt of over 1,600 periodicals and upwards of 1,900 transactions, yearbooks, and other serials. The Library is also a depository for United States government documents.

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

During term time the Central Library is open on week-days, Monday through Friday, from 8.45 A.M. to 9 P.M. Saturday hours, and hours during the summer session, will depend upon the demand. Individual reference service, bibliographical aid, and assistance in the use of the card catalogue are given at the Reference desk and the Vail desk in the Central Library and also in the branch libraries. Seniors, graduate students, and others engaged on theses or other research are granted admission to the stack.

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

The following branch libraries, well organized and in charge of competent librarians, are located near the departments which they serve and supplement the service of the Central Library: Aeronautical Engineering, Arthur Rotch (architecture, housing, and city planning), Dewey (civil and mechanical engineering, building construction, naval architecture and marine engineering, economics, social science, industrial relations, and business and engineering administration), Eastman (for graduate students and others doing advanced work in physics, mathematics, and chemistry), Lindgren (geology, metallurgy, and ceramics), and Walker Memorial. The last-named, primarily a library for recreational reading, contains also the principal collections in history and literature and in effect serves as a humanities library. The material in all these libraries is listed in the Central Library card catalogue, and telephone interconnection affords a well-integrated service. The new Hayden Memorial Library, now under construction, is planned for completion by October 1949.

MUSEUMS. The museum of science, engineering and industry is continually expanding within the main group of buildings. Each department has its own exhibits, along the corridor adjacent to its laboratories and offices; and these exhibits, largely the result of the research or the ingenuity of the staff, broaden and enrich the educational program of the students. In addition, two of the most significant units have ample quarters of their own: the Dard Hunter Paper Museum, containing the most complete collection of handmade paper and papermaking equipment in the world; and the Francis Russell Hart Nautical Museum, containing a magnificent collection of ship models and 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 has a policy of providing monthly traveling 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, often for the only showing 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. They are intended to serve as an introduction to the Institute family of a wide number of ideas and presentations of ideas and to enrich the entire 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, but including recesses and holidays which fall within and between these terms, making a total of 37 weeks.

Tuition, two terms	$ 800.00
Board, 37 weeks	450.00
Room	220.00
Books and Materials	65.00*
	$1,535.00

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 as to the place where a student must live and all students are free to make whatever living arrangements they choose. With respect to living arrangements, the student body of the Institute divides itself into four major groups:

First, there are some 1,500 men housed on the Campus in three units: the New Dormitory accommodates 350, with dining service; the remaining undergraduate residence halls house 720, with dining service adjacent, in Walker Memorial; and the Graduate House, with its own dining service, 450 graduate students. The Women's Dormitory, at 120 Bay State Road, Boston, accommodates 17 students, with a house mother; meals are served in the house.

Second, the 24 fraternities and the cooperative M. I. T. Student House, accommodate about 700 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, limited to veterans, who, with their families, occupy houses in "Westgate" or apartments in "Westgate West," both on the Campus.

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 dormitories, and the current maximum is $360. (See Appendix C, Housing.)

Outside lodgings, unless of inferior grade, can seldom be obtained below the dormitory rate. The fraternities average approximately the same as the dormitory cost, depending on the manner of living decided upon by the several groups. Lower costs are attained in the M. I. T. Student House where the members contribute services.

*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.

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 are thoroughly considered by the Faculty Committee on Undergraduate Scholarships 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 include the William Barton Rogers awards of $1,000 for the first year, nineteen Alumni Regional scholarships of full tuition and other grants carrying stipends from $100 to $600. Application must be made before March 15. (See Appendix A for complete details.)

UPPERCLASSMEN: After one year of residence any undergraduate may apply for scholarship aid. Applications are made to the Faculty Committee on Undergraduate Scholarships, and grants are made on the annual basis with stipends ranging from $100 to $400 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 $2,400 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, Teaching Fellowships, 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.)

PART-TIME EMPLOYMENT: To assist students desiring to help themselves in meeting their expenses, the Student Employment Bureau is maintained by the Technology Christian Association. It is to be understood, however, that the demands of the Institute curriculum are such as to make it impracticable to devote much time to outside employment, and prospective students are advised to have sufficient funds to cover the expenses of the first year at least. The maximum that can be earned through part-time employment does not exceed one hundred dollars per term. This amount may be realized in a limited number of jobs on the Campus, such as those in the dining services and the library. Some outside jobs are available in Boston and Cambridge but these are likely to be limited by the difficulty in scheduling them without conflict with academic appointments. Students from foreign lands, in particular, should clearly understand that the opportunities to secure remunerative employment are seriously restricted by their unfamiliarity with the English language and American business customs.

FEES, DEPOSITS, PAYMENTS, EXPENSES

TUITION FEES. The regular tuition fee is $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 Room 7-133. Veterans under PL16 must report to the Veterans' Administration Training Officer, Room 20-E-221.

(a) The tuition fee for students taking cooperative work in Course II-A or 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) The tuition fee for students in Course II-B or XVI-B for each required half of the Summer Session is one half of the regular term tuition or $200.

(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 44).

(e) 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.

(f) 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.

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.

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

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

DEPOSITS TO COVER CHEMICAL SUPPLIES, MILITARY UNIFORMS, ETC. All first-year students and all students taking Military Science, MS21 and MS22, will be required to make a deposit of $25, from which the costs of chemicals and laboratory supplies, shoes, non-returnable equipment and damage to military uniforms are to be deducted.

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

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

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

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

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.

(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.

SUMMER SESSION THESIS FEES BEGINNING JUNE 1950.

(a) Bachelor's, Master's or Graduate Engineering degree thesis is at the rate of $12 per credit unit up to $200 for non-staff: for staff appointees (not D. I. C.) up to $75 for full-time, $120 for half-time and $160 for third-time staff.

(b) 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, will be $200 for non-staff: for staff appointees (not D. I. C.), $75 for full-time, $120 for half-time and $160 for third-time staff.

(c) The fee for thesis writing and presentation only, with or without thesis examination, will be $50 for the bachelor's, master's or graduate engineering degree and $75 for a doctor's degree.

(d) The tuition fee for individual subjects and the maximum tuition fee for the Summer Session 1950 will be published at a later date.

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 doctors conducts various clinics daily except Saturday and Sunday. Clinics are maintained in Internal Medicine, 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, laboratory and physiotherapy facilities are maintained. Any student may receive medical, minor surgical and psychiatric treatment without charge. A small fee is charged for other special clinics, X-rays and unusual laboratory procedures.

In addition to the clinics, the Homberg Memorial Infirmary building contains a hospital equipped to care for thirty-six bed patients. There are six finely appointed, attractive wards, seven private rooms, and a large solarium. 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 three dollars a day, and the same service in a private room is furnished at four dollars a day.

A health insurance plan is offered on a voluntary basis to regular students upon the payment of eight dollars per semester. In return for this sum the insurance agency agrees, with certain limitations, to pay up to five hundred dollars toward meeting the cost of any illness or injury. Details of this plan may be secured at any time upon application to the Medical Department. It is particularly desirable that scholarship students and all those who have a limited budget take advantage of this plan.

Every entering student, undergraduate or graduate is required to be immunized against typhoid fever and small-pox 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. Each student should also have a physical examination in addition to his X-ray in the year prior to his graduation.

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. The exercises are omitted on the following Massachusetts legal holi-

days: January 1, February 22, April 19, May 30, July 4, Labor Day, October 12, November 11, Thanksgiving Day and December 25.

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. The Dean of Freshmen serves as Registration Officer for all first-year students. 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 City Planning, Engineering, and Science, 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, habitual tardiness or inattentiveness 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 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 cheerfully to such regulations as, from time to time, may be made by the Faculty, Administration, or the Institute Committee (student government). 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 dormitories or fraternities, extracurricular 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 Provisional Students and 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 and April 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 Petitions is the Faculty body through which the student may appeal for special consideration of his individual case. All requests must be submitted in writing on petition blanks which may be obtained at the Information Office, Room 7-111.

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 two handball courts. 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 dormitories 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. 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; twelve 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, has also a number of singles and wherries available for students, and in addition offers to all undergraduates the opportunity to learn how to row in an eight-oared shell under competent coaching. The Sailing Pavilion, located on the Charles River in front of Walker Memorial, is the headquarters of the Nautical Association.

Students who wish to pursue or develop hobbies as a recreation have access to the Hobby Shop — a name describing both a physical facility and the group of students brought together by it. Since the shop was opened in 1938, with space and equipment provided by the Institute, it has been doubled in size. 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-six of the more important student activities. The full Committee, numbering thirty-four 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, 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 secured by undergraduate dues, appropriated by the Institute from tuition, but 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. Among the activities are: track and field sports, cross-country running, rowing, baseball, skiing, hockey, basketball, fencing, golf, lacrosse, rifle, swimming, tennis, soccer, squash racquets. Spirited intramural league competitions are held annually in the sports of touch football, basketball, softball, volleyball, swimming and track.

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. Two glee clubs, a symphony orchestra, and a concert band rehearse weekly and present several concerts at M. I. T. as well as at various colleges in New England. 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 activity aims to be of practical service and to foster among members of the Institute community the ideals of Christian living and active Christian service. It organizes students for social service and religious activity in Metropolitan Boston, maintains a theater ticket service and book exchange, operates the Student Employment Bureau, the Tech Cabin and Freshman Camp, and publishes the Freshman *Handbook*.

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 Undergraduate Dormitories, the Inter-Fraternity Conference for the Fraternities, and the 5:15 Club for Commuters.

The Professional Societies, of which there are sixteen, hold meeting 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 at Commencement.

The Honorary Societies are of two classifications. There are five 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, the National Scouting fraternity, or the Tech De Molay Club 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 Hobby Shop; the Liberal Arts Society, which fosters creative writing and thinking in non-technical fields; 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 holds 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.

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 placement training program is approached from the long-range point of view rather than in terms of the first position after graduation, and stress is placed upon the importance of each individual's finding the type of opening for which he is best qualified by reason of his special aptitudes and training. A placement 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. Beginning in 1917, the Society has set its course by an annual series of Popular Science Lectures. These discourses, always illustrated, are held in Huntington Hall on one week-end in the months of December, January, February and March. On Friday and Saturday afternoons, by invitation, seniors from high schools and preparatory schools make up the greater part of the audiences. On Sundays, corporation members, faculty and the general public predominate. 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 giving detailed information regarding the nature of the entrance examinations and other requirements may be obtained by sending a stamped, self-addressed envelope to Professor Arthur L. Townsend, Director, The Lowell Institute School, Massachusetts Institute of Technology, Cambridge 39, Massachusetts.

REQUIREMENTS FOR ADMISSION

ENTRANCE DATES

First Year students will enter once a year on the Monday prior to the last Monday in September, and will not be accepted at other dates.

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. Since, however, relatively few public high schools in the United States offer German, and very few schools of any kind offer Russian, the student may find it expedient to take French and to postpone until a later stage the study of German, Russian, or other languages appropriate to his professional specialty.

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. Candidates are in general 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 10, 1949
Saturday,	January 14, 1950
Saturday,	March 11, 1950
Saturday,	May 20, 1950
Wednesday,	August 9, 1950

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 11, 1950 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 Box 775, Berkeley, 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.

Applicants from schools in the State of New York may offer, in place of the examinations described above, Regents examinations in corresponding subjects, namely, Algebra, Plane Geometry, Solid Geometry, Trigonometry, English, and Physics. The official report of these examinations will be secured by the Institute from the Board of Regents in Albany.

Entrance examinations may be waived for students entering directly from secondary schools if they graduate in the highest fifth of the class and if the school has qualified for this privilege by sending to the Institute a number of graduates whose records at the Institute have been satisfactory. Applicants will be notified if they are excused from taking the examinations; *they should plan to take the tests unless they are specifically notified that the requirement has been waived.*

SUMMER SESSION 1950. Preparatory subjects will be offered at the Institute from July 24 to September 1. 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.

The Institute reserves the right to cancel any subjects for which less than six apply; 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 1950.

SELECTION OF STUDENTS. Students who have completed one or more years with high standing at a recognized college, university, engineering school, or junior college, and who are entitled to honorable dismissal, may apply for admission by transfer without examination. Their eligibility for admission will be determined by the Committee on Admissions after a review of their academic records. They will be expected in every case to have completed the academic preparation required of students entering the Institute from secondary schools.

Students who plan to attend another college with the intention of later applying for admission to the Institute should note the Combined Plan 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 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. At the proper time the final application material will be sent to the applicant. Upon receipt of the Final Application for Admission with Advanced Standing, the student should 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 the applicant's final grades are available.

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

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

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

SPECIAL STUDENTS

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

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

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.

Since competition for places at the Institute is severe, it is possible to take action on admissions only after complete application material has been received. Applications accompanied by incomplete credentials 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 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. Humanities subjects constitute an integrated program running through 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, with options: Heavy Construction (1), Light Construction (2). Subjects 17·00 to 17·99.

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

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.

ECONOMICS AND ENGINEERING, Course XIV, with options: Human Relations (1), and Industrial Economics (2). Subjects Ec1 to Ec99.

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.

MECHANICAL ENGINEERING, Course II, with options: Power (1), Materials, Design, and Manufacturing (2), and Automotive (3). Cooperative Courses in Mechanical Engineering, Courses II-A and II-B. Subjects 2·00 to 2·99.

METALLURGY, Course III, with options: Metallurgy (1), and 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. Subjects 20·00 to 20·99.

GENERAL SCIENCE, Course IX-A.

GEOLOGY, Course XII, with options: Geology (1), and Geophysics (2). 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, and PHYSICAL BIOLOGY, Course VII-A. Subjects 7·00 to 7·99.

Roman numerals are used to designate courses of study. Individual subjects are numbered 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 and History, subjects E1 to E99; General Studies, subjects G1 to G99; Languages, subjects L1 to L99; and Military Science and Tactics, subjects MS1 to MS99.

Architecture (Course IV-A) and Marine Transportation (Course XIII-C) require five years for the Bachelor's degree. Courses II-A, VI-A, VII-A, and XX-A are of five years' duration, and lead to two degrees: Bachelor of Science and Master of Science. Courses II-A and VI-A are cooperative courses involving an organized schedule of work in industry.

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 Petitions, 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.

UNDERGRADUATE SEQUENCE IN THE HUMANITIES

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

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

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, and science, 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 required in all course schedules. All theses and records of work done in preparation of theses are the permanent property of the Institute, and must not be published, either wholly or in part, except by authorization of the heads of the respective departments.

In order to qualify for continued attendance at the Institute, students must meet the minimum requirements of the scholastic rating system, a full explanation of which is sent to all new students and their parents.

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 units, or 50 hours per week total time in class, laboratory, and in preparation. 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
	8.01	Physics	6–5
	D11	Engineering Drawing	6–0
	E11	English Composition	3–5
	M11	Calculus	3–6
	MS11	Military Science	3–0
	A1	Athletic Program	2–0
		Quiz Hour (Calc., Chem., Phys.)	1–0
			31–20

Second Term	5.02	Chemistry, General	7–4
	8.02	Physics	6–5
	D12	Descriptive Geometry	6–0
	E12	English Composition	3–5
	M12	Calculus	3–6
	MS12	Military Science	3–0
	A2	Athletic Program	2–0
		Quiz Hour (Calc., Chem., Phys.)	1–0
			31–20

UNDERGRADUATE COURSE SCHEDULES

All undergraduate course schedules given on the following pages will be in effect in 1949–50, 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 46)

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
	E21	History — Humanities II	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
	E22	History — Humanities II	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
			23–29

I. Civil Engineering Continued

Third Year††

First Term	*1·61	Fluid Mechanics	3–6	*Second Term*	*1·40	Structures	6–6
	*1·91T	Engineering Construction	3–3		*1·43	Reinf. Concrete Design	6–0
	*2·04	Strength of Materials	3–6		1·62	(1) Fluid Mechanics	2–4
	2·371	Testing Materials Lab.	2–2		1·90	(2) Conservation, Prin.	3–6
	*17.75T	Materials	6–6		1·92T	(3) Constr. Equip. & Methods	2–4
	§§Ec11	Economic Prin. I — Humanities III	3–5		§§2·41	(1) Heat Engineering	4–5
			20–28		*6·18	Electrical Eng., Fund.	4–6
					15·50	(3) Accounting	5–4
					Ec352	(2) Elementary Statistics	2–4
						†Humanities III	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	Structures	3–6
	*1·41	Structures	3–6		¶1·442	Bridge Design	6–0
	1·441	Structural Design	6–0		*1·94	Professional Problems	2–4
	2·687	Hydraulic Laboratory	2–2			†Humanities IV	3–5
		†Humanities IV	3–5			*Thesis	9
		Elective Subject	12			Elective Subject	9
			51				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	Structures	3–6		1·77	Water Supply & Sewerage	3–3
	1·72	Hydrology & Water Power Eng.	3–3		*1·94	Professional Problems	2–4
	4·59	Govt. & Public Admin.	3–6		4·12	Urban Sociology	2–4
	4·63	Regional Plan., Prin.	2–4			†Humanities IV	3–5
		†Humanities IV	3–5			*Thesis	9
		Elective Subject	6			Elective Subject	6
			52				47

*First Term Elective Subjects***

1·441	Structural Design	6–0
2·41	Heat Engineering	4–5
Ec49	Public Finance	2–4

*Second Term Elective Subjects***

1·42	Structures	3–6
1·62	Fluid Mechanics	2–4
4·60	Plan. Legis. & Admin.	2–4
Ec724	Manage. of People, Theory	2–4
E36	Seminar in Technical Writing	2–4

Option 3. Construction and Management

First Term	*1·351	Soil Mech. & Found. Eng.	4–4	*Second Term*	1·42	Structures	3–6
	*1·41	Structures	3–6		*1·94	Professional Problems	2–4
	1·441	Structural Design	6–0			†Humanities IV	3–5
		†Humanities IV	3–5			*Thesis	9
		Elective Subjects	15			Elective Subjects	18
			46				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***

1·62	Fluid Mechanics	2–4
1·77	Water Supply & Sewerage	3–3
15·11	Business Manage., Int.	3–6
15·61	Business Law	3–6
17·32	Building Construction	5–4
17·40	Estim. & Job Management	5–4

*See Requirements for Bachelor's Degree, page 46. † See page 145 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.

§§ Students particularly interested in Sanitary Engineering may substitute 1·831 Sanitary Chemistry 6–4 in place of Ec11 in the first term and take Ec11 Economic Principles I 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 certain fields of major interest to which they can give greater emphasis. For this purpose the fourth-year curriculum is divided into the following options:

OPTION 1. POWER. The background of thermodynamics is enlarged, and the instruction is focused on the design, construction, and operation of prime movers and power plants, such as steam turbines and gas turbines.

OPTION 2. MATERIALS, DESIGN AND MANUFACTURING. Special attention is given to the design of machinery, machine tools, metals processing, and general production problems.

OPTION 3. AUTOMOTIVE. The objectives are similar to Option 1, but attention is focused on the internal combustion engine.

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 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 46)

SECOND YEAR

First Term	2·00	Statics	3–5	*Second Term*	2·01	Dynamics	3–5
	2·701	Machine Drawing	6–0		2·852	Machine Tool Prac.	4–0
	2·851	Machine Tool Lab.	4–0		3·11	Engineering Metals	5–4
	8·03	Physics	5–5		8·04	Physics	5–5
	E21	History — Humanities II	3–5		E22	History — Humanities II	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			27–21				26–25

THIRD YEAR

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

*See Requirements for Bachelor's Degree, page 46.

†See page 145 for list of subjects.

II. Mechanical Engineering Continued

Fourth Year

Option 1. Power

First Term	2·081	Strength of Materials	3–6	*Second Term*	2·082	Mech. Eng. Problems	3–6
	2·43	Heat Engineering	3–6		2·56	Power Plant Eng.	6–6
	2·680	Engineering Laboratory	4–4			*Thesis	9
	3·12	Metal Processing	4–4			†Humanities IV	3–5
		†Humanities IV	3–5			Prof. Elective Subject	9
		Prof. Elective Subject	9				47
			51				

First Term Professional Elective Subjects¶

2·44	Heat Engineering	3–6
2·663	Air Conditioning	3–6
2·79	Internal Combustion Eng., Elem.	3–6
3·44	Behavior of Metals at Elev. Temps.	2–4

Second Term Professional Elective Subjects¶

2·261	Lubrication & Friction	2–4
2·48	Gas Turbines	3–6
2·621	Refrigeration	3–6
2·664	Refrigeration, App.	2–4
2·693	Refrig. & Air Cond. Lab.	3–6
6·19	Industrial Electronics	4–6

Option 2. Materials, Design and Manufacturing

First Term	2·081	Strength of Materials	3–6	*Second Term*	2·082	Mech. Eng. Problems	3–6
	2·43	Heat Engineering	3–6		2·680	Engineering Laboratory	4–4
	2·732	Machine Design	4–4			*Thesis	9
	3·12	Metal Processing	4–4			†Humanities IV	3–5
		†Humanities IV	3–5			Prof. Elective Subjects	15
		Prof. Elective Subject	9				49
			51				

First Term Professional Elective Subjects¶

2·871	Manufacturing Eng.	3–6
3·16	Powder Metallurgy	2–4
3·18	Mech. Behavior of Metals	2–4
3·331	Industrial Physical Met.	4–2
3·50	X-ray Metallurgy	4–4
15·70	Production	3–6
17·741	Eng. Prop. of Plastics	2–4

Second Term Professional Elective Subjects¶

2·126	Exp. Stress Analysis	5–4
2·261	Lubrication & Friction	2–4
2·34	Mech. Prop. of Metals	3–6
2·872	Prep. for Manufacturing	3–6
3·13	Foundry Engineering I	2–4
3·15	Welding Engineering	2–4
6·19	Industrial Electronics	4–6
15·71	Production	3–6
15·76	Mass Production Methods	3–6

Option 3. Automotive§

First Term	2·081	Strength of Materials	3–6	*Second Term*	2·082	Mech. Eng. Problems	3–6
	2·43	Heat Engineering	3–6		2·792	Internal Combustion Eng.	3–6
	2·681	Engineering Laboratory	3–3		2·7942	Internal Combustion Eng. Lab.	2–1
	2·791	Internal Combustion Eng.	3–6			*Thesis	9
	2·7941	Internal Combustion Eng. Lab.	2–1			†Humanities IV	3–5
	3·12	Metal Processing	4–4			Prof. Elective Subject	9
		†Humanities IV	3–5				47
			21–31				

Professional Elective Subjects¶

2·126	Experimental Stress Anal.	5–4
2·48	Gas Turbines	3–6
2·796	Internal Combust. Eng. Des.	3–6
16·81	General Aeronautics	3–6

II-A. MECHANICAL ENGINEERING

In Cooperation with the General Electric Company and the Boston Edison Company

(Applications for admission to Course II-A are not being accepted.)

* See Requirements for Bachelor's Degree, page 46. † See page 145 for list of subjects.
¶ Other electives may be chosen with approval of registration officer.
§ Application for admission to this option should be made to the Head of the Department before the end of the third year, since registration is limited.

II-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.

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

(Same as Course II through Second Year)

GROUP A

THIRD YEAR

Summer

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

Summer Term	*2·04	Strength of Materials	3–6
	*2·40	Heat Engineering	4–5
	*2·730	Machine Design	4–2
			11–13

Vacation (Approximately 2 weeks)

At Plants (Remainder of Summer)
First part of approximately
6 months continuous practice

Regular Academic Year

At Plants

First Term — Second part of approximately 6 months continuous practice

At M. I. T.

Second Term	*2·06	Dynamics	3–6
	*2·251	Fluid Mechanics	3–6
	*2·37	Testing Materials Lab.	4–4
	*2·42	Heat Engineering	3–6
	*6·18	Electrical Eng., Fund.	4–6
	Ec11	Economic Prin. I–Humanities III	3–5
			20–33

FOURTH YEAR

Summer (In effect June 1950)

Vacation (First 6 Weeks)

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

Summer Term	*2·252	Fluid Mechanics	2–4
	*2·731	Machine Design	5–4
		†Humanities III	3–5
			10–13

Regular Academic Year

(In effect 1950–51)

Same as Fourth Year in Course II

* See Requirements for Bachelor's Degree, page 46.

† See page 145 for list of subjects.

II-B. Mechanical Engineering Continued

GROUP B

THIRD YEAR

Summer

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

Summer Term	*2·04	Strength of Materials	3–6
	*2·40	Heat Engineering	4–5
	*2·730	Machine Design	4–2
			11–13

Vacation (Remainder of Summer)

Regular Academic Year

At M. I. T.				*At Plants*	
First Term	*2·06	Dynamics	3–6	*Second Term*	First part of approximately 6 months continuous practice
	*2·251	Fluid Mechanics	3–6		
	*2·37	Testing Materials Lab.	4–4		
	*2·42	Heat Engineering	3–6		
	*6·18	Electrical Eng., Fund.	4–6		
	Ec11	Economic Prin. I–Humanities III	3–5		
			20–33		

FOURTH YEAR

Summer (In effect June 1950)

At Plants (Approximately 4 weeks)

Second part of approximately 6 months continuous practice

Vacation (Approximately 2 weeks)

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

Summer Term	*2·252	Fluid Mechanics	2–4
	*2·731	Machine Design	5–4
	†Humanities III		3–5
			10–13

Regular Academic Year

(In effect 1950–51)

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

See Requirements for Bachelor's Degree, page 46.

† See page 145 for list of subjects.

III. Metallurgy Continued

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 courses; similarly, it is related to Metallurgy by its sequence of courses 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 46)

SECOND YEAR

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

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
	Ec11	Economic Prin. I — Humanities III	3–5		12·301	(2) Physical Geology	6–3
			26–26			†Humanities III	3–5
							(1) 24–24
							(2) 26–21

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	7–6			†Humanities IV	3–5
	3·20	Metal. Thermodynamics	4–4			Elective Subjects	18
	*3·50	X-ray Metallurgy	4–4				48
		†Humanities IV	3–5				
		Elective Subject	6				
			51				

First Term Elective Subjects

3·16	Powder Metallurgy	2–4
3·161	Powder Metallurgy Lab	4–2
3·18	Mech. Behavior of Metals	2–4
3·42	Applied Electrochemistry	2–4
3·70	Ceramics	5–4

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
3·82	Mineral Eng. II	6–4
3·85	Mineragraphy	4–2

* See Requirements for Bachelor's Degree, page 46. † See page 145 for list of subjects.

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

III. Metallurgy Continued

OPTION 2. MINERAL ENGINEERING

First	3·02	Metallurgical Engineering II	7–6	*Second*	3·03	Metallurgical Engineering III	2–4
Term	3·20	Metal. Thermodynamics	4–4	*Term*	3·70	Ceramics	5–4
	3·83	Mineral Engineering III	4–4			*Thesis	10
	12·94	Mineral Economics	2–4			†Humanities IV	3–5
		†Humanities IV	3–5			Elective Subjects	18
		Elective Subject	6				51
			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
12·91	Elements of Mining	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
12·24	Theoretical Crystallog.	2–4
15·11	Business 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, co-ordination of the general plan with a simple and economical structural system, research into best methods and materials of construction, control over proportions and details to achieve effective and eloquent expression and integration of planning with equipment and materials necessary to maintain desired conditions of health, enjoyment, and convenience.

Unusual opportunities are available for fundamental training in the basic sciences underlying building technology, for close contact with outstanding laboratory and research facilities in engineering fields related to architecture, and for understanding of the broad economic and social approach of the city planner. In recognition of a vital need in the profession for ever greater technical ability and judgment, the curriculum in Architecture integrates technical resources with social and cultural needs.

The Course leads to the degree of Bachelor in Architecture.

FIRST YEAR (See page 46)

SECOND YEAR

First	2·011	Statics & Dynamics	3–5	*Second*	2·04	Strength of Materials	3–6
Term	4·721	Architectural Design	9–3	*Term*	4·07	Shop	4–0
	8·03	Physics	5–5		4·12	Urban Sociology	2–4
	E21	History — Humanities II	3–5		4·722	Architectural Design	9–3
	M21	Calculus	3–6		17·71	Materials	3–4
	MS21	Military Science	3–0		E22	History — Humanities II	3–5
			26–24		MS22	Military Science	3–0
							27–22

THIRD YEAR

First	*1·771	Sanitation	2–4	*Second*	*2·662	Heating & Ventilation	2–4
Term	*2·661	Heating & Ventilation	2–4	*Term*	*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		*4·732T	Architectural Design	12–6
	*4·811	Structural Analysis	8–0		*4·812	Structural Analysis	8–0
	Ec11	Economic Prin. I — Humanities III	3–5			†Humanities III	3–5
			31–19				31–19

FOURTH YEAR

First	*4·741	Architectural Design	12–6	*Second*	4·041	Light and Color	6–0
Term	*6·16	Electricity	3–6	*Term*	*4·742T	Architectural Design	12–6
	8·132	Architectural Acoustics	5–3		*6·17	Illumination	2–4
	*17·73	Materials	3–4		*17·72T	Materials	6–4
		†Humanities IV	3–5			†Humanities IV	3–5
			26–24				29–19

Students registered in the Spring term 1950: Omit 17·72T. Add *4·641 City Planning, Prin., 2–4 and *17·722 Materials, 3–0.

* See Requirements for Bachelor's Degree, page 46. † See page 145 for list of subjects.

IV-A. Architecture Continued

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		Ec88	Building Economics	2–4
	*4·621	Site Plan & Construction	9–3			*Thesis	21
	*4·751	Architectural Design	9–3			Prof. Elective Subject	6
		Prof. Elective Subject	6				48
			51				

IV-B. CITY PLANNING

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

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

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

A feature of the Course is the close 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.

FIRST YEAR (See page 46)

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
	8·03	Physics	5–5		4·722	Architectural Design	9–3
	Ec35	Statistics, Elem.	3–6		8·04	Physics	5–5
	E21	History — Humanities II	3–5		12·321	Engineering Geology	4–4
	E37	Public Speaking	3–3		E22	History — Humanities II	3–5
	MS21	Military Science	3–0		MS22	Military Science	3–0
			26–22				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		4·682T	City & Regional Planning	12–9
	Ec11	Economic Prin. I — Humanities III	3–5			†Humanities III	3–5
			23–27				23–27

* See Requirements for Bachelor's Degree, page 46.

† See page 145 for list of subjects.

IV-B. City Planning Continued

REQUIRED DURING SUMMER

4·50	Office Practice	40 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.	9–3			*Thesis	20
	Ec49	Public Finance	2–4			†Humanities IV	3–5
		†Humanities IV	3–5			Prof. Elective Subject	6
		Prof. Elective Subject	6				49
			50				

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 46)

SECOND YEAR

First Term	5·10T	Qualitative Analysis	11–3	*Second Term*	5·13T	Quantitative Analysis	12–4
	8·03	Physics	5–5		8·04	Physics	5–5
	E21	History — Humanities II	3–5		E22	History — Humanities II	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
		‡Language	3–5				26–20
			28–24				

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
	*5·611	Physical Chem. Lab. I	4–0		*5·621	Physical Chem. Lab. II	4–0
	*5·63	Physical Chemistry I	4–6		*5·64	Physical Chemistry II	4–6
	Ec11	Economic Prin. I — Humanities III	3–5			†Humanities III	3–5
		Elective Subject	9			Elective Subject	9
			48				48

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 IV	3–5			†Humanities IV	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.)

* See Requirements for Bachelor's Degree, page 46. † See page 145 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.

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 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 46)

SECOND YEAR

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

THIRD YEAR‡

First Term	*2·04	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.	3–6
	*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) Electrical Com., Prin.	3–6
	Ec11	Economic Prin. 1 — Humanities III	3–5		*6·76	Eng. Electronics Lab.	3–3
	M31	Differential Equations	2–4		8·08	(3, 4) Electronics	4–5
			19–31			†Humanities III	3–5
							(1) 18–32
							(3, 4) 19–31

FOURTH YEAR

OPTION 1. ELECTRIC POWER

First Term	1·64	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 IV	3–5
		†Humanities IV	3–5			Prof. Elective Subjects (see next page)	18
		Prof. Elective Subject (see next page)	9				50
			49				

* See Requirements for Bachelor's Degree, page 46. † See page 145 for list of subjects.
‡ Students planning to take a certain option in the fourth year, take the Group Electives indicated by the corresponding number.

VI. Electrical Engineering Continued

Professional Elective Subjects

6·20	(1, 3) Electronic Control & Meas.	3–6
6·211	App. Electricity to Industry	3–6
6·221	Elec. Power Syst.	3–6
6·223	Power Frequency App. Eng.	3–6
6·23	(1,3) Elec. Implementation	3–6
6·241	Case Studies in Elec. Eng. Prac.	3–6
6·251	Electric Machinery Design	3–6
6·26	Insulators and Semi-Conductors	3–6
6·271	Illuminating Eng., Prin.	3–6
6·281	Wire Communications, Prin.	3–6
6·291T	Radar, Prin.	3–6
6·311	(1,4) Electrical Com., Prin.	3–6
6·321T	(1,4) Electrical Com., Prin.	3–6
6·35	Engineering Acoustics	3–6
6·37	Television, Prin.	3–6
6·80	Electrical Meas. Lab.	Time arr.
6·86	Electrical Machinery Lab.	Time arr.
M77	Vector Analysis	3–6

Professional Elective Subjects

6·202	Electronic Control & Meas.	3–6
6·212	App. Electricity to Industry	3–6
6·213	Ind. App. of Servomechanisms	3–6
6·222	Elec. Power Syst.	3–6
6·224	Power Frequency App. Eng.	3–6
6·23	(1, 3) Electrical Implementation	3–6
6·241	Case Studies in Elec. Eng. Prac.	3–6
6·252	Electric Machinery Design	3–6
6·272	Illuminating Eng., Prin.	3–6
6·292T	Radar, Prin.	3–6
6·312	Electrical Communications, Prin.	3–6
6·322T	(1, 4) Electrical Communications, Prin.	3–6
6·80	Electrical Meas. 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
	*6·311	Electrical Com., Prin.	3–6
	*6·321T	Electrical Com., Prin.	3–6
	*6·331	Electrical Com. Lab.	3–3
		†Humanities IV	3–5
		Prof. Elective Subject (See above)	9
			50
Second Term	*6·322T	Electrical Com., Prin.	3–6
	*6·332	Electrical Com. Lab.	4–5
	*6·781	Electrical Mach. Lab.	3–3
		*Thesis	9
		†Humanities IV	3–5
		Prof. Elective Subject (See above)	9
			50

OPTION 4. ELECTRONIC APPLICATIONS

First Term	2·251	Fluid Mechanics	3–6
	*6·032	Electrical Eng., Prin.	3–6
	*6·20	Electronic Control & Meas.	3–6
	*6·83	Electronic Eng. Lab.	3–3
		†Humanities IV	3–5
		Prof. Elective Subject (See above)	9
			50
Second Term	*6·23	Elec. Implementation	3–6
	*6·781	Electrical Mach. Lab.	3–3
	*6·84	Elec. Implement. Lab.	4–5
		*Thesis	9
		†Humanities IV	3–5
		Prof. Elective Subject (See above)	9
			50

VI-A. ELECTRICAL ENGINEERING

COOPERATIVE COURSE

THE engineering graduate, before he can take responsibility for important industrial projects, must have an educational background of sound fundamental scientific and economic principles, and in addition, must be acquainted with industrial practices in his specialized field of employment. This interlinking of theory and practice is provided in the Cooperative Course in Electrical Engineering, in which a selected group of students pursues a course of study and practice which correlates the scientific and engineering principles of the classroom and laboratory with approximately seventy weeks of practical experience in the plants of a particular industry. This educational plan makes it possible for the student to do his "undergraduate" work in industry in parallel with his undergraduate academic studies at the Institute and, at the time of graduation, to be in a position to utilize immediately the more advanced principles studied in the senior and graduate years. The first four years are identical in academic content with that option of Course VI which the student elects. The fifth or final year includes a complete academic year of graduate work subject to the provisions of the Graduate School. The Course leads to the degrees of Bachelor of Science and Master of Science in Electrical Engineering awarded simultaneously at the end of the graduate year.

The following six companies and the Naval Ordnance Laboratory 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, and Syracuse. 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 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

* See Requirements for Bachelor's Degree, page 46. † See page 145 for list of subjects.

VI-A. Electrical Engineering Continued

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

The GENERAL RADIO COMPANY provides practical experience in the manufacture of communications and electronic apparatus. The first period is spent in the 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. Students will receive early assignments with the Ohio Power Company in Canton, Philo and Brilliant, Ohio, where they will receive important assignments in system maintenance and operation. Later assignments will be in New York City, where network problems are studied. Opportunities in the field of power research are offered.

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 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.

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

(Same as Course VI through Second Year)

GROUP A

THIRD YEAR‡

At M. I. T.

Summer	*2·04	Strength of Materials	3–6
Term	*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
	Ec11	Economic Prin. I — Humanities III	3–5
			17–27

* See Requirements for Bachelor's Degree, page 46.

‡ 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	*6·02	Electrical Eng., Prin.	3–6
	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		

At M. I. T.

Second Term	1·64	(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) Elec. Com., Prin.	3–6
	*6·321T	(3) Elec. Com., Prin.	3–6
	*6·76	Eng. Electronics Lab.	3–3
	8·08	(3, 4) Electronics	4–5
		†Humanities III	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		

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
	*6·322T	(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 IV	3–5
		(1,3) Prof. Elective Subject	9
			(1) 46
			(3) 50
			(4) 47

At Plants

Second Term	M136	Advanced Calculus	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		

Graduate Year

At M. I. T.

Summer Term	6·501	Elec. Eng. Seminar	2–10
		†Humanities IV	3–5
		Graduate Study	24
			44

At Plants

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

At M. I. T.

Second Term	Graduate Study and Thesis	50
		50

* See Requirements for Bachelor's Degree, page 46.

† See page 145 for list of subjects.

VI-A. Electrical Engineering Continued

Group B

Third Year‡

At Plants

Summer	*6·01	Electrical Eng., Prin.	3–6
Term	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		

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.	3–6
	*6·75	Elec. Meas. Lab.	4–5
	*6·76	Eng. Electronics Lab.	3–3
	*8·071	(3, 4) Thermo. & Statist. Mech.	4–5
	Ec11	Economic Prin. I — Humanities III	3–5
			20–30

At Plants

Second Term	M36	Advanced Calculus	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		

Fourth Year

Option 1. Electric Power; Option 3. Electrical Communications; Option 4. Electronic Applications

At M. I. T.

Summer	*2·07	(1, 4) Dynamics	3–6
Term	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) Elec. Com., Prin.	3–6
	*6·321T	(3) Elec. Com., Prin.	3–6
	8·08	(3, 4) Electronics	4–5
		†Humanities IV	3–5
		(1) Prof. Elective Subject	9
			44

At Plants

First Term	*6·032	Electrical Eng., Prin.	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		

At M. I. T.

Second Term	1·64	(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
	*6·322T	(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 IV	3–5
		(3) Prof. Elective Subject	9
			(1) 19–27
			(3) 50
			(4) 19–28

Graduate Year

At Plants

Summer	M37	Advanced Calculus	3–6
Term	6·904		
	6·914	Industrial Practice	40 h.p.w.
	6·944	(Students to register for one of these sub-	
	6·954	jects.)	
	6·964		
	6·974		
	6·984		

At M. I. T.

First Term	6·501	Elec. Eng. Seminar	2–10
		Graduate Study and Thesis	35
			47

At M. I. T.

Second Term	†Humanities III	3–5
	Graduate Study and Thesis	40
		48

Students registered in the graduate year, second term, in the Spring Term 1950: Omit Humanities III. Change Graduate Study and Thesis to 48.

* See Requirements for Bachelor's Degree, page 46. † See page 145 for list of subjects.

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

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 46)

SECOND YEAR

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

REQUIRED DURING SUMMER

5·41	Organic Chemistry I	4–4
5·412	Organic Preparations I	10–0
		14–4

THIRD YEAR

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

FOURTH YEAR

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

VII-A. PHYSICAL BIOLOGY

THE purpose of this course is to prepare students for work of a research character in experimental and applied biology. In the wide range from pure biology to 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

* See Requirements for Bachelor's Degree, page 46. † See page 145 for list of subjects.

VII-A. Physical Biology Continued

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*	*7·03	Genetics	2–4
	*7·211	Gen. Physiol. Lab. I	4–0		*7·20	General Physiology II	2–4
	*7·831	Biochem. of Micro-organisms	7–4		*7·212	Gen. Physiol. Lab. II	4–0
	*8·05	Atomic Physics	4–6		*8·06	Nuclear Physics	4–6
		†Humanities IV	3–5		*8·09	Experimental Physics I	3–2
		Elective Subjects	10			†Humanities IV	3–5
			49			Elective Subject	8
							47

GRADUATE YEAR

First Term	7·85	Biophysics I	4–4	*Second Term*	7·86	Biophysics II	2–4
	7·91	Instrument. in Biol. I	8–8		7·882	Biophysics Lab.	4–0
		Thesis	16		7·92	Instrument. in Biol. II	4–0
		Elective Subject	8			Thesis	24
			48			Elective Subject	8
							46

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 46)

SECOND YEAR

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

THIRD YEAR

First Term	6·02	Electrical Eng., Prin.	3–6	*Second Term*	*8·08	Electronics	4–5
	6·76	Eng. Electronics Lab.	3–3		*8·10	Experimental Physics II	6–6
	*8·05	Atomic Physics	4–6		M37	Advanced Calculus	3–6
	*8·07	Thermodyn. & Statist. Mech.	4–5			†Humanities III	3–5
	*8·09	Experimental Physics I	3–2			Prof. Elective Subject	9
	Ec11	Economic Prin. I — Humanities III	3–5				47
			20–27			*Professional Elective Subjects*	
					8·06	Nuclear Physics	4–6
					8·16	Optics	3–6

FOURTH YEAR

First Term	8·11	Experimental Physics	8–4	*Second Term*	8·72	Int. Theoretical Physics II	4–8
	8·71	Int. Theoretical Physics I	4–8			*Thesis	18
		†Humanities IV	3–5			†Humanities IV	3–5
		Elective Subjects	15			Elective Subject	9
			47				47

* See Requirements for Bachelor's Degree, page 46.

† See page 145 for list of subjects.

IX-A. GENERAL SCIENCE

(Administered by a Committee of the Faculty)

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

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

The choice of electives is subject to the approval of the Committee on Course IX and, for the third and fourth years, must include a total of at least 48 units in one field of science not including the required subjects. Substitutions may be made for the subjects marked (**) by subjects of similar content or in the same field. The composite group of science subjects must comprise an amount of scientific training equivalent to that obtained in the standard science courses.

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

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

First Year (See page 46)

Second Year (See text above)

Third Year

First Term	**5·41	Organic Chemistry I	4–4	*Second Term*	**5·42	Organic Chemistry II	4–4
	**8·07	Thermodyn. & Statist. Mech.	4–5		**8·08	Electronics	4–5
	Ec11	Economic Prin. I — Humanities III	3–5		**M137	Advanced Calculus	3–6
	**M136	Advanced Calculus	3–6			†Humanities III	3–5
		‡Elective Subjects	16			‡Elective Subjects	16
			50				50

Fourth Year

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

Suggested Elective Subjects

	5·414	Organic Preparations I	9–0		5·424	Org. Prep. II & Anal.	9–0
	5·61	Physical Chemistry I	4–4		5·62	Physical Chemistry II	4–4
	5·611	Physical Chem. Lab. I	4–0		5·621	Physical Chem. Lab. II	4–0
	7·01	General Biology I	6–4		7·02	General Biology II	6–4
	7·211	General Physiology Lab. I	4–0		7·11	Embryology	8–4
	7·831	Biochemistry of Micro-organisms	7–4		8·10	Experimental Physics II	6–6
	8·05	Atomic Physics	4–6		8·15	Photography	2–1
	8·09	Experimental Physics I	3–2		8·16	Optics	3–6
	8·132	Architectural Acoustics	5–3		8·17	Color Measurements	3–2
	8·71	Int. Theoretical Physics I	4–8		8·72	Int. Theoretical Physics II	4–8
	20·41	Bacteriology	6–2		12·321	Engineering Geology	4–4
	M31	Differential Equations	2–4		12·322	Engineering Geology	2–4
	M77	Vector Analysis	3–6				

IX-B. GENERAL ENGINEERING

(Administered by a Committee of the Faculty)

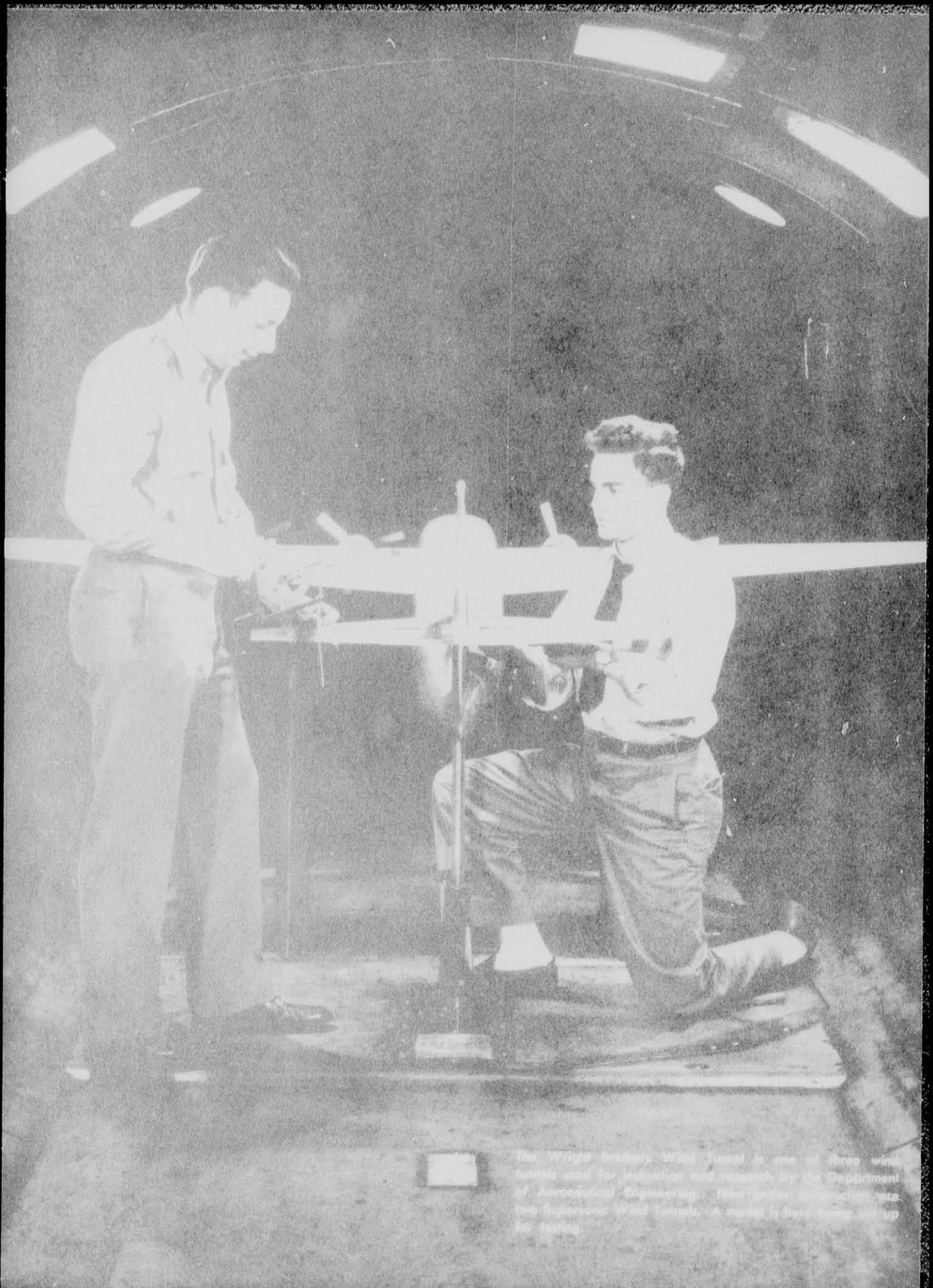
THE Course in General Engineering provides an opportunity for a student with a special objective to map out his own program of study in the fundamental engineering subjects.

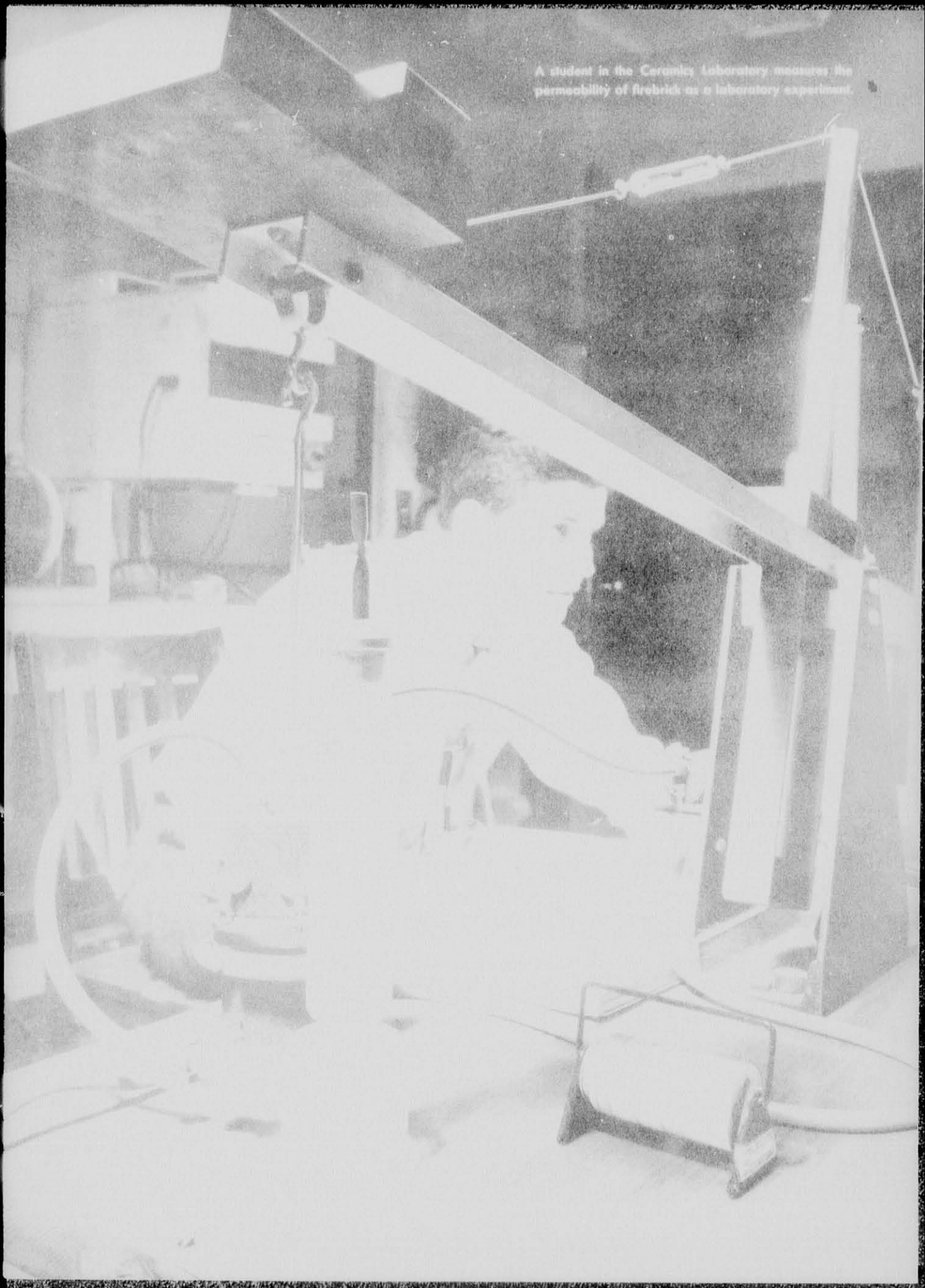
Since one-quarter of the units required for graduation are elective, the student may choose a comprehensive program involving several engineering subjects, with specialization in one field. If his specialization falls within one of the professional engineering courses, such as Aeronautical, Chemical,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

The choice of electives is subject to the approval of the Committee on Course IX and, for the third and fourth

* See Requirements for Bachelor's Degree, page 46. † See page 145 for list of subjects. ** Substitutions may be made only with subjects in the same field.

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





A student in the Ceramics Laboratory measures the permeability of firebrick as a laboratory experiment.

IX-B. General Engineering Continued

years, must include a total of at least 48 units in one field of engineering not including the required subjects. Substitutions may be made for the subjects marked (**) by subjects of similar content or in the same field. The composite group of engineering subjects must comprise an amount of engineering training equivalent to that obtained in the standard engineering courses.

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

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

FIRST YEAR (See page 46)

SECOND YEAR (See text above)

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		**6·40	Electrical Eng., Elem.	4–6
	Ec11	Economic Prin. I — Humanities III	3–5			†Humanities III	3–5
		‡Elective Subjects	24			‡Elective Subjects	23
			50				50

FOURTH YEAR

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

Suggested Elective Subjects

1·05	Surveying	3–1
1·64	Fluid Mechanics	3–6
2·081	Strength of Materials	3–6
2·663	Air Conditioning	3–6
2·683	Engineering Laboratory	4–4
2·701	Machine Drawing	6–0
2·730	Machine Design	4–2
2·791	Internal Combustion Eng.	3–6
5·11	Qualitative Analysis	7–3
6·221	Electric Power Systems	3–6
M36	Advanced Calculus	3–6

Suggested Elective Subjects

1·401	Structures	3–6
2·06	Dynamics	3–6
2·50	Heat Measurements	3–1
2·621	Refrigeration	3–6
2·792	Int. Comb. Engines	3–6
3·11	Engineering Metals	5–4
6·17	Illumination	2–4
6·19	Industrial Electronics	4–6
6·85	Electrical Eng. Lab.	2–3
15·50	Accounting	5–4
15·61	Business Law	3–6
E35	Reports	1–4
M37	Advanced Calculus	3–6

X. CHEMICAL ENGINEERING

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

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

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

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

FIRST YEAR (See page 46)

SECOND YEAR

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

* See Requirements for Bachelor's Degree, page 46. † See page 145 for list of subjects.

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

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

§ Students who have not had German will take L111 German, Elem. Students who have had German will take Russian.

X. Chemical Engineering Continued

THIRD YEAR

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

FOURTH YEAR

First Term	6·18	Electrical Eng. Fund	4–6	*Second Term*	10·21	Industrial Chemistry	3–6
	10·18	Industrial Chemistry	3–6		10·32	Chemical Engineering	4–6
	10·26	Industrial Chem. Lab.	10–0			*Thesis	12
		or				†Humanities IV	3–5
	10·27	Chemical Eng. Lab.	10–0			Elective Subject	9
	10·31	Chemical Engineering	4–6				48
		*Thesis	3				
		†Humanities IV	3–5				
			50				

X-B. CHEMICAL ENGINEERING PRACTICE

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

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

(*Same as Course X through Third Year*)

FOURTH YEAR

First Term	6·18	Electrical Eng., Fund.	4–6	*Second Term*	10·30	Engineering Equipment	6–0
	10·18	Industrial Chemistry	3–6			School Chem. Eng. Practice	
	10·31	Chemical Engineering	4–6			‡10·84 Bangor Station	12–0
	10·32	Chemical Engineering	4–6			‡10·85 Parlin Station	12–0
		†Humanities IV	3–5			‡10·86 Buffalo Station	12–0
			18–29			*Thesis	13
						†Humanities IV	3–5
							51

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 1·442 Bridge Design in the fourth year. Reference should be made to the Civil Engineering curriculum.

XII. GEOLOGY

THE objective of the Course in Geology is to train men for careers in theoretical and applied geology. The program of subjects provides a broad and fundamental training that integrates classical geology with the principles and techniques of those aspects of mathematics, physics and chemistry needed for progressive advancement in modern geological science.

The first three years of academic study, together with the summer field work, are devoted to basic training in geology and allied sciences. In the fourth year Course XII provides two options as a means for the beginning of specialization.

OPTION 1. GEOLOGY. The subjects of this option are designed to prepare men for geological work in the petroleum and mineral industries, or for work in scientific and academic institutions. By selection of appropriate electives, a program may be directed toward one of the following fields: general geology (including geomorphology, sedimentation, stratigraphy, paleontology, and structural geology); mineralogy, crystallography, and petrology; economic geology (including mineral deposits, geology of petroleum or coal, and engineering geology); and mineral industry (including mining methods, mineral economics and mine valuation).

* See Requirements for Bachelor's Degree, page 46. † See page 145 for list of subjects. ‡Students will take two of these stations.

XII. Geology Continued

Option 2. Geophysics. This option has been arranged to meet the demand by the petroleum and mineral industries, as well as by some groups in science and engineering, for men trained along the combined lines of geology and physics. The program of subjects places special emphasis on mathematics, physics, and certain phases of electrical engineering in recognition of the growing importance of fundamental research in geophysics.

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

First Year (See page 46)

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	6–3
	E21	History — Humanities II	3–5		E22	History — Humanities II	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			26–22				28–21

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

Third Year**

First Term	5·61	(1) Physical Chemistry I	4–4	*Second Term*	5·62	(1) Physical Chemistry II	4–4
	8·07	(2) Thermo. & Statist. Mech.	4–5		8·08	(2) Electronics	4–5
	8·09	(2) Experimental Physics I	3–2		12·15	(1) Petrography	6–2
	12·231	(1) Optical Crystallography	6–2		12·37	Geomorphology	2–4
	12·302	Historical Geology	7–3		12·702	(1) Structural Geology	3–6
	12·581	(1) Sedimentology	3–4		M37	(2) Advanced Calculus	3–6
	Ec11	Economic Prin. I — Humanities III	3–5			Language	3–5
	M36	(2) Advanced Calculus	3–6			†Humanities III	3–5
		Language	3–5			(2) Elective Subject	9
			(1) 26–23 (2) 23–26				(1) 21–26 (2) 49

Fourth Year

Option 1. Geology

(In effect 1950–51)

First Term	12·04	X-ray Mineralogy	3–2	*Second Term*	12·24	Theoretical Crystallog.	2–4
	12·40	Mineral Deposits	3–6		12·44	Mineral Fuels	2–4
	12·41	Mineral Deposits Lab.	6–0		12·45	Laboratory Methods	6–0
	12·87	Geophysics, Int.	2–4			*Thesis	15
	12·94	Mineral Economics	2–4			†Humanities IV	3–5
		†Humanities IV	3–5			Elective Subject	9
		Elective Subject	9				50
			49				

Elective Subjects‡

	12·35	Glacial Geology	3–6		12·73	Regional Geology	2–4
	12·39	Reg. Geomorphology of Earth	2–4		12·83	(1) Geophysics Laboratory	3–2
	12·42	Applied Economic Geology	3–6		12·86	Elements of Seismology	2–4
	12·511	Paleontology	7–2		12·91	Elements of Mining	3–6
	12·512	Paleontology	7–2		12·92	Mining Methods & Practice	3–6
	12·65	Special Problems	Time arr.				

Option 2. Geophysics

(In effect 1950–51)

First Term	8·71	Int. Theoretical Physics I	4–8	*Second Term*	8·72	Int. Theoretical Physics II	4–8
	12·40	Mineral Deposits	3–6			*Thesis	15
	12·83	Geophysics Lab.	3–2			†Humanities IV	3–5
	12·87	Geophysics, Int.	2–4			¶Elective Subjects (See Opt. 1)	12
		†Humanities IV	3–5				47
		¶Elective Subject (See Opt. 1)	9				
			49				

* See Requirements for Bachelor's Degree, page 46. † See page 145 for list of subjects.
** Students planning to take a certain option in the fourth year, take the Group Electives indicated by the corresponding number.
‡ Subjects in other Departments may be chosen with the approval of the Registration Officer.
¶ Students may also select any subject required in Option 1.

XII. Geology Continued

FOURTH YEAR (1949–50 only)

First Term	12·04	X-ray Mineralogy	3–2	*Second Term*	12·24	Theoretical Crystallog.	2–4
	12·40	Mineral Deposits	3–6		12·44	Mineral Fuels	2–4
	12·41	Mineral Deposits Lab.	6–0		12·45	Laboratory Methods	6–0
	12·581	Sedimentology	3–4			*Thesis	15
	12·87	Geophysics, Int.	2–4			†Humanities IV	3–5
	12·94	Mineral Economics	2–4			Elective Subject	9
		†Humanities IV	3–5				50
			22–25				

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 is included an introductory course in ship construction which deals with the broad aspects of shipbuilding and the power plant equipment of vessels, and with the operation of shipyards.

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

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

FIRST YEAR (See page 46)

SECOND YEAR

First Term	2·00	Statics	3–5	*Second Term*	2·01	Dynamics	3–5
	2·851	Machine Tool Lab.	4–0		2·852	Machine Tool Prac.	4–0
	8·03	Physics	5–5		3·11	Engineering Metals	5–4
	13·40	Ship Construction, Elem.	5–2		8·04	Physics	5–5
	E21	History — Humanities II	3–5		E22	History — Humanities II	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			26–23				26–25

THIRD YEAR

First Term	*2·04	Strength of Materials	3–6	*Second Term*	*2·062	Strength of Materials & Dynamics	3–6
	*2·251	Fluid Mechanics	3–6		*2·42	Heat Engineering	3–6
	*2·40	Heat Engineering	4–5		*13·02	Dynamics of Ship Design	3–6
	*13·01	Statics of Ship Design	3–6		*13·34	Ship Construction	3–3
	*13·42	Ship Hull Design	6–0		*13·52	Marine Engineering	3–6
	Ec11	Economic Prin. I — Humanities III	3–5			†Humanities III	3–5
			22–28				18–32

FOURTH YEAR

First Term	2·371	Testing Materials Lab.	2–2	*Second Term*	*13·46	Ship Design	7–1
	*2·683	Engineering Lab.	4–4		*13·55	Marine Engineering	2–4
	*6·18	Electrical Eng., Fund.	4–6		*13·62	Marine Engineering Design	6–1
	*13·45	Ship Structures Design	6–3		15·11	Business Management, Int.	3–6
	13·54	Marine Engineering Dynamics	2–4			*Thesis	10
	*13·61	Marine Engineering Design	6–1			†Humanities IV	3–5
		†Humanities IV	3–5				48
			27–25				

XIII-C. MARINE TRANSPORTATION

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

It is essential that a student have a certain amount of actual experience aboard ships at sea in order to grasp thoroughly the problems of ship operation before finishing his course of study. It is also deemed necessary that sea experience be obtained before engaging in the various shore

* See Requirements for Bachelor's Degree, page 46. † See page 145 for list of subjects.

XIII-C. Marine Transportation Continued

activities of a steamship company. For these reasons students in the Course are required to spend a year at sea as part of the requirements for graduation.

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

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

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

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

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

FIRST YEAR (See page 46)

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
	13·401	Ship Construction, Elem.	2–2		E22	History — Humanities II	3–5
	E21	History — Humanities II	3–5		M22	Differential Equations	3–6
	M21	Calculus	3–6		MS22	Military Science	3–0
	MS21	Military Science	3–0			Language	3–5
		Language	3–5				20–26
			23–23				

THIRD YEAR

First Term	*2·04	Strength of Materials	3–6	*Second Term*	*2·665	Refrigeration, Applied	3–4
	*2·40	Heat Engineering	4–5		*13·021	Ship Propulsion & Maneuvering	2·4
	*13·01	Statics of Ship Design	3–6		*13·52	Marine Engineering	3–6
	*13·83	Ports & Port Facilities	2–4		*13·84	Cargo Handling & Stowage	5–3
	*13·85	Cargoes in World Trade	3–6		*15·50	Accounting	5–4
	Ec11	Economic Prin. I — Humanities III	3–5			†Humanities III	3–5
			18–32				21–26

Students registered in the third year, first term, in the Fall term 1949–50: Omit 13·85. Add *2·851 Machine Tool Lab., 4–0, and *13·34 Ship Construction, 3–3.

FOURTH YEAR (At Sea. See text above.)

FIFTH YEAR

First Term	*2·681	Engineering Lab.	3–3	*Second Term*	*13·82	Ship Operation	2–4
	*6·18	Electrical Eng., Fund.	4–6		*13·86	Steamship Management	3–6
	*13·47T	Ship Design	8–2		15·61	Business Law	3–6
	*13·56	Marine Engineering Economics	3–6		Ec54	Corporations	2–4
	*13·81	Ship Operation	3–6			*Thesis	10
		†Humanities IV	3–5			†Humanities IV	3–5
			24–28				48

Students registered in the fifth year, first term, in the Fall Terms 1949–50, 1950–51, and 1951–52: Omit 13·47T. Add 13·47 Ship Design, 7–1.

XIV. ECONOMICS AND ENGINEERING

THE purpose of this course is to provide a basic training in economics and engineering. The Course is designed for those planning to become staff executives in the economic, personnel, statistical or other departments of a business, governmental, or labor organization, as well as for those who will go on to graduate work in Economics in preparation for teaching. In the past such persons have typically come into their profession from the

* See Requirements for Bachelor's Degree, page 46. † See page 145 for list of subjects.

XIV. Economics and Engineering Continued

liberal arts colleges. This course offers the engineering approach. The student will be equipped to use the methodology of exact science in the analysis of economic and social problems.

The subjects in Economics and Social Science have been selected with a view to achieving three main objectives: (1) to impart some knowledge of human behavior; (2) to indicate how our economy is organized and how it operates; and (3) to give a conception of the broader aspects of economic, political, and social problems. Students have their choice of two options: Human Relations, or Industrial Economics.

Option 1. Human Relations. Emphasis is placed on the first of these objectives — to help the student to be effective in his relations with his superiors, associates, and subordinates. The curriculum includes such subjects as Advanced Psychology, Labor Relations, and Management of People.

Option 2. Industrial Economics. Emphasis is placed on the second of the above objectives — to provide an understanding of economic institutions and of the functioning of our economic system. The program includes such subjects as Banking and Finance, and Prices and Production.

In both options, professional electives in the fourth year afford an opportunity to pursue further study in these and related fields.

On the engineering side, the student will elect one of three programs of coordinated subjects in Mechanical, Electrical, or Chemical Engineering. Each of these programs has been designed to provide a thorough understanding of the fundamental concepts in the particular field, as well as a knowledge of some of the most important practical applications.

This Course leads to the degree of Bachelor of Science in Economics and Engineering.

First Year (See page 46)

Second Year

(*a*) *Mechanical Engineering;* (*b*) *Electrical Engineering;*
(*c*) *Chemical Engineering*

First Term	2·00	(*a*, *b*) Statics	3–5	*Second Term*	2·01	(*a*, *b*) Dynamics	3–5
	2·851	(*a*, *b*) Machine Tool Lab.	4–0		5·12	(*c*) Quantitative Analysis	7–3
	5·11	(*c*) Qualitative Analysis	7–3		8·04	Physics	5–5
	8·03	Physics	5–5		§Ec70	Introductory Psychology	3–5
	Ec11	Economic Principles I	3–5		E22	History — Humanities II	3–5
	E21	History — Humanities II	3–5		M22	Differential Equations	3–6
	M21	Calculus	3–6		MS22	Military Science	3–0
	MS21	Military Science	3–0				
		(*a*, *b*)	24–26			(*a*, *b*)	20–26
		(*c*)	24–24			(*c*)	24–24

Third Year**

First Term	2·04	(*a*, *b*) Strength of Mat.	3–6	*Second Term*	2·42	(*a*, *b*) Heat Engineering	3–6
	2·40	(*a*, *b*) Heat Engineering	4–5		3·11	(*a*, *b*) Eng. Metals	5–4
	5·41	(*c*) Org. Chemistry I	4–4		5·62	(*c*) Phys. Chemistry II	4–4
	5·61	(*c*) Phys. Chemistry I	4–4		6·18	(*c*) Elec. Eng., Fund.	4–6
	6·18	(*a*, *b*) Elec. Eng., Fund.	4–6		6·19	(*a*, *b*) Industrial Electronics	4–6
	10·28	(*c*) Chemical Eng.	4–6		10·17	(*c*) Industrial Chemistry	3–4
	‡15·70	Production	3–6		15·50	Accounting	5–4
	‡Ec723	Manage. of People, Tech.	4–0		Ec352	Elementary Statistics	2–4
	Ec725	Comparative Contemp. Cultures	2–4		Ec60	Labor Relations	3–5
		(*a*, *b*)	20–27			(*a*, *b*)	22–29
		(*c*)	21–24			(*c*)	21–27

Fourth Year**

Option 1. Human Relations

First Term	2·251	(*a*) Fluid Mechanics	3–6	*Second Term*	2·06	(*a*) Dynamics	3–6
	6·47	(*b*) App. Elec. in Industry	3–6		2·252	(*a*) Fluid Mechanics	2–4
	10·18	(*c*) Industrial Chem.	3–6		6·213	(*b*) Ind. App. of Servomech	3–6
	10·31	(*c*) Chemical Eng.	4–6		6·222	(*b*) Elec. Power Systems	3–6
	Ec65	Industrial Relations	3–6		10·32	(*c*) Chemical Eng.	4–6
	Ec73	Psychology, Adv.	3–6		Ec724	Manage. of People, Th.	2–4
		†Humanities IV	3–5			*Thesis	9
		(*a*, *b*) Elective Subjects (See Opt. 2)	15			†Humanities IV	3–5
		(*c*) Elective Subject (See Opt. 2)	6			(*a*, *b*) Elective Subject (See Opt. 2)	9
						(*c*) Elective Subjects (See Opt. 2)	15
		(*a*, *b*)	50				
		(*c*)	51			(*a*) 47 (*b*)	50
						(*c*)	48

* See Requirements for Bachelor's Degree, page 46. ** See Second Year for explanation of Engineering Group Electives. † See page 145 for list of subjects.
‡ Students planning to take the Industrial Economics option substitute Ec70 Introductory Psychology 3–5 for Ec723, and Ec50 Money and Banking 2–4 for 15·70.
§ Students planning to take the Industrial Economics option substitute Ec12 Economic Principles II 3–5 for Ec70.

XIV. Economics and Engineering Continued

OPTION 2. INDUSTRIAL ECONOMICS**

First Term	2·251	(*a*) Fluid Mechanics	3–6	*Second Term*	2·06	(*a*) Dynamics	3–6
	6·47	(*b*) App. Elec. in Industry	3–6		2·252	(*a*) Fluid Mechanics	2–4
	10·18	(*c*) Industrial Chem.	3–6		6·213	(*b*) Ind. App. of Servomech.	3–6
	10·31	(*c*) Chemical Eng.	4–6		6·222	(*b*) Elec. Power Systems	3–6
	Ec13	Prices & Production	3–6		10·32	(*c*) Chemical Eng.	4–6
		†Humanities IV	3–5			*Thesis	14
		(*a*, *b*) Elective Subjects	24			†Humanities IV	3–5
		(*c*) Elective Subjects	15			(*a*, *b*) Elective Subjects	9
						(*c*) Elective Subjects	15
		(*a*, *b*)	50				
		(*c*)	51			(*a*) 46	(*b*) 49
							(*c*) 47

Elective Subjects§

15·41	Finance	3–6		Ec23	National Income	3–6
15·42	Financial Institutions	3–6		Ec36	Industrial Quality Control	3–6
15·51	Industrial Accounting	5–4		Ec49	Public Finance	2–4
15·71	Production Management	3–6		Ec52	Comp. Polit. & Ec. Systems	3–6
15·73	Management Lab.	6–3		Ec88	Building Economics	2–4
15·81T	Marketing	3–6		E51	Modern Industrial Society	3–6

Certain graduate subjects in Economics and Social Science may be taken as electives by properly qualified students.

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

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

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

XV-A. (BASED ON PHYSICAL SCIENCES)

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

XV-B. (BASED ON CHEMICAL SCIENCES)

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

Business and Engineering Subjects:

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

First, the student is introduced through the subject of production to the nature of modern factory organization and operation. Immediately thereafter, he considers the subject of personnel or labor relations. He then undertakes the study of economics, in which he learns the nature of the forces which underlie business phenomena. In his third year he begins his study of business relationships, with marketing and the law of contracts. He also becomes familiar with accounting, and its application to analysis and control. In his last year he studies the more involved relationships in finance as well as the applications of the statistical method. Finally, after the various individual business functions have been studied, a term subject, Industrial Problems, serves to provide a coordinated view of business as a whole.

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

Both Courses lead to the degree of Bachelor of Science in Business and Engineering Administration.

* See Requirements for Bachelor's Degree, page 46. † See page 145 for list of subjects.
§ Required subjects in one option may be used as electives in the other. ** See Second Year for explanation of Engineering Group Electives.

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

XV-A. Business and Engineering Administration (Based on Physical Sciences)

First Year (See page 46)

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		8·04	Physics	5–5
	8·03	Physics	5–5		15·30	Personnel Administration	3–5
	15·70	Production	3–6		E22	History — Humanities II	3–5
	E21	History — Humanities II	3–5		M22	Differential Equations	3–6
	M21	Calculus	3–6		MS22	Military Science	3–0
	MS21	Military Science	3–0				20–27
			24–27				

Third Year

First Term	*3·11	Engineering Metals	5–4	*Second Term*	1·63	Fluid Mechanics	2–4
	*6·18	Electrical Eng., Fund.	4–6		*2·41	Heat Engineering	4–5
	*15·50	Accounting	5–4		3·12	Metal Processing	4–4
	*15·81T	Marketing	3–6		*6·19	Industrial Electronics	4–6
	Ec11	Economic Prin. I — Humanities III	3–5		*15·61	Business Law	3–6
	*E35T	Reports	1–4			†Humanities III	3–5
			21–29				20–30

Fourth Year

First Term	3·331	Industrial Physical Metallurgy	4–2	*Second Term*	15·92	Industrial Problems	3–6
	*15·41	Finance	3–6			*Thesis	10
	Ec35	Elementary Statistics	3–6			†Humanities IV	3–5
		*Thesis	1			Business or Econ. Elective Subjects	17
		†Humanities IV	3–5			Engineering Elective Subject	6
		Business or Econ. Elective Subject	9				50
		Engineering Elective Subject	6				
			48				

Suggested Engineering Elective Subjects

	1·24	Transportation Planning	3–3		3·15	Welding Engineering	2–4
	2·11	Industrial Plant Eng.	4–5		3·16	Powder Metallurgy	2–4
	2·50	Heat Measurements	3–1		3·70	Ceramics	5–4
	2·663	Air Conditioning	3–6		6·213	Ind. App. of Servomechanisms	3–6
	2·79	Int. Comb. Eng., Elem.	3–6		6·47	App. Electricity in Industry	3–6
	2·901	Fabric Structure, Prin.	3–6		17·71	Materials	3–4
	2·903	Textile Manufacturing, Elem.	3–6		D31	Nomography	2–4
	3·13	Foundry Engineering I	2–4				

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

First Year (See page 46)

Second Year

First Term	5·11	Qualitative Analysis	7–3	*Second Term*	5·12	Quantitative Analysis	7–3
	8·03	Physics	5–5		8·04	Physics	5–5
	15·70	Production	3–6		15·30	Personnel Administration	3–5
	E21	History — Humanities II	3–5		E22	History — Humanities II	3–5
	M21	Calculus	3–6		M22	Differential Equations	3–6
	MS21	Military Science	3–0		MS22	Military Science	3–0
			24–25				24–24

Third Year

First Term	*5·41	Organic Chemistry I	4–4	*Second Term*	*5·62	Physical Chemistry II	4–4
	*5·61	Physical Chemistry I	4–4		*6·18	Electrical Eng., Fund.	4–6
	10·28	Chemical Engineering	4–6		10·17	Industrial Chemistry	3–4
	*15·81T	Marketing	3–6		*15·50	Accounting	5–4
	Ec11	Economic Prin. I — Humanities III	3–5		*15·61	Business Law	3–6
	*E35T	Reports	1–4			†Humanities III	3–5
			19–29				22–29

Fourth Year

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 IV	3–5
		†Humanities IV	3–5			Business or Econ. Elective Subject	8
		Business or Econ. Elective Subject	9				45
			46				

*See Requirements for Bachelor's Degree, page 46.

† See page 145 for list of subjects.

XVI. AERONAUTICAL ENGINEERING

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

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

The 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 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.

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 46)

Second Year

First Term	2·00	Statics	3–5	*Second Term*	2·01	Dynamics	3–5
	3·11	Engineering Metals	5–4		2·851	Machine Tool Lab.	4–0
	8·03	Physics	5–5		8·04	Physics	5–5
	E21	History — Humanities II	3–5		16·70	Aircraft Drafting	6–0
	M21	Calculus	3–6		16·82	Aeronautical Eng., Int.	3–1
	MS21	Military Science	3–0		E22	History — Humanities II	3–3
					M22	Differential Equations	3–6
			22–25		MS22	Military Science	3–0
							30–22

Third Year

First Term	*2·04	Strength of Materials	3–6	*Second Term*	2·42	Heat Engineering	3–6
	2·371	Testing Materials Lab.	2–2		*16·02	Aeronautical Mechanics, Int.	6–6
	2·40	Heat Engineering	4–5		*16·10	Aerodynamics, Applied	4–8
	*16·01	Aeronautical Mechanics, Int.	6–6		*16·20	Structures	3–6
	*16·71	Detail Des. of Aircraft	6–0			†Humanities III	3–5
	Ec11	Economic Prin. I — Humanities III	3–5				19–31
			24–24				

Fourth Year

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	10
	16·62	Aerodynamic Laboratory	4–4			†Humanities IV	3–5
		†Humanities IV	3–5			‡Prof. Elective Subject	9
		Prof. Elective Subject	9				45
			53				

*Suggested Professional Elective Subjects***

1·32	Airport Design	6–0	16·30	Aircraft Instruments	5–6
2·43	Heat Engineering	3–6	16·50	Rotat. Wing Aircraft	3–6
2·48	Gas Turbines	3–6	16·52	Aircraft Propeller Design	5–4
6·19	Industrial Electronics	4–6	16·91	Aero-Elasticity & Struct. Dyn.	3–6
16·105	Applied Aerodyn.	3–6	M351	Adv. Calculus for Eng.	3–6
16·14	Airplane Des. Prob.	8–4	M352	Adv. Calculus for Eng.	3–6
16·22	Aircraft Structures	5–6	M78	Theory of Elasticity, Int.	3–6

* See Requirements for Bachelor's Degree, page 46. † See page 145 for list of subjects.

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

‡ 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.

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, regular tuition for academic work taken during the school year, and one-half regular term tuition for each of the scheduled half-summers of instruction. There will be no change in total tuition for the four-year program.

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.

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)

Summer Term	*2·04	Strength of Materials	3–6
	*16·01	Aeronautical Mechanics, Int.	6–6
			9–12

Vacation (Approximately 2 weeks)

At Plants (Remainder of Summer)

First part of approximately 6 months continuous practice

Regular Academic Year

At Plants

First Term — Second part of approximately 6 months continuous practice

At M. I. T.

Second Term	2·40	Heat Engineering	4–5
	*16·02	Aeronautical Mechanics, Int.	6–6
	*16·20	Structures	3–6
	*16·71	Detail Des. of Aircraft	6–0
	Ec11	Economic Prin. I — Humanities III	3–5
		†Humanities III	3–5
			25–27

FOURTH YEAR

Summer (In effect June 1950)

Vacation (First 6 weeks)

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

Summer Term	2·42	Heat Engineering	3–6
	*16·10	Aerodynamics, Applied	4–8
			7–14

Regular Academic Year
(In effect 1950–51)

Same as Fourth Year in Course XVI

* See Requirements for Bachelor's Degree, page 46.

† See page 145 for list of subjects.

XVI-B Aeronautical Engineering Continued

GROUP B

THIRD YEAR

Summer

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

Summer Term	*2·04	Strength of Materials	3-6
	*16·01	Aeronautical Mechanics, Int.	6-6
			9-12

Vacation (Remainder of Summer)

Regular Academic Year

At M. I. T.				*At Plants*	
First Term	2·40	Heat Engineering	4-5	*Second Term*	First part of approximately 6 months continuous practice
	*16·02	Aeronautical Mechanics, Int.	6-6		
	*16·20	Structures	3-6		
	*16·71	Detail Des. of Aircraft	6-0		
	Ec11	Economic Prin. I — Humanities III	3-5		
		†Humanities III	3-5		
			25-27		

FOURTH YEAR

Summer (In effect June, 1950)

At Plants (Approximately 4 weeks)

Second part of approximately 6 months continuous practice

Vacation (Approximately 2 weeks)

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

Summer Term	*2·42	Heat Engineering	3-6
	*16·10	Aerodynamics, Applied	4-8
			7-14

Regular Academic Year

(In effect 1950-51)

Same as Fourth Year in Course XVI

XVII. BUILDING ENGINEERING AND CONSTRUCTION

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

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

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

OPTION 1. HEAVY CONSTRUCTION

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

OPTION 2. LIGHT CONSTRUCTION

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

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

FIRST YEAR (See page 46)

SECOND YEAR

First Term	2·00	Statics	3-5	*Second Term*	2·01	Dynamics	3-5
	8·03	Physics	5-5		4·78	Planning Principles	4-0
	17·22	Building Construction	5-4		8·04	Physics	5-5
	E21	History — Humanities II	3-5		17·71	Materials	3-4
	M21	Calculus	3-6		E22	History — Humanities II	3-5
	MS21	Military Science	3-0		M22	Differential Equations	3-6
			22-25		MS22	Military Science	3-0
							24-25

*See Requirements for Bachelor's Degree, page 46. †See page 145 for list of subjects.

XVII. Building Engineering and Construction Continued

REQUIRED DURING SUMMER AT CAMP TECHNOLOGY

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

THIRD YEAR¶

First Term	*2·04	Strength of Materials	3–6	*Second Term*	*1·401	Structures		3–6
	2·41	Heat Engineering	4–5		*2·371	Testing Materials Lab.		2–2
	6·40	Electrical Eng., Elem.	4–6		*17·32	(1) Building Construction		5–4
	*17·31	(1) Building Construction	5–4		*17·34	(2) Building Construction		5–4
	*17·33	(2) Building Construction	5–4		*17·52	Structural Problems		6–6
	Ec11	Economic Prin. I — Humanities III	3–5		*17·72T	Materials		6–4
						†Humanities III		3–5
			19–26					25–27

FOURTH YEAR

OPTION 1. HEAVY CONSTRUCTION

First Term	1·351	Soil Mech. & Found. Eng.	4–4	*Second Term*	*1·42	Structures		3–6
	*1·41	Structures	3–6		15·50	Accounting		5–4
	*17·53	Structural Design	6–6		*17·40	Estim. and Job Manage.		5–4
	*17·73	Materials	3–4		*17·54	Structural Design		6–6
		*Thesis	4			*Thesis		5
		†Humanities IV	3–5			†Humanities IV		3–5
			48					52

OPTION 2. LIGHT CONSTRUCTION

First Term	15·70	Production	3–6	*Second Term*	15·50	Accounting		5–4
	15·81T	Marketing	3–6		15·61	Business Law		3–6
	*17·56	Structural Design	6–6		*17·40	Estim. and Job. Manage.		5–4
	*17·73	Materials	3–4		Ec88	Building Economics		2–4
		*Thesis	2			*Thesis		7
		†Humanities IV	3–5			†Humanities IV		3–5
			47					48

XVIII. MATHEMATICS

THE Institute offers exceptional opportunities for the study of mathematics, in both its theoretical aspects and its applications to scientific and engineering work.

The Course outlined is for students who desire to study more mathematics than is contained in the other professional courses. It is well adapted to serve as a preparation for specializing in pure mathematics, in applied mathematics, in mathematical physics, or in engineering fields requiring proficiency in mathematics. The Course also offers excellent opportunities for students who wish to major in mathematical statistics or applied statistics. For most of the students in Course XVIII the curriculum serves as a preparation for further professional training at the graduate level.

Any student who has completed satisfactorily the work of the first two years in any of the professional courses in the Institute or their equivalent, provided always that he has obtained a sufficiently high record in mathematics and physics, 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 46)

SECOND YEAR

First Term	2·011	Statics & Dynamics	3–5	*Second Term*	8·04	Physics		5–5
	8·03	Physics	5–5		E22	History — Humanities II		3–5
	E21	History — Humanities II	3–5		M22	Differential Equations		3–5
	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	8·07	Thermo. & Statist. Mech.	4–5	*Second Term*	*M832	Analysis		3–9
	Ec11	Economic Prin. I — Humanities III	3–5			†Humanities III		3–5
	*M831	Analysis	3–9			‡Prof. Elective Subjects (see next page)		18
		‡Prof. Elective Subject (see next page)	9			Elective Subject		9
		Elective Subject	9					47
			47					

* See Requirements for Bachelor's Degree, page 46. † See page 145 for list of subjects.

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

‡ Each student must include in his program both subjects listed in Group A, one of the two subjects listed in Group B and 48 units from Group C.

XVIII. Mathematics Continued

FOURTH YEAR

First Term		*Thesis	4	*Second Term*		*Thesis	7
		†Humanities IV	3–5			†Humanities IV	3–5
		‡Prof. Elective Subjects	27			‡Prof. Elective Subjects	21
		Elective Subject	9			Elective Subject	12
			48				48

Professional Elective Subjects

Group A	M442	Diff. Geometry, Elem.	3–6	*Group C*	8·71	Int. Theoretical Physics I	4–8
	M62	Modern Algebra	3–6		8·72	Int. Theoretical Physics II	4–8
					M331	Math. Th. of Statistics	3–6
Group B	M352	Adv. Calculus for Eng.	3–6		M332	Math. Th. of Statistics	3–6
	M37	Advanced Calculus	3–6		M341	Modern Statistical Th.	3–6
					M351	Adv. Calculus for Eng.	3–6
					M42	Hydromechanics, Int.	3–6
					M78	Theory of Elasticity, Int.	3–6
						Any 12-Unit Math. Subject	

XIX. METEOROLOGY

THE purpose of the Course in Meteorology is to prepare students for weather forecasting in the aviation organizations, those industries whose operations are dependent on the weather, the Weather Bureau, and for further study and research. Emphasis is placed on the application of physics, of mathematics, and of other allied subjects to the atmosphere and its processes.

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

The meteorological instruments laboratory provides training in the observation of weather elements, maintenance of a weather station, and care of equipment. In climatology, the atmosphere in its average state is discussed from a meteorological point of view with emphasis on the geographical distribution of various factors. In oceanography, the dynamics of the fluid, the interaction of atmosphere and ocean, and other topics of meteorological interest are stressed. The special physical phenomena of the atmosphere, such as solar and terrestrial radiation, evaporation, condensation and precipitation processes, electricity and atmospheric optics are taken up in other subjects.

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

FIRST YEAR (See page 46)

SECOND YEAR

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

THIRD YEAR

First Term	2·251	Fluid Mechanics	3–6	*Second Term*	19·02	Descriptive Meteorol. II	3–6
	2·40	Heat Engineering	4–5		19·30	General Climatology	2–4
	*19·01	Descriptive Meteorol. I	3–6		*19·50	Meteorol. Lab., Int.	9–3
	*19·21	Meteorol. Observations	4–2		*19·60	Thermodyn. of Atmos.	3–6
	Ec11	Economic Prin. I — Humanities III	3–5		19·70	Physics of Atmos., Elem.	2–4
	M32	Statistics, Elementary	3–6			†Humanities III	3–5
			20–30				22–28

FOURTH YEAR

First Term	*19·43	Synoptic Meteorol. I	3–6	*Second Term*	*19·44	Synoptic Meteorol. II	3–6
	*19·51	Synoptic Lab. I	15–0		*19·52	Synoptic Lab. II	15–0
	*19·61	Dynamic Meteorol. I	2–4		*19·62	Dynamic Meteorol. II	3–6
	19·83	Oceanography	2–4			*Thesis	9
		*Thesis	3			†Humanities IV	3–5
		†Humanities IV	3–5				50
			47				

* See Requirements for Bachelor's Degree, page 46. † See page 145 for list of subjects.

‡ Each student must include in his program both subjects listed in Group A, one of the two subjects listed in Group B and 48 units from Group C.

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 especial interests in contiguous fields.

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

FIRST YEAR (See page 46)

SECOND YEAR

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

REQUIRED DURING SUMMER

*5·41	Organic Chemistry I	4-4
*5·412	Organic Preparations I	10-0

THIRD YEAR

First Term	*5·61	Physical Chemistry I	4-4	*Second Term*	*5·62	Physical Chemistry II	4-4
	*5·611	Physical Chem. Lab. I	4-0		*5·621	Physical Chem. Lab. II	4-0
	*20·01	Tech. & Chem. Food Sup.	6-2		15·11	Business Management, Int.	3-6
	*20·41	Bacteriology	6-2		*20·02	Tech. & Chem. Food Sup.	6-4
	Ec11	Economic Prin. I — Humanities III	3-5		*20·42	Industrial Microbiology	6-4
		Elective Subjects	12			†Humanities III	3-5
			48				26-23

FOURTH YEAR

First Term	2·601	Food Engineering	4-2	*Second Term*	2·602	Food Engineering	4-2
	*7·80	Biochemistry	8-4		*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 IV	3-5			†Humanities IV	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 Term	2·601	Food Engineering	4-2	*Second Term*	2·602	Food Engineering	4-2
	*7·80	Biochemistry	8-4		*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 IV	3-5		20·322	Chem. of Nutrition Lab.	5-0
			25-21			†Humanities IV	3-5
						Elective Subject	8
							51

* See Requirements for Bachelor's Degree, page 46. † See page 145 for list of subjects.

XX-A. Food Technology Continued

GRADUATE YEAR

First Term	7·81T	Enzymology	2–4
	20·51	Food Technology, Adv.	8–4
	20·61	Food Technology Seminar	2–2
		Thesis	16
		Elective Subject	10
			48
Second Term	20·52	Food Technology, Adv.	6–4
	20·62	Food Technology Seminar	2–2
		Thesis	20
		Elective Subjects	14
			48

MILITARY 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 Regular Army and the Regular 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.

Seven units have been authorized: Engineer, Signal, Ordnance, Air, Chemical, Army Security, and Quartermaster.

Basic Course

The Basic Course includes the Military Science subjects required in the first two years. The first-year program consists of general military training including drill, military organization, military policy of the United States, evolution of warfare, maps and aerial photographs, military psychology and personnel management, first aid and hygiene, geographical foundations of national power, military problems of the United States, and military mobilization and demobilization.

On completion of the first year's work a student elects either the Air Force or the Army program of instruction for the second year. A student who elects the Army program will also indicate his choice of one of the six Army units at the Institute. Opportunity is given the student to choose the unit in which he desires to continue his training. Those who do not make a choice of a unit at the beginning of the second term of the first year will be arbitrarily assigned to a unit. The sophomore courses 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.

All physically fit male students who are citizens of the United States, under twenty-six years of age, and who enter the Institute as first-year students, are required to complete the basic course, unless exempted therefrom on conscientious grounds as approved by the Faculty. Similarly qualified students who have received instruction in an approved R.O.T.C. unit at another institution will receive credit therefor upon presentation of suitable evidence to the Professor of Military Science and Tactics. Also, those who have been members of any of the armed services will receive credit in accordance with established policies.

The first-year program includes MS11 and MS12. The program of subjects required in the respective units in the second year is given below:

Corps of Engineers: MS212 and MS222.
Signal Corps: MS213 and MS223.
Ordnance Department: MS214 and MS224.
Air Force: MS215 and MS225.
Chemical Corps: MS216 and MS226.
Army Security Agency: MS217 and MS227.
Quartermaster Corps: MS218 and MS228.

Advanced Course

The object of the Advanced Course is to prepare well qualified students to become reserve or permanent 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. They must continue the unit in which they were registered in the second year. Students who complete the Advanced Course are commissioned as Second Lieutenants in the Officers' Reserve Corps of the U. S. Army or Air Force on graduation. Each year a number of R.O.T.C. graduates will 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 ninety 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 R.O.T.C. camp, when he is subsisted by the Government and currently paid at the rate of seventy-five dollars per month.

To enroll, a student must execute a contract to continue the course of instruction for two years, should he remain that length of time at the Institute. The contract includes the obligation to attend the R.O.T.C. 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 be postponed until after the senior year.

Students who enroll in the Advanced Course of the R.O.T.C. are required to choose as Humanities the following subjects:

Humanities III, Ec60, Labor Relations *or* Ec70, Psychology, Introductory, and
Humanities IV, Ec57 and Ec58, International Relations.

15·30 Personnel Administration will be accepted in place of the Military Science requirement of Ec60 or Ec70, but will *not* be accepted as completing the Humanities III requirement of the Institute.

The program of subjects required in the respective units of the Advanced Course is given below.

Corps of Engineers: MS312, MS322, MS412, MS422.
Signal Corps: MS313, MS323, MS413, MS423.
Ordnance Department: MS314, MS324, MS414, MS424.
Air Force: MS315, MS325, MS415, MS425.
Chemical Corps: MS316, MS326, MS416, MS426.
Army Security Agency: MS317, MS327, MS417, MS427.
Quartermaster Corps: MS318, MS328, MS418, MS428.

THE GRADUATE SCHOOL

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S. OBER, S.B.
Professor of Aeronautical Engineering

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

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Professor of Accounting

R. R. SHROCK, PH.D.
Associate Professor of Geology

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

W. E. STANLEY, C.E.
Professor of Sanitary Engineering

G. B. THOMAS, JR., PH.D.
Assistant Professor of Mathematics

W. C. VOSS, S.M.
Professor of Building Construction

G. C. WILLIAMS, SC.D.
Associate Professor of Chemical Engineering

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Architecture	L. B. ANDERSON
Biology	I. W. SIZER
Building Engineering and Construction	W. C. VOSS
Business and Engineering Administration	R. H. ROBNETT
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Food Technology	B. E. PROCTOR
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Meteorology	J. M. AUSTIN
Naval Architecture and Marine Engineering	E. L. COCHRANE
Physics	J. C. SLATER
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 84).
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)

Building Engineering and Construction, Course XVII
- Building Management
- Materials of Construction
- Structural Design

Business and Engineering Administration, Course XV

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
- Communications
- Electric Power
- Electronics Applications and Automatic Control

Food Technology, Course XX

Geology, Course XII
- Economic Geology
- Geophysics
- Mineral Industry
- Mineralogy and Crystallography
- Physical and Historical Geology

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 department 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 sciences. 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 coordinate the activities of various departments in fields of overlapping interest. These interdepartmental laboratories unite the staff and student personnel of the various

departments for concerted effort with centralized facilities and services.

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 of 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 Clinton Laboratories 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 preferably 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 the Graduate School, 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.

Acceptance of a Special Graduate Student is for one academic term only, and for continuance of this status for a succeeding term, a new application must be approved.

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 80).

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. This requirement may be satisfied by presenting satisfactory grades on the Graduate Record Examination.

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 attain-

ment of the advanced degree is likely to be unduly protracted, he may be advised to postpone his application until his deficiencies have been reduced. Minor deficiencies in his preparation may be removed while he is pursuing graduate study.

In exceptional cases, the Committee on the Graduate School 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 remaining 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 the Graduate School, upon the satisfactory completion of a course of advanced study and research approved by the department in which the student has been enrolled and complying with the regulations as set forth hereunder, during residence of at least one academic year.

For a Master's Degree there is required a period of residence of at least one academic year of study and research at the Institute including a substantially full schedule of graduate study or combined graduate study and academic staff service in one regular term.

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

Each recipient of a Doctor's degree who presents himself at the Commencement Exercises next following the date of his recommendation by the Faculty for the degree will be presented with the appropriate Doctor's hood; otherwise a hood is not given.

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.

Requests on behalf of Harvard students will be granted at M. I. T. only if presented by the end of the second week of a term.

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, which includes a number of advanced subjects dealing with methods of analysis and design of statically indeterminate and other complex structures

Soil Mechanics, covering both theoretical treatment and experimental technique

Hydraulics, including theoretical and experimental work in fluids, and *Water Power Engineering*

Transportation Engineering: the design, construction and economics of airports, highways and railways

Geodesy and *Photogrammetry*

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 83, 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	Structures
1·43	Reinforced Concrete Design
1·441	Structural Design
1·61	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 Structures.

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 while pursuing a program of graduate work but 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 certain subjects listed above under Departmental Requirements for Graduate Work may be accepted in partial fulfillment of the requirements for the degree of Master of Science.

The Degree, Civil Engineer

Programs of study leading to the degree of Civil Engineer provide opportunities for students to obtain training broader than that required for the Master's degree and better preparation for undertaking professional practice in Civil Engineering. The rigor of the program and the quality of academic performance required are substantially those demanded of students working toward the Master's degree or those preparing for the general examination for the Doctor's degree.

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 85.

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, Vibrations, Instrumentation, Control Phenomena, Fluid Mechanics, Temperature Measurements, and Heat Transfer. 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 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 83. 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, 2·082, 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.

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

Mechanical Engineering Continued

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, or Doctor of Science in Metallurgy or in 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 synthesis.

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 83.

Professional subjects prerequisite for graduate study in the Department of Metallurgy are given below.

For students in *Metallurgy:*

3·01	Metallurgical Engineering I
3·02	Metallurgical Engineering II
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
3·02	Metallurgical Engineering II
3·81	Mineral Engineering I
3·82	Mineral Engineering II
3·83	Mineral Engineering III
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.

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)
2·222	Advanced Plasticity Problems (A)
2·43	Heat Engineering
2·50	Heat Measurements
3·81	Mineral Engineering I
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)
12·15	Petrography
12·20	Elementary Crystallography
12·231	Optical Crystallography
12·24	Theoretical Crystallography

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III. Metallurgy Continued

15·11	Introduction to Business Management
17·72T	Building Materials
17·771	Cementitious Materials
17·772	Cement and Concrete (A)
Ec60	Labor Relations
Ec65	Industrial Relations
M36	Advanced Calculus
M37	Advanced Calculus

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 84.

The Degree, Metallurgical Engineer

The specifications for the degree of Metallurgical Engineer are as set forth on page 84.

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 85.

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 83, 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 the professional level, they may contribute, up to 24 units if approved by the Department, toward the requirements for the Master's degree.

The Degree, Master in Architecture

The degree of Master in Architecture is awarded upon satisfactory completion of a course with a minimum of 96 units of advanced study, subdivided as set forth on page 84, including a minimum of two terms of architectural design and a thesis of from 20 to 40 units.

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, if accepted for admission to the Graduate School, should be able to complete the requirements for the degree of Master in City Planning in one year.

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 83, 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

IV-B. City Planning Continued

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 84, 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 84, 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 Fellows

The Department appoints a limited number of Teaching Fellows who are candidates for the degree of Doctor of Philosophy in Chemistry. Teaching Fellows serve in the laboratories of the Department, 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.
Molecular weights of gases by limiting densities.
Heat capacities and latent heats at low temperatures.
Properties of gases at low pressures.
Scattering and other properties of molecular beams.
Electromotive force in concentration cells, and oxidation-reduction potentials.
Freezing points of liquid solutions.
Vapor pressures of liquid solutions.
Infra-red, ultra-violet and Raman spectroscopy.
Precision photometry.
Kinetics of thermal and photochemical reactions.
Properties of high polymers.
Properties of protein solutions.
Properties of thin metal deposits.

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 quite broadly organic reactions and their application to synthetic problems; theoretical organic chemistry; characterization or identification of organic compounds by the methods of qualitative organic analysis (including a survey of functional groups and their reactions).

Fields of research in Organic Chemistry which are being investigated actively in the department include carbohydrates; heterocyclic compounds; identification and analytical methods; organic peroxides; organometallic compounds; electrolytic oxidations and reductions; 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; other natural products and physiologically active compounds.

Inorganic and Nuclear Chemistry

Inorganic Chemistry. The remarkable advances which have been reported in recent years in the utilization of the less familiar elements, such as zirconium, columbium 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 element No. 61 (variously named prometheum, illinium, etc.), 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.

V. Chemistry Continued

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 radio elements; 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. In order to do this, 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 being encouraged.

Departmental Requirements for Graduate Work

The general admission requirements are those set forth on page 83, 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: 5·10T, 5·13T
Organic Chemistry: 5·41, 5·42, 5·414, 5·424
Physical Chemistry: 5·61, 5·62, 5·71

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 just prior to the opening of the Fall and Spring Terms of each year. Students may take the Qualifying Examination as soon as they feel adequately prepared but must take it before beginning their third term (summer session excluded) of graduate registration in chemistry at M. I. T.

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 5·10T; Quantitative Analysis 5·13T; 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.

Each candidate must complete or be certified in the following subjects in the Course V curriculum: viz., 5·01, 5·02, 5·10T, 5·13T, 5·41, 5·42, 5·414, 5·424, 5·63, 5·64, 5·061, 5·43.

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 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, 5·70, 5·71, together with 14 to 18 units in 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, 5·53, 5·54, 5·582, 5·67, 5·71, and during each year of residence after the first 5·913 and 5·914.

Physical Chemistry: 5·68, 5·70, 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.

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.

The development and application of mechanical methods of mathematical analysis is a major activity consolidated in the Center of Analysis. The Center of Analysis has the most modern Differential Analyzer. In addition, there are other extensive computational facilities.

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 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 the seminar and 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 83, 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

VI. Electrical Engineering Continued

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:

M31	Differential Equations
2·00, 2·01	Statics, Dynamics
2·04	Strength of Materials
6·00, 6·01, 6·02, 6·031, 6·032	Electrical Engineering, Principles
6·75	Electrical Measurements Laboratory
6·76	Engineering Electronics Laboratory

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

6·30, 6·311, 6·321T	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

2·07	Dynamics
2·251	Fluid Mechanics
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

In addition to general requirements set forth on page 84, the Department of Electrical Engineering requires the following:

Modern Languages. A reading knowledge of technical German, Russian, or French, satisfactorily demonstrated to the Department of Modern Languages. Special one-semester 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 to be 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.

Seminar. All graduate students in the Department who have not had equivalent experience in the preparation and oral presentation of technical papers are required to take Seminar, 6·501 and 6·502. In the Seminar meetings, papers dealing with the history of the development of various phases of electrical engineering and the influence of these developments upon present practices, are presented and discussed. The student may select his seminar topic so as to utilize the seminar time for examination of the literature relating to the general field of his thesis.

Students working for the Master's degree are expected to devote themselves to a few subjects, not more than three each term, in addition to their Seminar and research. The subjects of study are wholly elective, with the exception of Electrical Engineering Seminar and Thesis, and not restricted to those given by the Department of Electrical Engineering; however, the program of study must be well balanced, emphasizing one or more of the mathematical, economic, and experimental aspects of electrical engineering.

Course VI-A, listed under the undergraduate course schedules, leads to the degrees of Bachelor of Science and Master of Science in Electrical Engineering.

The Degree, Electrical Engineer

Able students who are desirous of preparing for creative application of engineering and scientific principles in engineering practice, who want more extensive training than 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 Seminar, and will ordinarily require at least four terms of graduate study beyond the Bachelor's degree level. The Modern Language and Seminar requirements are the same as those for the Master's degree.

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. 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 substantial and noteworthy contribution in Electrical Engineering or a related field.

The general requirements for the doctor's degree are given on page 85.

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 should be satisfied by the time the general examination is taken, and before undertaking the thesis research.

The field of the Minor is not prescribed by the Department, but usually Mathematics, Physics, or Economics is chosen. The Minor requirement should be satisfied by the time the general examination is taken.

Doctorate students who have not previously satisfied the Seminar requirement listed above are required to take Seminar, 6·501 and 6·502.

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,

VII. Biology Continued

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, listed under the undergraduate course schedules, leads to the degrees of Master of Science in Physical Biology and Bachelor of Science in Quantitative Biology.

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 83 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. 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 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

VIII. Physics Continued

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 under construction 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 Magnet 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, and the Optics Laboratory specializes in the field of color measurements. Work in X-ray diffraction and crystal structure, electron microscopy, and the structure of dielectrics, is actively carried on.

Courses of study include work in almost all of these experimental fields, and in the various branches of theoretical physics as well. It is expected that the graduate student will gain real familiarity with several of the branches of physics, not merely with one specialty. Whether he plans to go into academic work, or into industrial research, the training includes a broad and thorough understanding of the fundamentals of physics, as well as of its more advanced applications.

Departmental Requirements for Graduate Work

General requirements are those set forth on page 83 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 84 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 to training in fundamentals, and strictly professional subjects must be 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.

School of Chemical Engineering Practice

The Department of Chemical Engineering offers a Course leading to the degree of Master of Science in Chemical Engineering Practice (designated as X-A).

In the School of Chemical Engineering Practice a 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.

X. Chemical Engineering Continued

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 to eight 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 pages 82 and 144, 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 alternate to 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 two terms at the Institute plus 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 83, 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

A prerequisite for the award of the Master's degree is elementary French, German or Russian.

The Degree, Chemical Engineer

For the degree of Chemical Engineer, see the general statement on Engineering Degrees on page 84.

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 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 — 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.

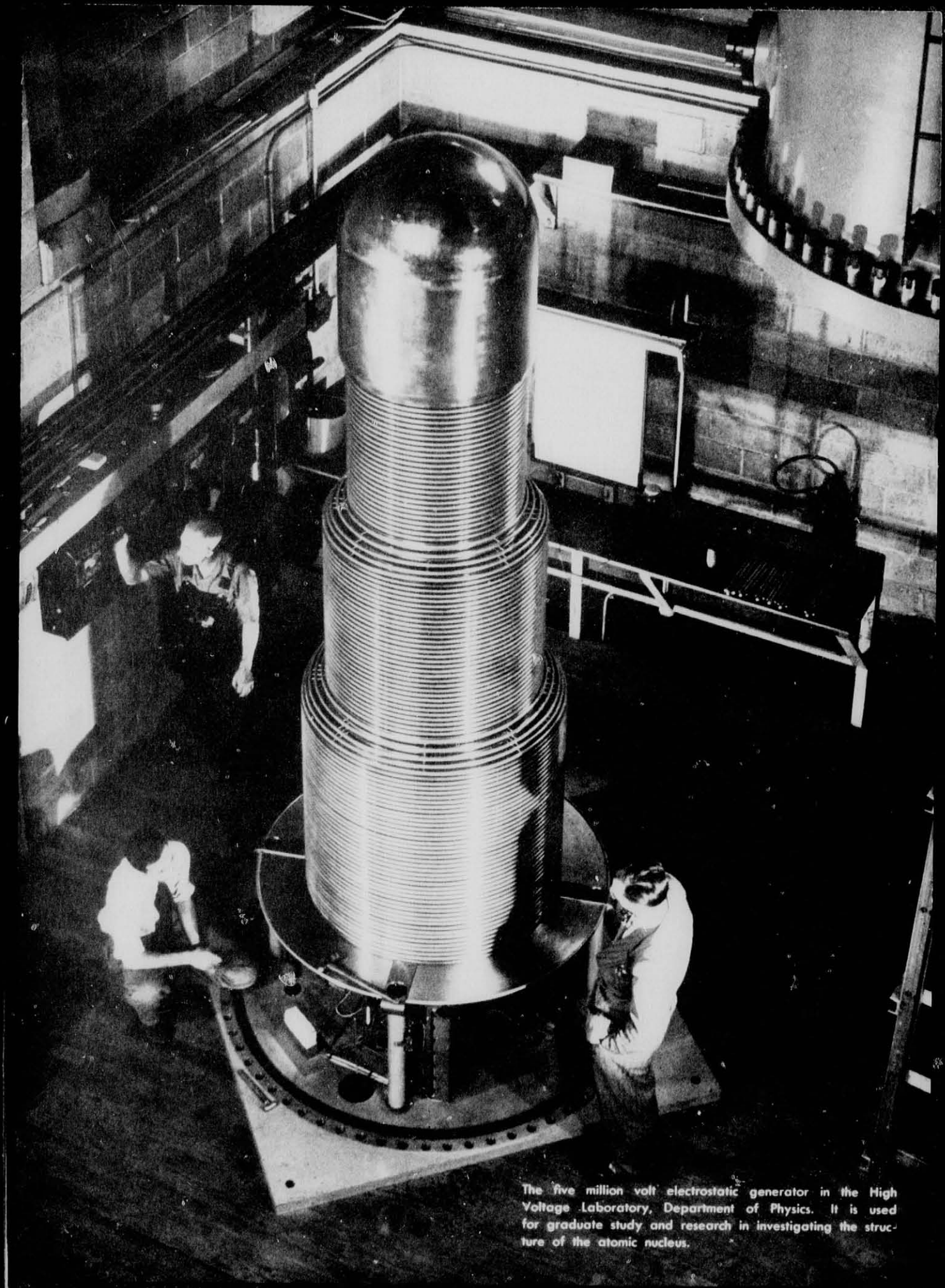
Programs of study may be arranged to provide the fundamental training required for professional careers in the special fields of Sanitary Engineering, including: engineering design and construction of sanitary facilities, and consulting engineering practice; process or functional design for water, sewage, 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



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.

XI. Sanitary Engineering Continued

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.

The general requirements are those given on page 83, 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:

1·61	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	Structures
1·43	Reinforced Concrete Design
1·62	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. Without the subjects listed above, however, he will not be properly trained to engage in the design and construction phases of Sanitary Engineering.

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.

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 85.

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

The Department of Geology offers a wide choice of graduate study and research for specialization in the following fields: general geology, structural geology, or tectonics; mineralogy, crystallography, or petrology; sedimentology, stratigraphy, or paleontology; economic geology (mineral deposits, geology of petroleum or coal, or engineering geology); mineral industry (mineral economics or mine valuation); and geophysics. In the borderland between geology and another science, the student may arrange a program of study and research under supervision by a special interdepartmental committee. Advanced work in any of these fields leads to the degrees of Master of Science in Geology, or Doctor of Philosophy or Doctor of Science in the field of specialization.

The Department is equipped to offer the graduate student an unusual opportunity to pursue study and research in both theoretical and applied geology, X-ray crystallography, geochemistry, and geophysics. Modern laboratory facilities and research instruments and extensive collections of specimens and materials are available to qualified graduate students. Field studies are included as an essential part of the graduate curriculum in geology, geophysics and mineral industry and special arrangements have been made for field research with industrial organizations and governmental agencies.

Departmental Requirements for Graduate Work

The general admission requirements are those given on page 83, with the following exception: Mathematics, M22, may not be required as a prerequisite.

In addition, the Department requires preparation in geology essentially equivalent to the program of subjects leading to the degree, Bachelor of Science 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 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.

XII. Geology Continued

The Doctorates

The general requirements for the degrees of Doctor of Philosophy or Doctor of Science are given on page 85. 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 and mineralogy given at Harvard University.

Each candidate for the doctorate must demonstrate to the Department of Modern Languages that he can read scientific literature in his field of specialization in English, and in two of the following languages: French, German, Russian, or such other languages as are appropriate. Ordinarily this requirement should be satisfied by the time the general examination is taken, and before undertaking thesis research.

The Minor requirement is generally satisfied by taking in another department at least 24 units of approved study.

XIII. NAVAL ARCHITECTURE AND MARINE ENGINEERING

The Department of Naval Architecture and Marine Engineering offers 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 and Naval Engineer (restricted generally to commissioned officers of the United States Navy and United States Coast Guard).

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 83. 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, 2·062	Strength of Materials and Dynamics
2·251	Fluid Mechanics
2·40, 2·42	Heat Engineering
2·683	Engineering Laboratory
6·18	Electrical Engineering, Fundamentals
13·01, 13·02	Statics and Dynamics of Ship Design
13·34	Ship Construction
13·42	Ship Hull Design
13·45	Ship Structures, Design
13·46	Ship Design
13·52, 13·54	Marine Engineering and Dynamics

Work in the graduate school should include 13·03, Principles of Ship Design, and 13·04, Ship Design, Advanced, and other graduate subjects in related fields offered in the Department, such as 13·73, 13·74, and 13·79. The major part of the program of study must be in the field of Naval Architecture but may include advanced mathematics and physics, related subjects or those having applications to hull design and construction which are taught in other Departments, such as applied mechanics, hydrodynamics, metallurgy and metallography.

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, 2·062	Strength of Materials and Dynamics
2·251	Fluid Mechanics
2·40, 2·42	Heat Engineering
2·683	Engineering Laboratory
2·851	Machine Tool Laboratory
6·18	Electrical Engineering, Fundamentals
13·01, 13·02	Statics and Dynamics of Ship Design
13·34	Ship Construction
13·52, 13·55	Marine Engineering
13·61, 13·62	Marine Engineering Design

Work in the graduate school should include graduate subjects in the field of Marine Engineering offered in the Department, such as 13·71, 13·72, 13·73, 13·74, 13·78 and 13·79 but part of the program may consist of subjects given in other Departments which have applications in the field of Marine Engineering such as applied mechanics, hydrodynamics, thermodynamics, machine design, refrigeration, internal combustion engineering, gas or steam turbine design, power plant engineering, heat transmission, metallurgy and metallography, advanced mathematics, advanced physics.

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, 2·062	Strength of Materials and Dynamics
2·251	Fluid Mechanics
2·40, 2·42	Heat Engineering
2·683	Engineering Laboratory
13·01, 13·02	Statics and Dynamics of Ship Design
13·34	Ship Construction
13·52	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.

XIII. Naval Architecture and Marine Engineering Continued

Course XIII-A includes seven different curricula leading to specialization in seven different fields of engineering involved in naval construction and engineering. The seven curricula are fully prescribed, each requiring three years for completion. Approximately three-quarters of the term subjects are common to all of the seven 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.

XIII-A. Naval Construction and Engineering

The subjects which are common to all seven 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
2·422	Heat Engineering	2–4
3·391	Properties of Metals	3–3
3·392	Properties of Metals	3–3
8·03	Physics	5–5
8·04	Physics	5–5
10·311	Heat Transfer	3–3
13·01	Statics of Ship Design	3–6
13·02	Dynamics of Ship Design	3–6
13·12	Warship General Arrangements	2–4
13·15	Warship Basic Design I	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	8–0
13·75	Warship Propulsion I	3–6
13·751	Warship Machinery Design I	2–0
13·76	Warship Propulsion II	2–4
13·761	Warship Machinery Design II	4–0
Ec15	Economics and Labor Relations, Prin.	4–8
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:

2·256	Fluid Mechanics	3–6
6·43	Electrical Engineering	3–6
6·44	Electrical Engineering	4–7
6·45	Electrical Engineering	4–7
13·54	Marine Engineering Dynamics	2–4
M36	Advanced Calculus	3–6
M37	Advanced Calculus	3–6

The remainder of the program is devoted to subjects determined by the student's registration in one of the following specialized curricula:

Basic Hull Design and Structures
Marine Electrical Engineering
Electronics
Power Plants (Turbines, etc.)
Nuclear Engineering
Ship Habitability
Internal Combustion Engines (Diesel)

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, in either the Human Relations or the Industrial Economics option. The other admission requirements are those set forth on page 83, 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.

A graduate of Course XIV 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 83, 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 six fields. 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. Three of the candidate's six fields, designated as *primary*, require more intensive preparation than the other 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

XIV. Economics and Social Science Continued

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. BUSINESS AND ENGINEERING ADMINISTRATION

Designed to prepare the technical graduate for ultimate executive responsibilities of an important nature, the course leading to the degree of Master of Science in Business and Engineering Administration has for its three primary objectives an appreciation of the social implications of industry, an understanding of the interrelations of business and economics, and a familiarity with managerial as well as technical problems.

Breadth of viewpoint is developed by foundation subjects dealing with the economic, social and political background of business. Facility is stimulated through the study of actual problems encountered in the major fields of management: production, marketing, finance, accounting, law and labor relations. The professional point of view is encouraged by original investigations of contemporary industrial situations, selected because of their unusual interest and value to the individual student. Finally, through the privilege of electing subjects in other departments of the Institute, opportunity is offered for further advance in allied technical areas which have especial bearing upon the student's subsequent industrial activities.

Graduate study in this department presupposes preparation equivalent to that of a graduate of the Courses in Business and Engineering Administration. With this preparation the candidate may reasonably expect to complete the requirements for the Master's degree in one year: without it, graduates in engineering or science at the Massachusetts Institute of Technology or other accredited technical schools will undertake a two-year program. The first year of residence is devoted to the satisfying of prerequisites, and any remaining time during that year is assigned to additional subjects chosen from undergraduate electives. The second year is given wholly to graduate work, in accordance with the general requirements for the Master's degree.

Departmental Requirements for Graduate Work

The general admission requirements are those set forth on page 83, with the following exceptions:

Mathematics. M22 Differential Equations is not a prerequisite.

Physics. The department requires a complete college course in Physics of at least one year.

Engineering Subjects. A substantial number of engineering units similar to those prescribed in XV-A or XV-B, the undergraduate Courses in Business and Engineering Administration.

Professional Subjects. The following subjects are prerequisite for graduate study.

15·301 Personnel Administration
15.411 Finance
15·501 Accounting
15·611 Business Law
15·701 Production
15·811T Marketing
15·92 Industrial Problems
Ec111 Current Economic Problems and the equivalent of *any three* additional fourth year elective subjects in Business or Economics.

Deficiencies in prerequisites for admission or for the receipt of the degree may be taken along with graduate work.

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.

Aero-Elastic 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 Aero-Elastic 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

XVI. Aeronautical Engineering Continued

studying aircraft instruments, including an electronic simulator, harmonic synthesizer, and apparatus by which flight conditions can be reproduced. A second laboratory is equipped for the measurement of vibratory displacement, acceleration and strain. It is provided with calibration apparatus and vibration-testing machines. A third laboratory is devoted to fire control apparatus and systems.

Gas Turbine Laboratory: 8 by 8 inch turbine component tunnel, as well as equipment for the study of phenomena of fluid mechanics involved in turbines, compressors and combustion chambers, boundary layer flow and mixing of jets.

Sloan Automotive Laboratory: Equipment for research of all kinds on reciprocating engines and their components, as well as equipment for investigating combustion, for measuring rapidly fluctuating pressures, air flow, and temperature, for taking high-speed photographs, etc.

Departmental Requirements for Graduate Work

The general requirements for admission and degrees are those set forth on pages 83 through 85 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
3·11	Engineering Metals
6·18	Electrical Engineering, Fund.
16·02	Aeronautical Mechanics, Int.
16·10	Aerodynamics, Applied
16·21	Structures

For advanced work in various fields professional preparation is required as follows:

For *Aerodynamics:* 16·13, 16·62, 16·72
For *Aeronautical Design:* 16·13, 16·14, 16·22, 16·62, 16·71, 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 83, 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
1·401, (1·41) (1·42)	Structures
2·04	Strength of Materials
17·71, 17·72T (17·73)	Materials
17·22, 17·31, 17·32	Building Construction
(17·40)	Estimating and Job Management
17·52	Structural Problems
(17·53) (17·54)	Structural Design
15·50	Accounting
2·371	Testing Materials Laboratory

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

XVIII. Mathematics Continued

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.

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 83, with the following additions:

Professional Subjects. Candidates are expected to have completed, before admission, the equivalents of the following subjects:

M442	Differential Geometry
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

For the degrees of Doctor of Philosophy or Doctor of Science, all candidates are required to pass a general examination showing proficiency in a specified group of mathematics subjects, namely M62, M442, M571, M381, M382, and M551. The additional material covered in the general examination varies in accordance with individual needs and tastes subject to certain broad principles specified by the Departmental Graduate Committee.

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 83.

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 84.

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 calibre.

XIX. Meteorology Continued

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 83.

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 84. A five-year course leading to the degree of Master of Science in Food Technology is outlined under the Undergraduate Course Schedules. This course, combining the undergraduate four-year course with a fifth year of instruction following a six-month period in industry, presents opportunities for those desiring actual experience in food industries before starting their graduate year of advanced work.

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 necessarily subject to change due to present conditions. The prerequisites, units of exercise and preparation, and instructors in charge of each subject will be found under "Subjects of Instruction Tabulated"

CIVIL AND SANITARY ENGINEERING

SUBJECTS 1·00 TO 1·99

1·00. SURVEYING. 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*.

1·055. SURVEYING. At Camp Technology. Condensation of 1·00, 1·01 and 1·20 for Courses I and IV-B and of 1·00 and 1·04 for Course XVII.

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.

1·07. 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.

1·071. GEODETIC SURVEYING. Abridgment of 1·07.

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 supplementing 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.

1·301, 1·302. 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.

1·32. AIRPORT DESIGN (A). Development of a complete layout for an airport, including selection of site, layout of runways, drainage, runway surface type and thickness, terminal layout, lighting, traffic control and maintenance facilities.

1·35. SOIL MECHANICS AND FOUNDATION ENGINEERING. Physical and mechanical properties affecting soil action in engineering problems; coefficients of permeability, capillarity and compressibility and their application in practical problems relative to seepage, uplift, liquefaction and the settlement of buildings located above buried compressible soil strata; shearing strength and bearing capacity and their application in problems relative to stabilities of embankments, cuts, 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.

Civil and Sanitary Engineering Continued

1·351. Soil Mechanics and Foundation Engineering. Same material in general as covered in 1·35 but considerably abbreviated.

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, including measurements of specific gravity, water content, and limits of consistency; grain size analyses; permeability, consolidation, compaction and shear tests; various special tests.

1·38. Soil Engineering Special Studies (A). Assigned reading, special lectures and conferences covering advanced studies of either theoretical or practical nature in various phases of soil engineering. Material varying with the theoretical background and the special interests of individual students or small groups of students.

1·40. Structures. Introductory theory of stress analysis for civil engineering structures such as buildings and bridges. Subject matter includes loadings, reactions, shears, bending moments, influence lines for beams and girders, effects of moving-load systems, elementary analysis of trusses, and an introduction to the use of the Moment-Distribution procedure. Drafting room exercises include Graphic Statics and supervised problems.

1·401. Structures. Same as 1·40 with the problem section omitted.

1·41. Structures. Continuation of 1·40. Theory of plate girder design and riveted connections; stress analysis for statically determinate trusses of various forms including trusses with secondary web systems, three hinged arches, cantilevers, bracing, towers, and space frames; statically indeterminate structures of certain types such as building frames, trusses with multiple web systems, and portal frames, by approximate methods; also gravity type masonry dams.

1·42. Structures. 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. Prefaced by determination of deflections of structures by methods of Virtual Work, Moment Area and Williot-Mohr.

1·43. Reinforced Concrete Design. Elementary principles involved in the determination of stresses in beams and columns. Design of reinforced concrete buildings of various types and other structures as governed by current specifications.

1·441. Structural Design. Relation of the theory of structures to engineering practice through the preparation of designs and drawings for a riveted plate girder railway bridge, and a steel truss highway bridge. Development of careful, systematic and practical habits of computation.

1·442. Bridge Design. An extension of 1·441 including the design of a welded girder bridge, a wooden roof truss, a reinforced concrete highway bridge, a reinforced concrete retaining wall, and a steel truss continuous over two spans.

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.

1·61. Fluid Mechanics. Elementary mechanics of incompressible and compressible fluids. Properties of fluids. Fluids at rest, geometry of fluid motion, general equations of motion. Dynamic similarity for inertia, gravity and viscous forces, laminar and turbulent flow, skin friction, lift and form-drag. Basic principles applied to steady flow through orifices, nozzles and other flow meters. Fluid flow in pipes and open channels. Flow through pipe systems.

1·62. Fluid Mechanics. Continuation of 1·61. 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.

1·63. 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.

1·64. 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.

1·641. 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.

1·65. Applied Hydromechanics (A). General equations of motion, potential flow, conformal mapping applied to hydraulic structures, laminar and turbulent motion in con-

duits, boundary layer phenomena, surface and form resistance, statistical theory of turbulence, turbulent mixing and transfer of matter in fluid streams.

1·66. 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.

1·67. 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 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

Civil and Sanitary Engineering Continued

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. Principles of Sanitary Science (A). Lectures and discussions dealing with sources of infection, modes of spread, principles of immunity, antibiotic agents, and the relationship of water, sewage, milk, food, insects and rodents to the spread of disease. Sanitary problems such as rural sanitation; the sanitation of swimming pools and bathing beaches; summer camps and other overnight camps; street cleaning; refuse collection and disposal; food sanitation; the sanitation of eating and drinking establishments; housing; the atmosphere in relation to health and comfort; school sanitation; industrial sanitation.

1·871. Public Health Administrative Practice (A). Lectures, discussions and problems pertaining to public health administration, epidemiology and vital statistics including organization and proper functioning of municipal, state and federal health agencies; the case history of specific epidemics of particular interest to the sanitary engineer; and the use of statistical methods and procedures in the collection, analysis and interpretation of vital statistics.

1·872. Public Health Engineering Fieldwork (A). Field trips under professional guidance and for purposes of study and report of public health engineering activities that are included in the program of municipal, state and federal health agencies. Field trips covering the items enumerated under 1·86.

1·881. Advanced Sanitary Design (A). 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.

1·891, 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. Principles of conservation and reclamation as they concern the planning of engineering works. Conservation and utilization of water resources in the fields of water supply, water-power development, irrigation, navigation and flood prevention. Attention given to land and soil conservation and its engineering aspects. Discussion of the conservation of forest, mineral, industrial, agricultural and wild-life resources.

1·91T. 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.

1·92T. 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.

2·01. 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, riveted and welded joints; stress concentration; cases of simple loading of thin rings, cylinders and spheres. Theory of bending including shearing forces and bending moments; distribution of normal and shearing stresses, composite and curved beams, differential equation of the elastic curve, methods for the determination of slopes and deflections. Statically indeterminate problems in bending. Combined loading. Column theory. Working stresses. Applications to important engineering problems. Timoshenko and MacCullough, *Elements of Strength of Materials*.

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. Army, Navy and Coast Guard.)

2·06. Dynamics. Simple problems on free and forced vibrations with damping. Rayleigh's method applied to systems of several degrees of freedom. Momentum and energy of rigid bodies and systems in plane motion. Relative motion. The gyroscope.

Mechanical Engineering Continued

2·062. Strength of Materials and Dynamics. Analysis of stress and strain at a point, theories of failure of engineering metals. Beams on elastic foundations, plates and shells. Hardy cross method applied to continuous beams, Castigliano's theorem, method of least work. Problems in plane motion, relative motion, and gyroscopes.

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.

2·10. Ordnance Engineering. Lectures and calculations on gun design, including stresses and strains in built-up and wire-wrapped guns; the design of recoil and counter recoil mechanisms.

2·11. Industrial Plant Engineering. Soils, foundations, footings (plain and reinforced concrete) and types of superstructures; heating and ventilation, air conditioning, and mechanical equipment of buildings; fire protection methods.

2·121. Photoelasticity. Use of commercial photoelastic apparatus with applications in the analysis of common engineering problems in two and three dimensions, together with lectures on modern photoelastic theory, materials, and methods.

2·125. 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. Introduction to the special theory of relativity. Vibrations and stability of systems with many degrees of freedom, normal modes and frequencies; approximate methods. Systems with variable coefficients and nonlinear 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). Coordinated application of fundamental 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. Operating characteristics of gas turbine power plants including part load performance and control. 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.

2·215. Relaxation Methods. Applications of the Relaxation method to solve problems in engineering. Examples will be given in statics, dynamics, heat flow, elasticity and electricity.

2·221. Plasticity (A). Mechanics of the plastic state of materials with particular emphasis on engineering applications. Mohr's representation of stress and strain in both two and three dimensions. Theories of strength in relation to design. Choice of working stresses under combined stress. New developments in true stress-strain relations for metals as affected by strain rate, temperature, etc. Brittle fracture of metals. General laws of plastic flow as applied to torsion bars under combined stress, rotating disks, rotors, the cold working of tubes under internal pressure, etc.

2·222. Advanced Plasticity Problems (A). Continuation of 2·221 with practical applications to a number of modern engineering problems. Bending, deflection, and buckling of bars and tubes in the plastic state. Creep of both metals and non-metals at normal and elevated temperatures. Relaxation of stresses in bolted flanged connections, and in other design applications. Residual stresses as determined from calculation and experiment. Rolling, drawing, shell forming and extrusion of metals. Plastic flow problems in the field of synthetic plastics. Selection of special problems in consultation with the instructor, and some laboratory work.

2·223. Plasticity Research (A). Experimental and theoretical investigations in the general fields of the plastic flow and the brittle fracture of engineering materials.

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.

2·251. Fluid Mechanics. Physical properties of fluids, hydrostatics, continuity, Euler's equation, energy, momentum, dimensional analysis. Application to laminar and turbulent flow in pipes.

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.

2·256. 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.

Mechanical Engineering Continued

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, dynamic loading; hydrostatic lubrication; 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.

2·271. Hydromechanics (A). Equations of motion of ideal fluid, vortex motion, potential flow, circulation, wing theory, Navier-Stokes equation, boundary layers, stability of laminar flow, turbulence.

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.

2·34. 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. Battelle Memorial Inst., *The Prevention of Failures of Metals Under Repeated Stress.*

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. Testing Materials Laboratory. Laboratory methods for the determination of the physical properties of engineering materials and their behavior under stress. Usual methods supplemented by study of true stress-strain for plastic action, stress analysis through strain study and by photoelastic analysis. Tests at abnormal temperatures, Magnaflux and Zyglo inspection, special hardness tests, fabrics testing, X-ray examination and research problems included in the lecture material. Cowdrey and Adams, *Materials Testing.*

2·371. Testing Materials Laboratory. Methods of making physical tests to determine the properties of the more common engineering materials and a study of their behavior under stress. Cowdrey and Adams, *Materials Testing.*

2·40. 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.)

2·41. 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.*

2·44. Heat Engineering. Kinetic theory of gases: treatment of pressure phenomena in ideal and non-ideal gases; Maxwell's velocity distribution; free paths in gases; the transport phenomena of viscosity, heat conduction and diffusion; a gas in a non-steady state; elementary introduction of general statistical mechanics; calorimetry and molecular structure; the theory of specific heats; intermolecular forces. Jeans, *Kinetic Theory of Gases.*

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.

2·46. Engineering Applications of Kinetic Theory (A). Applications of kinetic theory from the engineering viewpoint. Equations of state; specific heats from molecular models and from spectroscopic data; introduction to statistical mechanics of gases; correlation of kinetic theory and thermodynamics; transport of heat, momentum, and mass in a non-uniform gas; flow of gases at low pressures; rates of reactions.

2·48. Gas Turbines. Principles of thermodynamics, fluid mechanics and dynamics applied to the analysis and design of gas turbines.

2·491, 2·492. Flow of Compressible Fluids (A). One-dimensional treatment, with effects of area change, friction and heat transfer. Normal compression shocks. Method of small perturbations for subsonic and supersonic flow. Super-

Mechanical Engineering Continued

sonic flow around a corner. Oblique compression shocks. Method of characteristics. Hodograph method. Iteration and numerical techniques. Experimental methods.

2·50. Heat Measurements. Laboratory exercises in the practice of heat measurements, including various types of temperature measuring instruments, heat of combustion and heat transfer. Lectures on the theory of temperature measurement, heat transfer and heat insulating materials.

2·51. 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. 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). Continuation of 2·521. 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. Thermal stresses in solids. Heat transfer-friction relationship in heat exchangers.

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.

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.

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.

2·680. Engineering Laboratory. Use and calibration of instruments in mechanical engineering; use of metering devices for air, steam, and water; heat transfer; experimental studies involving use of steam engines, steam turbine driven pumps, steam pumps, steam specialties, stationary internal combustion engines, an air blower and a single stage air compressor.

2·681. Engineering Laboratory. Use and calibration of instruments in mechanical engineering; use of metering devices for air, steam, and water; practice of heat measurements including heat transfer; experimental studies involving use of steam engines, steam pumps, stationary internal combustion engines, an air blower and a single stage air compressor, air conditioning and refrigeration equipment.

2·683. Engineering Laboratory. More complete coverage of the work outlined in 2·681.

2·687. Hydraulic Laboratory. Supplement to classroom theory, including exercises upon orifices, nozzles, weirs, pipes, centrifugal pumps, and other hydraulic 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.

2·730. 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. Consideration of problems involved in operational high speed.

2·732. Machine Design. Continuation of 2·731, but emphasizing the problems that arise in the design of automatic machinery. The lecture material of the course consists of a detailed study of cams, including the dynamics of the follower motion, and a discussion of linkages and other mechanisms that are useful in automatic machinery design. Regular lectures supplemented by talks from men in industry.

Mechanical Engineering Continued

2·733. Machine Design. Open to a selected group of students interested in design as a possible career. Completion of a layout of a fairly complex machine and a report describing the manufacture and operation of the machine, including a bill of materials and all necessary design calculations, the choice of the machine being left to the student. A wide variety of designs to be carried out by the group. Weekly seminars enabling the entire group to contribute to the solution of problems peculiar to one type of machine. Plant trips to be scheduled when they appear advantageous to the group.

2·751. Machine Design (A). Thorough and rigorous discussion of the many factors involved in the design of complex machines.

2·78. Design of Hydraulic Machinery. Theory and design of displacement type hydraulic machinery and its applications in industry. Discussion of problems in the control of speed, position, torque, and power.

2·783. 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 the internal combustion engine, including capacity, efficiency, thermodynamics and combustion. Taylor and Taylor, *The Internal Combustion Engine.*

2·792. Internal Combustion Engines. Continuation of 2·791. Fuels, lubricants, cooling, carburetion, distribution, ignition, friction, and supercharging. 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. Laboratory exercises supplementing the classroom work of 2·792. Measurement of the effects of operating and design variables studied in 2·792.

2·796. Internal Combustion Engine Design. Introduction to engine design, including work in engine dynamics, stresses, materials, and design procedure.

2·797. Internal Combustion Engine Design (A). Fundamental principles of design, laws of similitude, properties of engine materials, design of important elements. Student chooses a particular type of engine-aircraft, automotive or Diesel, and makes preliminary calculations and assembly drawings of important parts.

2·798. Internal Combustion Engine Design (A). Continuation of 2·797. Lectures on detail design of additional parts and of auxiliaries. Calculations and drawings on valve gear, superchargers and auxiliary equipment.

2·799. Automotive Dynamics (A). Balance of automotive engines and vibration problems associated with automotive engines and vehicles. Den Hartog, *Mechanical Vibrations.*

2·801, 2·802. 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.

2·851. 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. Smith, *Advanced Machine Work.*

2·852. Machine Tool Practice. Advanced machine tool work dealing with semi-general purpose machine tools. Also analysis of methods engineering and brief exercises in time study, comparison of turning methods, comparison of plane surfacing methods, comparison of threading methods, relationship of manufacturing tolerances to cost, inspection, surface roughness measuring, precision measuring, machine tool design, production designs, functional design, estimating and operation sheets. Smith, *Advanced Machine Work.*

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 Manufacturing;* 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, 2·906. Textile Technical Analysis (A). Physical determinations of strength, stretch, moisture regain, twist and various mechanical properties of interest to the yarn and fabric technician. Formulation and proper presentation of data, precision of measurements, graphical interpretation of data, variable factors which influence textile testing results, and outlining of present trends in textile research in this country and abroad. A.S.T.M. *Standards on Textile Materials.*

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.*

Mechanical Engineering Continued

2·911. Textile Testing Laboratory (A). Opportunity for the student to operate standard textile-testing equipment and obtain practical experience in the field covered by the lectures of 2·905.

2·912. Textile Research Laboratory (A). Studies of the variable factors influencing textile tests with opportunity to carry out one or more individual research problems in the physical or optical analysis of textiles.

2·913, 2·914. Textile Technology Seminar (A). Opportunity for students and staff members to present critical discussions of important problems in fiber technology, textile analysis and textile microscopy together with reviews of the current literature, and the results of researches in these fields at the Institute.

2·991, 2·992. Mechanical Engineering Seminar (A). Discussion and reports on special topics in mechanical engineering and related fields. Development and test of ability of candidates for the doctorate to digest and summarize an assigned topic within their general field of study, taking an active part in discussion and criticism of such presentation. At least one contribution per term by each registrant. (Open only to students working for the Sc.D. degree.)

METALLURGY

Subjects 3·00 to 3·99

3·01. 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 3·01T. Apparatus, design and operating variables, and engineering calculations for the important unit processes. Hydrometallurgical and electrometallurgical processes considered briefly. Recognition and measurement of the important variables in typical metallurgical processes and small-scale process equipment stressed in laboratory practice.

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.

3·06. Advanced Non-Ferrous Metallurgy (A). Smelting and refining of the principal non-ferrous metals discussed in a weekly seminar. Present practice discussed and possible improvements suggested and criticized.

3·08. Advanced General Metallurgy (A). Fuels, refractories and the principles of roasting and smelting. Critical analysis of the manner in which these principles are carried out in present practice and suggested improvements.

3·10. Metallurgical Plant Visits. One week spent in visiting metallurgical plants in New Jersey and Eastern Pennsylvania. Production of iron and steel, zinc, copper, lead and non-ferrous alloys. Students meet instructor about one week before opening of fall term.

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.

3·161. Powder Metallurgy Laboratory. Laboratory work and conferences with powder metallurgy practice and its application to industrial problems.

3·18. Mechanical Behavior of Metals. Fundamental aspects of the effects of stress on metals. Discussion of the states of stress and laws of yielding, as well as effects of temperature, rate of strain, complexity of stresses, and metallurgical structure on resistance of metals to deformation and fracture. Review of modern theory of the mechanism of plastic deformation and fracture in single crystals with reference to the dislocation concept and other viewpoints; application of the resulting conclusions to the behavior of polycrystalline metals. Study of internal friction emphasizing applications to grain boundary, anelasticity, and other problems. Application of modern ideas to the study of the slow deformation of metals under small stresses.

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.

Metallurgy Continued

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 U. S. Naval Officers.)

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 U. S. Navy and Coast Guard Officers.)

3·41. Light Alloys. Detailed study of the properties, heat treatment and uses of alloys of aluminum, magnesium, and beryllium.

3·42. Applied Electrochemistry. Detailed principles of electrochemical theory and 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.

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 3·82T, including amalgamation, flotation, leaching, thickening and filtration as well as the 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.

Metallurgy Continued

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 Dressing (A). Informal discussion of topics selected according to the needs of the students. Examples of suitable topics: application of fluid mechanics to gravity concentration, of physical chemistry to flotation, of colloid chemistry to flocculation and thickening, of elasticity and plasticity to comminution.

3·901. Advanced Mineral Dressing Laboratory (A). Study of an ore, a process, or a machine in the field of mineral dressing.

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 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). Open only to a limited number of mature students, and not given if there are less than five registrants. General introductory evaluation of the housing problem; intensive critique of concepts and relationships in housing from social, technical, economic, and administrative points of view; historical survey beginning with the 1914 legislation in Europe, with special critical attention directed to contemporary solutions in Europe and the United States; consideration of present social and economic trends and their future implications to housing. Fortnightly exercises, each student presenting a portion of the subject selected for that exercise, his presentation being based upon extensive reading offered by a large bibliography. Oral presentations supplemented by written reports. Serious library work.

4·59. Government and Public Administration. Structure of local and state governments; powers and duties of local authorities; general survey of the field of public administration, including the relationship of administrative agencies to the legislative and judicial branches of government; general principles of municipal finance; long-term programming and financing of public works.

4·60. Planning Legislation and Administration. 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.

4·621. Site Planning and Construction. Contains all of the subject matter of 4·62 presented primarily for advanced students in Architecture.

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.

4·641. 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

Architecture and Planning Continued

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.

4·681. 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.

4·682T. City and Regional Planning. Continuation of 4·681.

4·683. City and Regional Planning. Continuation of 4·682T.

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, 4·732T. 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, 4·742T. 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, and inviting speculation as to the future possibilities for adequate solutions to these problems. Disposition of groups of buildings on new sites with analysis of economic considerations.

4·761, 4·762. Architectural Design (A). Research, development of program, and design of buildings with particular attention to thorough consideration of social, economic, and technical influences and integration of these factors in the solution of the problem. Site plans, considered in their architectural and engineering aspects; and collaborative projects with graduate students in City Planning.

4·78. Planning Principles. Principles underlying all good planning such as the logical relation to one another of the different parts of a building, the arrangement of proper lighting and circulation, 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 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 and Latimer, *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 Waal's 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

Chemistry Continued

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 radio-elements. Applications to chemical problems.

5·091. Radiochemistry Laboratory (A). Laboratory study of special topics including radio chemical analysis, the fission process, and the reactions following nucleogenesis.

Analytical Chemistry
undergraduate subjects

5·10T. 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 of a large number of solutions and solids, including alloys, pigments, minerals, slags and miscellaneous commercial products. Preparation for quantitative analysis, correlating and systematizing much of the information already obtained in general inorganic chemistry. Noyes and Swift, *Qualitative Chemical Analysis;* 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 of 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.*

5·13T. 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, polarimeter, colorimeter, polarograph, potentiometer, recording potentiometer, conductance bridge and Geiger counter. Gibb, *Optical Methods of Chemical Analysis;* Kolthoff and Laitenen, *pH and Electro Titrations.*

graduate subjects

5·192, 5·193, 5·194. Advanced Analytical Chemistry (A). Physical and chemical methods for the separation, detection, and determination of organic and inorganic substances. Detailed consideration of coprecipitation phenomena, chromatography and ion exchange, electrolysis and polarography, organic reagents, trace analysis including spot reactions, organic functional group determinations, analytical chemistry of the rarer elements, problems in the analysis of technical products, and statistical treatment of data.

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, resonance, 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, sterols, and alkaloids).

graduate subjects

5·51. Organic Chemistry: Synthesis, Advanced (A). Survey of organic reactions and the methods by which they are applied to synthetic problems in organic chemistry.

5·52. Organic Chemistry: Mechanism, Advanced (A). Theory and factors which govern the reactivity of organic compounds. Present state of knowledge of mechanism of reactions. Molecular structure and influence of resonance.

5·53. Organic Chemistry: Identification, Advanced (A). Systematic methods for the unequivocal identification of organic classes, functional groups, and individual compounds. Study of methods of establishment of structure. Modes of differentiation between compounds with closely similar properties.

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. Hammett, *Physical Organic Chemistry.*

5·582. Advanced Organic Laboratory: Identification (A). Laboratory practice in identification, structural determination, and characterization of functional groups.

Physical Chemistry
undergraduate subjects

5·61. Physical Chemistry I. Atomic weights, elementary thermodynamics, properties of gases, liquids and crystals, ideal solutions, transference and conductance of ionized solutes, thermochemistry, homogeneous equilibrium. Millard, *Physical Chemistry for Colleges.*

5·611. Physical Chemistry Laboratory I. Laboratory co-ordinated 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 co-ordinated with the topics of 5·62.

5·622. Physical Chemistry Laboratory II. Abridgement of 5·621.

Chemistry Continued

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. Noyes and Sherrill, *A Course of Study in Chemical Principles.*

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.

5·66. 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; ultra-violet absorption of molecules and their electronic structure.

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

5·70. Physico-Chemical Experimental Techniques (A). Unit experiments designed to illustrate principles and research techniques in the following fields, among others: production, control, and measurement of pressures, temperatures and temperature differences in various ranges from very low to very high; measurement of mass and volume; determination of physical properties of fluid mixtures; measurements of electromotive force, current, and resistance; determination of energy, intensity and wave length of radiation; production of and determination of the properties of molecular, ionic and electronic beams. (Not offered 1949–50.)

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 inferred from results of experiments: deflection of charged particles in electric and magnetic fields, interaction of matter with charged particles or neutral particles of high velocity; emission and absorption of radiation. Discussion of these results and the periodic table in terms of the quantum theory. Transition to the study of molecular structure provided through the concepts presented.

5·76. 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.

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.

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, although the report is expected to include a brief review of the field related to the particular paper chosen for discussion. 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

6·00. Principles of Electrical Engineering (Electric Circuits). Limitations of circuit theory; idealizations inherent in symbolic representation by means of circuit elements; steady-state alternating-current theory for linear circuits, including polyphase systems; complex function loci; transient behavior of linear and nonlinear circuits; electric-circuit representation of electromechanically coupled systems. *Electric Circuits*, by Members of the Department Staff.

Electrical Engineering Continued

6·002. Principles of Electrical Engineering. Second half of 6·00. Transient behavior of linear and non-linear circuits; electromechanically coupled systems.

6·01. Principles of Electrical Engineering (Magnetic Circuits and Transformers). Properties of magnetic materials; magnetic circuits; transformers for power and communications circuits; transformers in polyphase systems. *Magnetic Circuits and Transformers*, by Members of the Department Staff.

6·02. Principles of Electrical Engineering (Engineering Electronics). Engineering electronics including the internal phenomena of vacuum and gas tubes, and the analysis of circuits containing such tubes; single-phase and polyphase rectifiers, amplifiers, oscillators, modulators, and demodulators. *Applied Electronics*, by Members of the Department Staff.

6·031. Principles of Electrical Engineering. Survey of energy-conversion methods. Detailed consideration of principles of electromagnetic energy conversion, leading to a general treatment of electric machines. Application of this general theory to direct current machines.

6·032. Principles of Electrical Engineering. Basic theory of polyphase machines from the rotating-magnetic-field viewpoint, followed by analysis of synchronous, induction, and fractional horsepower machines. Introduction to system analysis in the transient or dynamic state, including both purely electrical and electromechanical aspects.

6·04. Principles of Electrical Engineering (Electric Power Transmission). General survey of transmission-line problems, calculation of line constants, short-line solutions, skin effect, corona, insulator stresses, hyperbolic-function solution of long-line problems, graphical methods, circle diagrams, transients, system stability, fault currents. Woodruff, *Principles of Electric Power Transmission; 2d Edition.*

6·05. Principles of Electrical Engineering. Resistance and resistance networks; associated electrical measurements laboratory experiments; orientation lectures. *Electric Circuits*, by Members of the Department Staff.

6·16. Electricity. Electricity rate structures and schedules; wires and safe wiring practice; d-c and a-c generators, transformers; electronic devices and rectifiers; d-c and a-c motors; motor control equipment; batteries. This subject treats the foregoing equipment as components of the modern building and the principles involved as the concern of the designer. Applications in heating, ventilating, air-conditioning, lighting, refrigeration, elevators, conveyors, communications, signal systems, protection of person and property, therapeutics and other services to occupants of the buildings are studied as separate or combined devices. Elevators are treated as a traffic problem in vertical transportation.

6·17. Illumination. A study of the design of lighting systems for best seeing. Photometric units and measurements, properties of the eye, characteristics of lamps and luminaires, daylight. 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 laid out as the first part of a two-term program with electronic and other aspects of electrical engineering considered during the second term subject. Classroom instruction supplemented by experimental work in the electrical-engineering laboratories. Fitzgerald, *Basic Electrical Engineering.*

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, voltage regulators, water-level controls, spot-welder controls, sensitive wattmeters, voltmeters, ohmmeters, high-speed recording instruments, stroboscopes, flash-photography apparatus, etc. Detailed consideration of the following subjects: grid current and its effect in high-impedance circuits; amplifiers with direct, resistance-capacitance, push-pull and degenerative coupling; methods of frequency conversion to facilitate amplification or measurement; trigger circuits; and negative-resistance oscillators. Emphasis on importance of the 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 given to the following: voltage-stabilized and current-stabilized-power supplies; grid-controlled gas-filled tubes applied as rectifiers and as inverters; electronic control of d-c and a-c motors; induction and dielectric heating principles. Typical examples from commercial equipment to illustrate the principles discussed.

6·211. Application of Electricity to Industry. Scientific basis for modern applications of electricity in industry. Sources of energy. Analysis of power production in United States. Choice of system. Elements of electrical energy costs. Distribution of energy within the p ant. Principles of electric heating, including energy conversion to heat, heat transfer, heating and cooling of metals, resistance heating, arc furnaces, low-frequency and high-frequency induction furnaces.

6·212. Applications of Electricity to Industry. Mechanical, thermionic and photo-electric applications. Duty cycles. Operating characteristics of motors. Controller design and application, including types, methods of acceleration and retardation, protective devices. Essentials of connecting motor to load. Principles of moving fluids and solids. Problems in the application of motors, electron tubes and photo-electric cells.

6·213. Industrial Applications of Servomechanisms. Presentation of the elements of the dynamics of closed-cycle control systems with emphasis of their application to Industry, illustrated by the treatment of control problems in Aeronautical, Chemical, Electrical, and Mechanical Industries, etc. The procedures for expressing analytically the characteristics of the process and for synthesizing the control to accomplish desired control operations considered quantitatively for a wide range of industrial problems.

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. Power Frequency Application Engineering. Application of electrical equipment to the typical public utility system and to the principal consumers, including the power-house, both steam and hydro-electric, and transmission system, the larger industrial customers, and the urban and rural distribution systems.

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. Subjects given by notable practicing engineers designed to show the whole problem faced by the engineer including the influence of such matters as economic, legal,

Electrical Engineering Continued

public relations, manufacturing sales, and servicing considerations as well as the technical engineering. Registration officers to be consulted about the particular field and instructor for any given term.

6·251. Electric Machinery Design. Transformers and induction motors. Materials of construction, methods of construction, calculation of electrical characteristics, eddy-current losses in the windings, and influence of various factors of design on manufacture and operation of machines.

6·252. Electric Machinery Design. Design of synchronous and direct-current machines. Continuation of 6·251, but also complete within the 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.

6·271, 6·272. Principles of Illuminating Engineering. Broad survey of the whole field of illuminating engineering in the first term, with particular emphasis on new methods of lighting design. More detailed analysis of particular aspects of illumination, light, and color in second term. 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.

6·291T, 6·292T. 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; computer circuits. M. I. T. Radar School Staff, *Principles of Radar, Second Edition*.

6·30. Principles of Electrical Communications. Fundamental principles for the solution of electric circuit problems in the Communications field, including the following topics: Fourier series and Fourier integrals and their use in analysis and synthesis; introduction to network synthesis with emphasis upon the reactive case; equivalent and impedance-transforming networks; effect of small amounts of incidental dissipation; single- and double-tuned circuits and other simple types of coupling networks, 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.

6·321T. 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.

6·322T. 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. Use 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.

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. Presentation of the characteristics of sound waves, acoustical radiating systems, acoustical elements, acoustical receiving systems, recording apparatus, and of enclosures where sounds are produced. Application of analagous 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.

6·37. 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*.

6·43. Electrical Engineering. Fundamental theory of direct-current and magnetic circuits, magnetic and electric fields. Fundamentals and characteristics of direct-current machinery, with emphasis on the selection of machinery and control equipment as affected by torque requirements and duty cycles imposed by the load. Timbie and Bush, *Principles of Electrical Engineering, Third Edition;* Kloeffler, Brenneman, and Kerchner, *Direct-Current Machinery*.

6·44. Electrical Engineering. Continuation of 6·43 on direct-current machinery, with experimental work in the Electrical Machinery Laboratory. Fundamental theory of alternating-current circuits, with comprehensive problems illustrating the theory and its applications. Kloeffler, Brenneman, and Kerchner, *Direct-Current Machinery;* Lawrence, *Principles of Alternating Currents, Second Edition; Instructions for Students in Electrical Engineering Laboratories, Twelfth Edition*.

6·45. Electrical Engineering. Theory and characteristics of transformers, synchronous machines and induction machines, with emphasis on selection of alternating-current machinery and control equipment as affected by torque requirements and duty cycles imposed by the load. Lawrence, *Principles of Alternating-Current Machinery, Third Edition; Instructions for Students in Electrical Engineering Laboratories, Twelfth Edition*.

6·46. Electrical Engineering. Elementary theory of electronic devices and their applications in circuits for meas-

Electrical Engineering Continued

urement and control purposes, with emphasis on amplifiers and rectified-power supplies. Fitzgerald, *Basic Electrical Engineering.* (Primarily for Course XIII-A.)

6·47. Applications of Electricity in Industry. Considerations governing the choice, applications, and economics of distribution and use of electrical energy in industry. The operating characteristics of motors and their control as governed by mechanical, electrical, or electronic methods. The elements of industrial lighting, electric welding, and electric furnaces are discussed so far as time permits. The application of electrical principles to instrumentation in other engineering fields is presented.

6·501, 6·502. Electrical Engineering Seminar (A). Designed to give graduate students experience in the preparation and presentation of technical papers, and to present to the students and staff of the Department, both at the meetings and by means of the file of completed Seminar papers which is maintained in the Vail Library, the developments which are of special interest to electrical engineers.

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 conditions. Calculation of resistance, inductance, and capacitance of transmission lines for currents of the different symmetrical-component sequences. Comprehensive treatment of system performance in the steady state. Edith Clarke, *Circuit Analysis of A-C Power Systems.*

6·512. Electric Power Circuits (A). General theory of traveling waves, followed by a consideration of reflections and refractions at junction points, circuit discontinuities and terminals; the effect of resistance, inductance, and capacitance in series and in parallel with lines. Principles and practice involved in the protection of lines and machines against lightning and switching surges. Review of laboratory and field test methods and apparatus. Bewley, *Traveling Waves on Transmission Systems.*

6·515. Power Systems Laboratory (A). Power-network analysis using the network analyzer (an alternating-current calculating board). Problems including those relating to steady-state operation; to symmetrical and unsymmetrical faults; and to steady-state and transient stability. Problems preferably submitted by the student.

6·516. Power System Analysis (A). Basic analysis of the systems problems arising in the planning and operation of electric power circuits. Transient two-reaction theory of machines, leading to the viewpoint of the machine as a circuit or system element. Systems problems concerned with 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 work on the study of representative modern power systems on the M. I. T. Network Analyzer.

6·521, 6·522. Advanced Alternating-Current Machinery (A). Analysis of more intricate electrical problems met in the operation of alternating-current machinery; such as effect of unbalanced conditions on the operation of synchronous and induction machines; eddy currents in laminations, solid rotors, and conductors of direct-current and alternating-current machines; harmonic analysis of the magnetic density existing in the air gap of synchronous and induction machines including the effect on generated e.m.f., torque, and vibration; transient conditions due to the sudden alteration of the electric circuits or to the sudden variation of the shaft load of synchronous and induction machines, particularly the effect of sudden short circuit on the current and torque and the conditions which arise while pulling into step and phase swinging. Facilities available in the machine-transients laboratory for supplementary experimental work.

6·561, 6·562. Advanced Network Theory (A). Discussion of the methods of network synthesis and their applications to the design of networks for prescribed driving-point or transfer characteristics including such networks as wave filters, attenuation or phase equalizers, coupling networks for wide-band or feedback amplifiers, etc. Theoretical development beginning with an enlargement of the more elementary methods of network analysis out of which are established the properties of physical driving-point impedance functions and the necessary conditions for the physical realizability of a prescribed impedance or of a set of impedance functions characterizing a network with several terminal-pairs. Discussion of synthesis procedures including a variety of methods pertinent to the design of nondissipative and dissipative networks with one and two terminal-pairs, with consideration of various methods of obtaining equivalent networks and of the collaterally useful concept of the duality. Discussion of pertinent properties of analytic functions of a complex variable.

6·563. Statistical Communication Theory (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. Information and entropy. Rate of transmission of information.

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 which permit of linear treatment; analogies; mathematical studies of transient disturbances in these systems, using the Laplace transformation method as a means of solving the ordinary and partial differential equations. Formulation of difference equations of engineering problems and their solution using the Laplace transformation. 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 treatment of methods for the solution of Laplace's equation and their practical applications. A supplement to the usual electric-circuit theory (one space dimension) by developing methods for two and three dimensions.

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.

6·601. Machine Computation (A). Systematic study of topics in numerical analysis selected to prepare the student for the task of converting differential and integral equations of physics and engineering into equivalent forms which can be handled by digital computation machinery. Approximation of analytic functions by power polynomials and interpolation in terms of ordinates as well as finite differences. Development of methods for numerical differentiation and integration, and application to the solution of various types of ordinary differential equations, with various types of boundary conditions. Development of methods for treating problems involving non-equidistant ordinates. Introduction to the numerical treatment of partial differential equations.

6·602. Machine Computation (A). Study of computing mechanisms, both of the analogue type and of the digital type. Emphasis on the management of variables in both types, and on the engineering of computing elements and computing systems. Work on digital computation including a presentation of the logic of large-scale digital computers. Illustration of basic digital computation methods by the use of punched-card machinery and by laboratory work on electronic computing components.

Electrical Engineering Continued

6·605. Servomechanisms (A). Principles of dynamic analysis of closed-cycle automatic control systems with emphasis on the quantitative study of system behavior and its correlation with system synthesis in terms of differential equations and complex functions. Relation between transient behavior following sudden disturbances and steady-state behavior to sinusoidal disturbances is treated in terms of time solutions, and magnitude and phase characteristics expressed as vector contours to a linear or decibel scale. System synthesis to meet performance specifications applicable to a wide class of control or regulation problems is basic objective. Brown and Campbell, *Principles of Servomechanisms.*

6·606. Servomechanisms (A). Servomechanism theory embodying advanced analysis and quantitative design of a number of automatic control systems. Investigation of electric, hydraulic, and electro-hydraulic servomechanisms with the aid of supporting applied electronics, electric circuits, electrical machinery and fluid machinery theory as applied to servomechanisms. Laboratory work on quantitative measurements and evaluation of servomechanism performance.

6·607. Servomechanisms Laboratory (A). Quantitative measurement and synthesis of a wide variety of typical closed-cycle systems. Program varied to meet particular needs of the student. Project type of problems recommended in contrast to unrelated minor studies.

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.

6·609. Design of Automatic Control Systems for Aircraft (A). Review of methods of analysis applicable to automatic control systems. Development of advanced automatic control theory. Simplification of complex dynamic equations. Formulation of equations of motion of automatically controlled aircraft. Design of control systems to match specific aircraft characteristics and to secure particular operational characteristics. Determination of specifications for control components. Review of present-day control components. Component design to secure predetermined characteristics.

6·61. Engineering of High Voltages and Particle Accelerators (A). Fundamental mechanisms in the passage of electricity between electrodes in high vacuum and in gases. Characteristics of high-voltage insulating media with emphasis on compressed gases and high vacuum and on solids immersed in these. Principles and techniques in the production of voltages in the 100 to 5000 kv. range by electrostatic, alternating-current, and impulse voltage sources. The 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). Theory and application of waveguides; microwave circuit components of various types including cavity resonators, matching elements, and coupling devices; principles 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 types of pulse-forming circuits including overdriven amplifiers, multivibrators, blocking oscillators, and artificial transmission lines. Consideration of counting circuits, cathode-ray-tube sweep circuits and pulse amplifiers. Application to radar, television, pulse-modulation communication systems and laboratory instruments.

6·624. Electrodynamics of Particles (A). Analysis of the dynamics of particles by the methods of Lagrange and Hamilton; extension of Maxwell's Electromagnetic Field Theory to Special Relativity; and application to problems of space charge, forces beween currents, electron motions in electric and magnetic fields, electron optics, radiation from accelerated electrons, interaction of electrons and electrodes in vacuum tubes, and considerations of particle acceleration machines. (Alternate Years.)

6·625. Modulation, Noise, and the Transmission of Information (A). Statistics and elementary theory of random phenomena. Thermal noise and tube noise. Noise in amplifiers. Theories of Modulation with emphasis on pulse modulation. Introduction to the Theory of Transmission of Information, and the application of the theory in noise reduction.

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). Grid control of arc tubes, including mercury and hydrogen thyratrons, ignitrons. Spark tube control for d-c pulses and microwave switching. Gaseous light sources.

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. Engineering application of electronic apparatus with emphasis on 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. 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.

6·661, 6·662. Principles of Electric Machine Development (A). Various types of electric machines and apparatus and calculation of their characteristics. Eddy-current loss in rectangular wire windings in transformers and generators. Theory of measurement of core loss with poor wave form. Allowable overloads for transformers. Heat resistivity, free convection and radiation. Slot harmonics in induction motors and choice of slot numbers. Reactance and temperature rise of bus-bars. Inductance, magnetic field strength and mechanical force of round coils in air. Flux-plotting. Usual methods of calculation including the potential method. Graphical flux-plotting. Unbalanced magnetic pull in rotating machines. Eddy currents in round wires, tubular conductors and induction furnaces and solutions by means of Bessel functions.

6·68. 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 in-

Electrical Engineering Continued

dividual requirements by the student and staff members interested, subject to approval of the professor in charge.

6·681 Special Problems in Fire Control (RA). (Restricted to selected U. S. Naval Officers only.)

6·691. Advanced Acoustics (A). Designed to give theoretical and practical foundation for acoustical research. Theoretical portions include 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 include psychological phenomena in acoustics with demonstrations; design of acoustical materials and broadcast studios. Selected problems.

6·692T. Advanced Acoustics (A). Designed for students interested in 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.

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 phase components, transformers, synchronous machines. Ricker and Tucker, *Electrical Engineering Laboratory Experiments, Fourth Edition; Instructions for Students in Electrical Engineering Laboratories, Twelfth Edition*, 1947.

6·781. Electrical Machinery Laboratory. Polyphase circuits, symmetrical phase components, transformers, synchronous machines, induction motors, and power rectifiers. *Textbooks same as for* 6·78.

6·79. Electrical Machinery Laboratory. Induction machines, power rectifiers, special purpose alternating-current machinery, characteristics of power transmission lines. *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.

6·83. 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, Twelfth Edition*, 1947.

6·86. Electrical Machinery Laboratory. For Electrical Engineering students who desire work in addition to that included in any of the subjects 6·77, 6·78, 6·781, or 6·79, and for any 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, 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 System Communications Practice. Work done by cooperative students in the manufacture of communication equipment at Kearny, N. J., and in its installation and maintenance in a Bell Telephone operating company, including at least one term's work devoted to research and development of communication and electronic apparatus at the Bell Telephone Laboratories.

6·951—6·954. General Radio Industrial Practice. Work done in the plants of the General Radio Company, Cambridge, in research, engineering, manufacture and testing of high-grade measuring instruments especially adapted to the fields of communications and electronics.

6·961—6·964. Philco Corporation Industrial Practice. Work done by cooperative students in testing, manufacture, engineering and research in the plants of the Philco Corporation in Philadelphia, Pa., which operates an experimental television broadcasting station and specializes in the manufacture of communication and electronic devices.

6·971—6·974. American Gas and Electric Service Corporation 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.

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.

7·11. EMBRYOLOGY. Classroom and laboratory work on the development of animals from the germ cells to the organ systems.

7·12. GENERAL CYTOLOGY (A). Fundamental cytology of mitosis, meiosis, spermatogenesis, and genetic mechanics, together with the morphology of secretory, excretory, contractile, absorptive, and conducting cells; activities of cells and cell structures in physical chemical terms. Application of methods of modern cytology in the laboratory with emphasis on study of living material.

7·14. COMPARATIVE ANATOMY. Comparative gross anatomy of vertebrates. 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 co-ordinated with the topics of 7·19.

7·212. GENERAL PHYSIOLOGY LABORATORY II. Laboratory co-ordinated with the topics of 7·20.

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.

7·81T. ENZYMOLOGY (A). Quantitative study of enzymes emphasizing their general properties, the kinetics of reactions catalyzed by them, and the conditions which control their activity.

7·811. ENZYMOLOGY LABORATORY. 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). Course of lectures and laboratory exercises selected to emphasize the current trends in biochemical investigation. Lectures and laboratory planned to illustrate the special problems, techniques and approaches of biochemical research; to train the student in the planning and solution of biochemical problems and the presentation of the results.

7·831. BIOCHEMISTRY OF MICRO-ORGANISMS. 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 emphasizing the various general techniques of microbiology as well as the quantitative aspects of the metabolic activities of micro-organisms.

7·832. BIOCHEMISTRY OF MICRO-ORGANISMS (A). Emphasis on quantitative aspects of the metabolic activities of micro-organisms. Investigation of problems in the general biochemistry of yeasts, molds, and bacteria, by analytical and research methods now in use in various laboratories. Isolation and identification of various metabolic products, metabolic balance sheets, and respiration studies.

7·85. BIOPHYSICS I (A). Optical methods useful in biochemical and biological research. Techniques used in 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.

7·87. SPECTROSCOPY OF BIOLOGICAL MATERIALS (A). Spectroscopic methods applied to biological and biochemical problems. Visible and ultraviolet absorption spectrophotometry, photochemical techniques, infrared, Raman, fluorescence, and emission spectroscopy. Special emphasis given to microspectroscopy and low-temperature spectroscopy.

7·871. SPECTROSCOPY OF BIOLOGICAL MATERIALS LABORATORY (A). Laboratory work co-ordinated with the topics of 7·87.

7·882. BIOPHYSICS LABORATORY (A). Laboratory co-ordinated with the topics of 7·86.

7·91, 7·92. INSTRUMENTATION IN BIOLOGY I and II (A). Principles of electrical instrumentation in the biological sciences including research and industrial biology and certain aspects of medical science. 7·91: principles of electrical measurements and the construction and operation of electrical instruments 7·92: principles of electronics and electronic devices, including amplifiers, oscillographs, photoelectric cells, X-ray tubes, and dosimeters.

7·93. SELECTED TOPICS IN BIOLOGY (A). Class work in various fields of biology not covered by the regular subjects of instruction.

7·941, 7·942. RESEARCH PROBLEMS (A). Directed research in a field of biological science, but not contributory to graduate thesis.

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. 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. Not offered 1949–50.)

7·98. TISSUE ULTRASTRUCTURE. Continuation of 7·97. Study of chromosomes, plasma membrane, mitotic mechanisms and cytoplasmic constituents (mitochondria, plastids, particulates). (Alternate years. Not offered 1949–50.)

7·99. BIOLOGICAL EFFECTS OF RADIATION (A). Effects of electromagnetic radiation and high-energy particles on living systems and their constituents. Preliminary consideration of theory, experimental methods, present status of empirical data, and major problems requiring solution with emphasis on group discussions of current research.

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.

8·01. Physics (Mechanics). Fundamental laws of point and rigid body mechanics. Free use of elementary calculus.

8·02. Physics (Mechanics and Heat). Lectures, laboratory and recitations. Divided into two parts: (*a*) Mechanics of continuous media preceded by a study of gravitational field of force and orbital motion. (*b*) The first and second laws of thermodynamics and elementary kinetic theory of gases.

8·03. Physics (Electricity). Introduction to the fundamental laws of electricity and magnetism and their applications. Electrostatics, steady currents and magnetic fields, and time-varying electric and magnetic fields. Quantitative work throughout, with free use of calculus, both in the theory and applications.

8·04. Physics (Electricity, Optics, and Modern Physics). Continuation of 8·03, approximately one-third of the subject bringing to a conclusion the study of electricity. Discussion of electromagnetic waves leads to optics; devoted to both geometrical and physical optics. Quantitative character of 8·03 continued and free use of calculus.

8·05. Atomic Physics. The atomistic 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 emission, Schottky effect, high field emission, secondary emission and photoelectric effect.

8·09. Experimental Physics I. Introduction to experimental physics with emphasis on laboratory manipulation. Glass blowing, microsoldering, vacuum technique, evaporation of metals and assembly of optical systems. Application of the techniques to physical measurements. Selected experiments on heat, electricity, light, X-rays, gas kinetics and properties of matter.

8·10. Experimental Physics II. Continuation of 8·09 with application of the laboratory techniques to the study of selected topics in modern physics such as electronic and electrical measurements, modern electronic devices, absorption and emission spectra, inelastic impacts of the first and second kind, resonance radiation, fluorescence, critical potentials, gamma ray absorption, and artificial radioactivity.

8·101. Experimental Physics. Selected experiments chosen from 8·10.

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. First part: a study of the dynamics of vibrating bodies; coupled oscillators, strings, membranes and plates. Second part: a study of the transmission and radiation of sound. Properties of loudspeakers and microphones treated, and the characteristics of speech and hearing discussed.

8·131. 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 supersonics and in physiological acoustics.

8·132. Architectural Acoustics. Study of the acoustical design of rooms and buildings. Experiments will accompany many of the principal topics; measurement of sound, reverberation, absorption coefficients, room resonance, vibration isolation, sound transmission, and insulation.

8·135. 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

Physics Continued

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; not offered 1949-50.)

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 (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. 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.

8·362. Statistical Theory of Matter (A). Thermal properties of atoms, molecules, and solids, treated by statistical mechanics, intended as continuation of 8·361. Review of thermodynamics, elements of statistical mechanics. The Maxwell-Boltzmann distribution law, illustrated by blackbody radiation and statistics of perfect gases. Chemical equilibrium in gases. Phase equilibrium of gases, liquids, and solids. The equation of state, specific heat, and thermodynamic properties of solids. The liquid state and fusion, with relation to plasticity of solids. Phase equilibrium in binary systems. Phase changes of the second order. The Fermi-Dirac statistics, applied to free electron and energy-band theories of metals, semiconductors, and insulators. Thermal dependence of magnetism and superconductivity.

8·39. Macroscopic Properties of Matter I (A). Static and dynamic properties of matter in bulk. Elastic, dielectric, magnetic properties of solids and liquids. Interactions as they occur in piezoelectricity and magnetostriction, thermal and caloric effects, specific heats. (Alternate years.)

8·40. Macroscopic Properties of Matter II (A). Optical properties of matter and their relation to the elastic, electric, and magnetic properties. Crystal optics, electro- and magneto-optical effects, photoelasticity, diffraction by supersonic waves, light scattering, dichroism, metallic reflection. (Alternate years; not offered 1949-50.)

8·411T. Statistical Thermodynamics (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. Boltzmann, Fermi-Dirac and Bose-Einstein statistics. Fluctuations. Polyatomic gases.

8·412T. Quantum Theory of Solids (A). The adiabatic method. Lattice vibrations and specific heat. Electronic structure of solids. Metals, insulators, semiconductors. Kinetics. Electrical and heat conductivity. Para-, dia-, and ferromagnetic properties of matter. Relaxation effects. Phase transitions in solids. Outline of a theory of liquids.

8·42T. 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.

8·43T. 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.

8·45T. 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.

8·52T. Nuclear Physics III (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. Selected Topics in Nuclear Physics I (A). Proton-proton scattering; neutron-proton scattering; interaction of electrons and electromagnetic radiation with nuclei; stationary properties of nuclei, spins, and moments; transitions in radioactive nuclei; properties of light nuclei; determination of energy levels in light nuclei; high energy disintegra-

Physics Continued

tion processes; interaction of neutrons with matter; properties of mesons. Discussion of each topic by a man active in the appropriate field. Largely experimental approach with experimental apparatus available for discussion in almost every case.

8·542. Selected Topics in Nuclear Physics II (A). Continuation of 8·541.

8·55T. 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.

8·56T. 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. Introduction to Nuclear Engineering (A). Principles of nuclear physics underlying chain-reacting systems. Time behavior, critical size, resonance absorption and temperature effects in nuclear reactors. Design, construction and operation of nuclear power plants. Processing of fissionable material and fission products. Shielding and biological aspects of nuclear radiations.

8·60T. 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). 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). 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.

8·79. Methods of Theoretical Physics (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, electromagnetic theory, quantum mechanics, etc.

8·80. Advanced Mechanics (A). Transformation theory of dynamics, perturbation theory, theory of orbits. Applications to light and electron optics. (Alternate years.)

8·82. Relativity (A). Review of Hamiltonian dynamics and Newtonian relativity, of classical electromagnetic theory and charged-particle dynamics. Crucial experiments of relativity: special relativity: relativistic dynamics with application to particle accelerators. Selected topics in relativistic quantum theory and general relativity.

8·84. Electromagnetic Wave Theory (A). Radiation theory, electromagnetic boundary-value problems, propagation in dispersive media with application to the ionosphere. Application of Fourier and Laplace transform theory to field equations. (Not offered 1949–50.)

8·85. Microwave Electronics (A). Wave guides and resonant cavities, handled by orthogonal function theory. Motion of electrons in high frequency fields, with application to microwave oscillators and to particle accelerators. (Not offered 1949–50.)

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.

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

10·17. 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*.

Chemical Engineering Continued

10·25. Industrial Chemistry (A). Industrial stoichiometry and the technology of more important chemical industries, with emphasis on applied physical chemistry. Discussion of the interrelationships of the important industries and problem work on the various processes. For graduate students primarily interested in industrial chemistry and particularly for new students from other schools who have had insufficient training in industrial stoichiometry.

10·26. Industrial Chemical Laboratory. A laboratory and design study of the evolution of a chemical process through the successive stages which culminate in the design of the necessary plant, and exemplifying the integration of chemistry and engineering. Effective presentation of conclusions is developed through oral and written reports.

10·27. Chemical Engineering Laboratory. A program of laboratory experiments and reports dealing with fluid flow, heat transfer and other unit operations such as evaporation, absorption, distillation, drying, filtration and combustion.

10·28. Chemical Engineering. Thermal properties of matter and the energy relationships underlying mechanical and chemical processes, including discussion of the first law of thermodynamics as applied to both batch and flow processes, and such operations as combustion, compression and handling of fluids and thermal control of chemical reactions. Development of second law and its elementary applications. 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. Engineering Equipment. For students selecting the Chemical Engineering Practice Option, X-B. Instruction and practice in testing engineering equipment such as pumps, fans, turbo-blowers, blowing engines, motors, generators, etc., commonly used in chemical engineering operations. Emphasis on determining the operating characteristics of such equipment under plant conditions.

10·31, 10·32. Chemical Engineering. Basic principles underlying the unit operations of chemical industry; material and energy balances, rate laws, and equilibrium considerations. Application of primary unit operations in 10.31 to problems in heat transmission, evaporation, condensation, and filtration. Application of laws of mass transfer in 10.32 to distillation, absorption, extraction, air conditioning, and drying. Walker, Lewis, McAdams and Gilliland, *Principles of Chemical Engineering;* McAdams, *Heat Transmission,* Second Edition.

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.*

Engineering Operations

10·40. Chemical Engineering Thermodynamics (A). Properties of homogeneous and heterogeneous systems, physical and chemical equilibria and energy effects, and mechanical manipulation and control of industrial processes. Emphasis on behavior of complex mixtures, correlation of data, and methods of approximation. Weber, *Thermodynamics for Chemical Engineers.*

10·41. Distillation (A). Basic principles of distillation, as applied to binary and multi-component mixtures. Problems involve the vapor-liquid equilibria of ideal and non-ideal solutions, batch and continuous simple distillations, steam distillations, vacuum and pressure distillation, and rectification. Special attention is given to the distillation of systems of limited miscibility, azeotropic distillation, extractive distillation, and adsorption distillation. Robinson and Gilliland, *Elements of Fractional Distillation.*

10·45. Distillation and Absorption (A). Distillation, including rectification of binary and complex mixtures. Diffusional processes, with attention to design computations for gas absorption equipment. A combination and condensation of subjects 10·41 and 10·46, using same texts.

10·46. Absorption and Extraction (A). Basic principles of equilibria, mechanism and rate of interaction. Quantitative applications including the absorption of single gases, such as sulfur dioxide, ammonia and hydrochloric acid, and complex mixtures, such as light oil, casing-head gasoline, refinery gases, and the like. Attention to graphical methods. Basic principles of extraction by liquids, solvent recovery by absorption and the leaching of various solids. Sherwood, *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. Emphasizes the economic balance concept applied to unit operations and processes.

Applied Chemistry

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 research. Attention focused 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.*

Chemical Engineering Continued

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.

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 Engineering Practice Schools, page 144)

10·81. School of Chemical Engineering Practice — Bangor Station (A). Conducted in the plants of the Eastern Corporation at South Brewer, Maine, manufacturers of writing papers and sulphite pulp, and of the Penobscot Chemical Fibre Company at Oldtown, Maine, manufacturers of soda and sulphite pulp. Operations include production of chlorine and caustic by electrolysis, of sulfite liquor by absorption, the recovery of soda by leaching, evaporation, smelting and electrical precipitation and many applications of drying.

10·82. School of Chemical Engineering Practice — Parlin Station (A). Conducted in the Cellulose Products plant of Hercules Powder Company in Parlin, New Jersey. The central operations of nitric acid production and nitration of cellulose involve many problems of distillation, catalysis at high pressure, corrosion and disposal of fume and waste.

10·83. School of Chemical Engineering Practice — Buffalo Station (A). Conducted in the Lackawanna Plant of the Bethlehem Steel Company. Blast furnace, open hearth and steel finishing operations, together with by-product coke production, involve a wide variety of work in such fields as combustion, heat transfer, flow of fluids, absorption and distillation.

10·84. School of Chemical Engineering Practice — Bangor Station. Similar to 10·81. Given during the second period of the academic year.

10·85. School of Chemical Engineering Practice — Parlin Station. Similar to 10·82. Given during the second period of the academic year.

10·86. School of Chemical Engineering Practice — Buffalo Station. Similar to 10·83. Given during the second period of the academic year.

General

10·90. Experimental Research Problem (A). Designed to meet the needs of special and graduate students who wish to carry out some minor investigation in a particular field. Subject and hours arranged to fit individual requirements.

10·911, 10·912. Research Conferences (A). Regular conferences are held with research students by the Staff of the Laboratories of Chemical Engineering in which the work is conducted.

10·991, 10·992. Seminar in Chemical Engineering (A). For graduate students engaged on doctorate theses.

GEOLOGY

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.

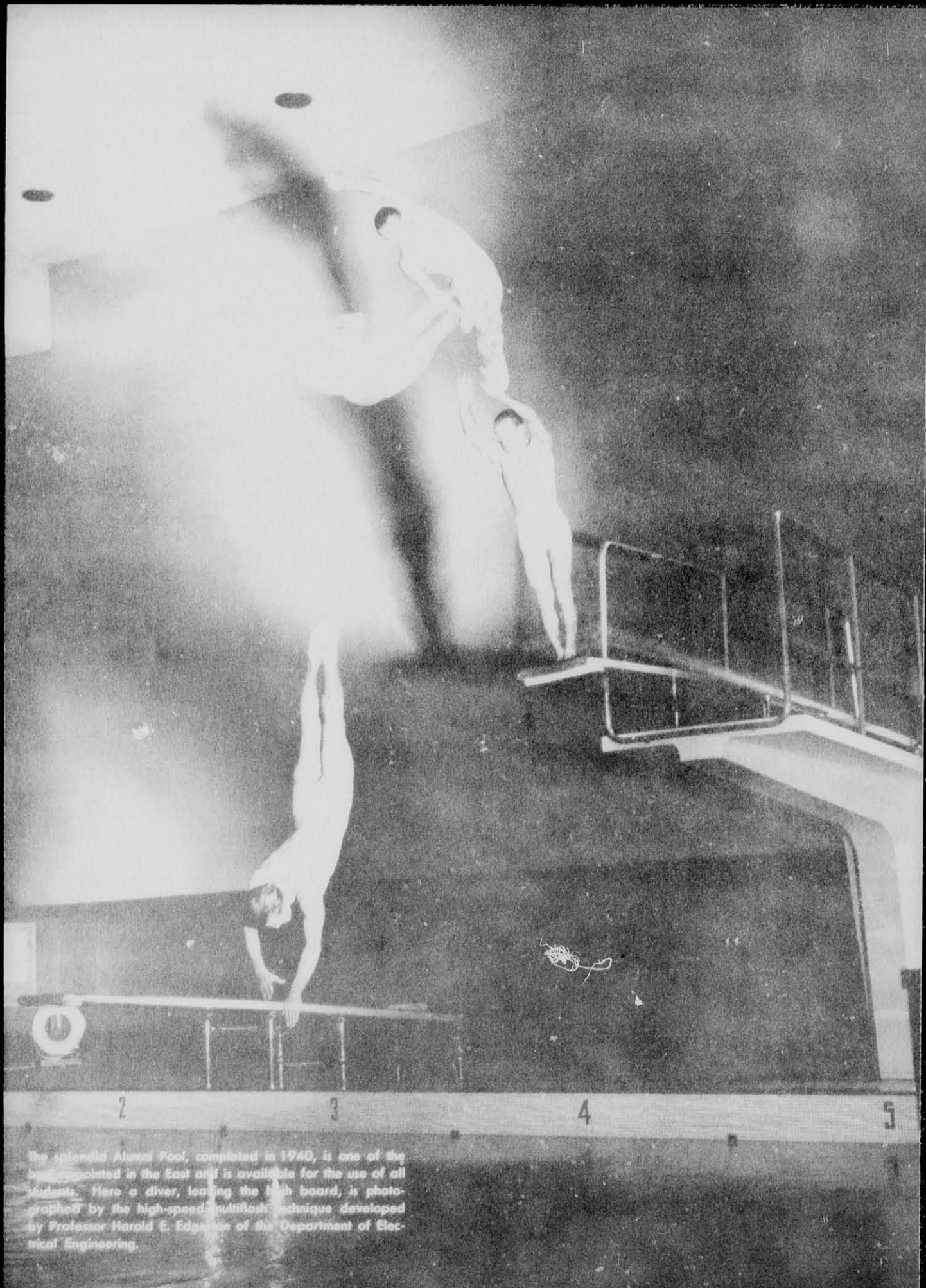
12·06. Mineralogical Research (A). Supervised research on some mineralogical or crystallographic problem, with the intention that each investigation will result in a publication.

12·15. Petrography. Laboratory work on rock-thin sections, using the polarizing microscope. Lectures on the occurrence and genesis of rocks and rock minerals. Confined to igneous and metamorphic rocks. Harker, *Petrology for Students;* Tyrrell, *Principles of Petrology;* Rogers and Kerr, *Optical Mineralogy;* Wahlstrom, *Igneous Minerals and Rocks.*

12·16. Petrology Seminar (A). Discussion of the geological relations of igneous and metamorphic rocks from the standpoint of mineral and chemical composition.

12·17. Petrology Laboratory (A). Techniques of petrological research, spectrochemistry excepted. Arranged to suit the requirements of individual students, and may include mechanical fractionation and staining methods; quantitative mineralogic analysis of rocks; mineral identification using X-ray powder diffraction, Universal stage, and thermographic methods; fabric analysis of rocks by X-ray and Universal stage methods.

In spring, the broad reaches of the Charles River basin are churned by the oars of Technology's crews. Rowing is the favorite sport of the Institute, and Varsities and Junior Varsities are always top contenders in the Eastern Sprints. Crews participate in the Poughkeepsie Regatta, Dad's Day, Tech



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.

Geology Continued

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. Kemp, *Handbook of Rocks*, revised by Grout.

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.

12·321. 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.

12·35. Glacial Geology. Consideration of the origin and motion of glaciers leads to the study of the land forms resulting from glacial action. Consideration of causes and history of ice-ages as part of the geologic history of the earth. Opportunity for local field studies. Thwaites, *Outline of Glacial Geology;* and Flint, *Glacial Geology and the Pleistocene Epoch.*

12·37. Geomorphology. Constructional land forms are first examined and classified. Then cycles of erosion are considered as caused by diverse agencies of erosion — streams, ice, wind, waves, etc., thus developing the concept of destructional land forms, and leading to shore lines and the final intergradation of destructional with constructional land forms. Use of references rather than texts, with study of abundant maps and airplane pictures. Voluntary field excursions.

12·38. Advanced Geomorphology (A). Critical study of the several theories of geomorphology, illustrated by special problems, varying from year to year with the interests of the students. Opportunities for research and for field studies. Use of references rather than texts.

12·39. Regional Geomorphology of the Earth. Comprehensive treatment of all lands in terms of the processes that shaped them; including the continents, the continental and oceanic islands and the geomorphology of the sea-floors. Emphasis upon cause and process and upon comparison between homologous regions. Use of references rather than texts.

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).

12·42. Applied Economic Geology. Application of geology to prospecting for new ore bodies, geophysical prospecting, alluvial prospecting, diamond drill core interpretation, mine sampling, and ore estimation. Discussion of methods of underground geological mapping.

12·432. Advanced Mineral Deposits Laboratory (A). Study of specimens or suites of specimens from mineral deposits; metallographic or petrographic work.

12·433, 12·434. Mineral Deposits Seminar (A). Seminar including reading and reports based upon the literature of ore deposits.

12·44. Mineral Fuels. Geology of natural gas, petroleum and coal with emphasis on structural features and genesis.

12·45. Laboratory Methods. Survey of methods of analysis used in the study of consolidated and unconsolidated rock materials. Statistical analysis, differential thermal analysis, separation and identification of light and heavy accessory minerals, insoluble residues, and examinations using binocular and petrographic microscopes.

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.

12·511. Paleontology. Study of the past plant and vertebrate life of the earth through comparison of fossils with living plants and animals. Shimer, *Introduction to the Study of Fossils.*

12·512. Paleontology. Study of the past invertebrate life of the earth through comparison of fossils with living forms. Twenhofel and Shrock, *Invertebrate Paleontology.*

12·52. Advanced Paleontology (A). Laboratory work and assigned reading on fossil invertebrates, or on some aspect of stratigraphic paleontology.

12·53. Index Fossils (A). Determination of the geologic age of rock formations in North America through a study of their fossils. Shimer and Shrock, *Index Fossils of North America.*

12·581. Sedimentology. Survey of the chief types of sediments and sedimentary rocks, with some consideration of the environmental conditions under which sediments are formed and deposited. Twenhofel, *Principles of Sedimentation.*

12·582. Advanced Sedimentology (A). Study of the important primary and secondary physical and chemical characteristics of sedimentary rocks, supplemented by microscopic examination in the laboratory, and by occasional field trips. Pettijohn, *Sedimentary Rocks.*

Geology Continued

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.

12·71. Advanced Structural Geology (A). Nature, significance, and causes of structural features produced by earth deformation.

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.

12·83. Geophysics Laboratory. Study of geophysical instruments and analysis of data.

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. Advanced Geophysics (A). Selected topics in the physics of the earth: seismology, geomagnetism, geothermal problems, figure of the earth and gravitational problems.

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. Baxter and Parks, *Mine Examination and Valuation*.

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. Statics of Ship Design. Principle of flotation; method of delineating hull form; methods of making form calculations; curves of form; load line, tonnage, and capacity of merchant ships; statical stability of ships, afloat and partially waterborne; buoyancy and stability of ships in damaged condition, floodable length, factor of subdivision; trochoidal water waves; principles of strength computations.

13·02. Dynamics of Ship Design. Resistance of ships; ship propelling apparatus, screw propeller; propulsion of ships; powering of ships; rudders and steering of ships; oscillations of ships as rigid bodies; launching of ships.

13·021. Ship Propulsion and Maneuvering. Resistance of ships; ship propelling apparatus, screw propellers; propulsion of ships; powering of ships; rudders and maneuvering of ships; oscillations of ships as rigid bodies.

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 U. S. Naval Officers.)

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*.

13·04. 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.

13·12. 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, with emphasis on the problems peculiar to aircraft carriers, submarines, and foundations of various types. Hovgaard, *Structural Design of Warships; Technical papers and reports*. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

Naval Architecture and Marine Engineering Continued

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. 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 inter-relationships of such characteristics and the Naval policies of the several powers, particularly the United States. Emphasis is on warship developments of World War II and possible developments of the future. (Primarily for Course XIII-A.)

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, a bulkhead and a shell expansion. (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 strength deck, 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. Manning, *Basic Design of Ships.* (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·34. Ship Construction. Structural arrangements of ships; general arrangements of ships of various classes; hull systems, including fire, drainage, sanitary, oil and ventilation systems; hull fittings and equipment, including anchor handling, steering gear, cargo and boat handling equipment.

13·40. Elementary Ship Construction. Introductory subject on types of ships, structual and general arrangements of ships, their propelling machinery, flotation and stability. Drawing room work on fairing the lines, calculating the displacement and designing the midship section of a small vessel. Manning, *Manual of Ship Construction.*

13·401. Elementary Ship Construction. Same as 13·40 omitting drawing.

13·42. Ship Hull Design. Displacement calculation; curves of form; calculations for stability and floodable length. Rossell and Chapman, *Principles of Naval Architecture.*

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.*

13·46. 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.*

13·47, 13·47T. 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 not offered 1949–50.)

13·52. Marine Engineering. Steam and Diesel machinery; fuels, combustion, boilers, reciprocating engines, turbines, condensers, feed heaters, feed water systems and steam power plant layouts. Diesel and oil engines; types of engines, fuel injection and combustion, valve gears, supercharging, oil engine fuels, Diesel electric drive and motor ship auxiliaries. Chapman, *The Marine Power Plant.*

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, 13·62. Marine Engineering Design. Calculations and preliminary design of main propelling units for a steamship; determination of sizes of auxiliaries; machinery layout; diagrammatic arrangements of principal piping systems; application of modern heat transfer formulas; propeller design, and other marine engineering problems.

13·71. 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 and outside reading. (Students to attend selected lectures in 13·75.)

13·711. Ship Machinery Design I (A). Design studies, including calculations, of components of ship propulsion plant.

13·72. Ship Propulsion II (A). Preparation, presentation, and discussion of papers on current topics associated with ship propulsion plant design. (Seminar in unrestricted topics to be taken with 13·76.)

13·721. 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; nonlinear systems; self-sustained oscillation.

Naval Architecture and Marine Engineering Continued

13·75. Warship Propulsion I (RA). Design of important components of warship propulsion plants, with emphasis on current trends and selection of units to meet requirements of various types of warships. Lectures and outside reading. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·751. Warship Machinery Design I (RA). Design studies, including calculations, of components of warship propulsion plant. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·76. Warship Propulsion II (RA). Preparation, presentation, and discussion of papers on current topics associated with warship propulsion plant design. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·761. Warship Machinery Design II (RA). Selection and arrangement of machinery in warship designed by the student in Course XIII-A. (Restricted to selected officers of the U. S. Navy and Coast Guard.)

13·78. Propeller Theory and Experimental Research (A). Discussion of modern ideas of propeller action based on air-foil theory; cavitation; interactions of hull and propellers; various available methods of design.

13·79. Propeller Design (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.

13·81, 13·82. Ship Operation. Engineering and economic aspects of ship operation; various items making up the operating disbursements and incomes; calculations for operating expenses and profits on various trade routes, comparison of different types of 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 and passenger vessels from the owner's point of view; tonnage measurements, fuel conservation, repairs and maintenance; study of present and future trade routes, cargo movements, and factors influencing ocean freight rates. Coastwise, inland water transportation and interrelation of land and marine transportation. Problems in cargo and passenger ship operation.

13·83. Ports and Port Facilities. Functions, layouts and facilities of ports and passage of cargo through ports; piers, quays, roadstead ports; transit sheds; shipside cranes, warehouses, lighters; movement of cargo to and from hinterland, port belt line railroad, road vehicles and roadways, inland water craft, feeder line vessels; study and comparison of world ports and their cargoes, facilities and hinterlands; port administration, port planning and port charges; port competition; marine passenger terminals; coordination of inland transportation with ocean shipping. 13·85 must be taken simultaneously.

13·84. Cargo Handling and Stowage. Methods of cargo transfer between ship and shore; handling of bulk and liquid cargoes; cargo handling equipment; cargo transfer through deck hatches, the longshoremen's gang, cycle of operation, types of slings; movement of cargo between shipside and transit shed, transit shed vehicles; design of the ship from the point of view of cargo handling, hatches, booms, winches and rigging; cargo transfer through side ports; conveyors and elevators; costs and speeds of cargo transfer; essential requirements in the stowage of cargo, palletized cargo, cargo stowage plans; refrigerated cargoes, cargo ventilation; factors making for rapid turn-around and reduction of cargo handling costs; longshore labor problems. Presentation and discussion of a paper by each student on an assigned port. Trips to the waterfront to observe cargo handling and to visit various types of cargo ships.

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 basis of world trade; means of financing international transactions; tariffs and other restrictions to foreign trade. (Restricted to Course XIII-C.)

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.

BUSINESS AND ENGINEERING ADMINISTRATION

Subjects 15·00 to 15·99

15·11. Introduction to Business Management. Functions and methods of business. Corporate organization, finance, accounting, production, marketing, with emphasis on interrelations between these functions. Considers business problems in the order they would be encountered in a new business: survey for a new venture; promotion, organization; personnel; operation; control; expansion or liquidation. (Not open to Course XV; may be taken as elective in other Courses.)

15·18. 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. Specially arranged for graduate students only.

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.

Business and Engineering Administration Continued

15·411. FINANCE. Similar to 15·41. Specially arranged for graduate students only.

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. Use of accounting as a practical tool of management. Brief grounding in double-entry bookkeeping. Basic accounting systems and records. Problems of costs and standards. Problems of valuation, amortization, and surplus. Analysis of the accounting concepts of expense and revenue. Preparation of financial reports. Familiarization with the current accounting problems and methods of actual companies.

15·501. ACCOUNTING. Similar to 15·50. Specially arranged for graduate students only.

15·51. INDUSTRIAL ACCOUNTING. Application of accounting control to industry. Principles of cost analysis as applied to problems of manufacturing, distribution, and administration. Teaching material from a wide variety of business situations.

15·55. PROBLEMS IN ACCOUNTING POLICY (A). Consideration of case problems involving accounting policy approached from administrative viewpoint. Application of analytical methods to financial data. Nature and determination of income, asset valuation, presentation of net worth, consolidated statements.

15·58. PROBLEMS IN ACCOUNTING CONTROL (A). Scope of accounting function with emphasis upon duties and responsibilities of controller. Records systems and extent to which various actual systems meet desired requirements. Periodic reports, budgets, costs, cash control, internal control, intercompany and branch control, and other special problems, including relation of controller to stockholders and to public bodies.

15·61. BUSINESS LAW. Legal aspects of business relationships between managers and employees, customers, vendors, stockholders and financial interests, governmental agencies and the public; rules applicable to the formation, performance and discharge of contracts; constitutional powers and limitations of Federal and State authorities; and trends in administrative law.

15·611. BUSINESS LAW. Similar to 15·61. Specially arranged for graduate students only.

15·64. PATENT LAW. Legal aspects of patents, copyrights, and trade-marks. Detailed discussion on what constitutes patentable invention; methods by which a patent may be obtained; its protection after issuance against infringement; rights obtained under copyright laws of the United States; and trade-mark laws of both the United States and the several states; 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. Specially arranged for graduate students only.

15·71. PRODUCTION MANAGEMENT. Application of principles of scientific management to production control; materials control; quality control; estimating; standardization and simplification; design and administration of wage systems; new product control; industrial conversion and management engineering techniques.

15·72. 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.

15·73. MANAGEMENT LABORATORY. Work Simplification and Time Study. Technique of motion study in simplification and standardization of manual work. Process charts, micro-motion and principles of motion economy, proper workplace layout, labor-saving tools and equipment, assembly jigs, etc. Motion picture films of industrial operations; labor relations involved in introduction of work simplification; problems of employee training; and bearing of motion economy upon morale. Use of stop watch for rate setting includes such topics as selected times, leveling factors, fatigue study, 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 of manufacturing analysis, supplemented by laboratory applications of such procedures in several cooperating companies. Production analysis includes processing, workplace examination, quantity and quality of output, productive and storage facilities. Financial analysis emphasizes balance sheet, income statements and ratio analysis as well as use of standard ratio frequency curves. Marketing analysis evaluates such factors as sales organization, sales planning and control methods, price policy, credit management, salesmen selection, training and compensation. Economic analysis considers methods of establishing comparisons between the operation of the industrial enterprise and related economic, industrial and trade trends as well as procedures for obtaining information from governmental, banking, and specialized sources.

15·76. MASS PRODUCTION METHODS. Principles and advantages of direct-line method of manufacture. Production engineering and preliminary work necessary to set up fabrication and assembly lines. Planning and control systems used to establish and maintain production flow. Modifications of line-production to meet demands of flexibility, product variety, standardization, and technical manufacturing problems. Problems from actual plants, plant visits, reading and reports.

15·81T. 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.

15·811T. MARKETING. Similar to 15·81. Specially arranged for graduate students only.

Business and Engineering Administration Continued

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 organization for efficient operation of the activity. Treatment of management of the sales force including selection, training, supervision and control of salesmen with brief consideration of principles of salesmanship. Administrative control of sales operations through marketing research and planning, and role of price policy as it affects promotional problems. Several discussion sessions with marketing executives.

15·83. Marketing Research: Field Surveys. 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.

15·84. Marketing Research: Sales Analysis and Potentials. Sources of information and techniques used in analyzing sales activities and in measuring market potentials. Characteristics and usefulness of variety of sources of market data. Emphasis on market for manufactured products including both industrial and consumer goods. Class projects involving analysis of sales records, of product use reports and of buying power indices and other measures of market opportunities. Stress on use of existing data.

15·86. New Product Appraisal and Development (A). Sources of ideas for new or improved products and methods for screening such ideas in light of potential market demand, costs, prices, and suitability to company's production and marketing facilities; organizational relationships and methods used to insure 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. Much of case material from direct contact with business executives actively engaged in product development and evaluation.

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.

15·92. Industrial Problems. Survey and analysis of methods through which management directs, coordinates, and controls business. Includes field interviews with industrial executives, conferences, classroom presentations and discussions to give insight into current industrial practices and to reflect interdependence of marketing, finance, accounting, production, law, and labor, and interrelation of the business as a whole with the public.

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 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

16·01, 16·02. Introduction to Aeronautical Mechanics. Dynamics applied to the various phases of aeronautical engineering. Presentation of dynamics of particles, fluids and solid bodies as branches of one comprehensive subject. Fixed and moving reference systems; impulse and momentum, work and energy; center of gravity theorems; kinetic theory of gases; fluids as continuous media; fundamental equations of fluid motion; Bernoulli's equation for compressible and incompressible fluids; jet propulsion; stream function and velocity potential; adaptation of streams to given boundaries; boundary layers and streamlining; lift on rotating cylinders; conformal transformation; lift and moment on airfoils in two-dimensional flows; start of circulation; airfoils in three dimensions; Fourier Series; viscosity; dimensional analysis; kinematics and kinetics of rigid bodies in three dimensions; gyro instruments; oscillations of linear systems with one degree of freedom; forced

Aeronautical Engineering Continued

motions — resonance; oscillations of systems with several degrees of freedom; determinants and their use in the treatment of homogeneous simultaneous equations.

16·03. Aerodynamics — Non Viscous Fluids (A). Extended treatment of two-dimensional airfoils, including v. Mises, Karman-Trefftz, and more general types. Modification 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.

16·07. Aerodynamics — Kinetics of Gases (A). Pressure phenomena and equations of state in ideal and non-ideal gases; Maxwell's molecular velocity distribution; molecular free paths in gases; calorimetry and molecular structure; the transport phenomena of viscosity, heat conduction and diffusion; superaerodynamics; description of the upper atmosphere.

16·10. Applied Aerodynamics. Application of aerodynamic theory to airplane design and aircraft propellers. Warner, *Airplane Design, Vol. I;* Weick, *Aircraft Propeller Design.*

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. Outer forces, reactions, shears and bending moments, influence lines, slopes and deflections of beams by elastic weights and moment areas, the three-moment equation and method of moment distribution, design of simple beams, and analysis of trusses by algebraic and graphical methods. Niles and Newell, *Airplane Structures.*

16·21. 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.*

16·22. 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 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. Aircraft Instruments. Lectures and laboratory exercises dealing with the operating principles and flight performance of instruments used in aircraft, including power plant, flight and navigation instruments. An elective for students not specializing in instruments, and a background for the more advanced problems treated in other instrument subjects.

16·31. Principles of Instrumentation and Control (A). Discussion of static and dynamic behaviour of the operating components used in measuring instruments and automatic control systems. A generalized system of concepts is developed for describing and specifying the functional performance of operating systems. The theory of systems describable by first- and second-order differential equations is treated in detail and used as the basis for analysis of more complicated systems. Emphasis is placed on the use of non-dimensional variables in the solution of dynamical problems by various procedures for solving differential equations, including both classical and operational methods. Transient response and frequency response characteristics represented by logarithmic plots and polar diagrams are used to represent the behaviour of both simple and complex systems. Practical examples drawn from the field of measuring instruments and control systems are used to illustrate applications of the general theory. Students electing this course may take 16·33 simultaneously.

16·32. Instruments and Automatic Control Systems for Aircraft (A). Dynamic analysis under flight conditions of various instruments and control systems used in aircraft. Typical instruments studied are accelerometers, magnetic compasses, gyroscopic instruments and various pressure actuated instruments. These are considered separately and as they occur in combinations utilized for control systems.

Aeronautical Engineering Continued

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. This course is considered as basic preparation for the advanced instrumentation courses, 16·34, 16·36, and 16·48.

16·34. Aircraft Flight Test Instrumentation and Control Systems (A). Lectures and laboratory exercises dealing with the principles and techniques used in making flight test measurements. Systems used for the automatic control of flight, power plant and other aircraft functions are studied. Consideration is given to the design requirements for meeting specified dynamic performance on components of measuring and control systems, including equipment for the remote indication and telemetering of information.

16·35. Special Problems in Aircraft Instrumentation (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. Instruments and Control System Design Practice (A). Discussion and design of typical instrument components to given specifications with emphasis on specialized techniques used in instrument construction. Methods of treating non-linear elements and of compensation are considered. Various practical effects such as bearing friction are studied from the viewpoint of their effects in limiting the performance of operative components. General methods of analysis and design are illustrated by the synthesis of complete automatic control systems.

16·38. Instruments and Control System Design Practice (A). Continuation of 16·37 in which the student carries out the design and produces a working model of a complete instrument or control system.

16·39. 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.

16·40. 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. The treatment is developed from the standpoint of the engineer, using both the methods of vector analysis and those of conventional co-ordinate components. The results of the generalized theory are applied to the analysis of gyroscopic devices used in airborne and marine craft.

16·41. Introduction to Fire Control Instruments (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 antiaircraft fire control. (Restricted to selected U. S. Army and Naval Officers only.)

16·42. Advanced Fire Control Instruments (RA). Continuation of the study of antiaircraft fire control in instruments started in 16·41, with particular emphasis upon the approximations made in the design of existing equipment. Detailed discussion of the generalized engineering theory of gyroscopic instruments. Application of this theory to the analysis of various types of gyroscopic equipment including stable verticals, gyroscopic compasses, gyroscopic lead computers and angular rate measuring instruments. The theory of other components used in fire control computers is developed as necessary. Consideration of the dynamic characteristics of fire control equipment including solution time and smoothing action. Study of the design factors controlling dynamic performance with reference to possible methods for realizing satisfactory performance in actual systems. (Restricted to selected U. S. Army and Naval Officers only.)

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 U. S. Army and Naval Officers only.)

16·44. Advanced Fire Control Instruments (RA). Continuation of 16·41 with particular emphasis on the fire control problems associated with equipment to be carried in aircraft for operation either against ground targets or other aircraft. General subject matter similar to that of 16·42, except that the theory developed is applied to airborne equipment. Consideration of special problems introduced by bombing, rocketfire and other modern developments. (Restricted to selected U. S. Army and Naval Officers only.)

16·45. Advanced Fire Control Instruments (RA). Continuation of 16·42 or 16·44. Extension of the theoretical work to cover the general design, details, and performance limitations of various types of fire control equipment to solve the problems introduced by current advances in armament. Comparison of the systems of various types, from the standpoint of ultimate possible performance. (Restricted to selected U. S. Army and Naval Officers only.)

16·46. Advanced Fire Control Instrument Laboratory (RA). Continuation of 16·43. Designed to demonstrate the principles of airborne fire control equipment developed in the lectures of 16·44 and taken concurrently with it. Experiments carried out on service fire control equipment and special demonstration units to study the static and dynamic performance characteristic of typical airborne computers. Particular attention given to the problems of solution time, smoothing and tracking. (Restricted to selected U. S. Army and Naval Officers only.)

16·50. Rotating Wing Aircraft. Discussion and problems of the rudiments of design of rotating wing aircraft.

16·501. Rotating Wing Aircraft (A). Discussion of problems of performance evaluation, control and stability, vibration and design, as applied to rotating wing aircraft.

16·52. Aircraft Propeller Design (A). Study in class and drafting room of aircraft propeller design including aerodynamics, strength and vibration problems.

16·53. Principles of Aircraft Power Plants. Analysis and comparison of reciprocating engines, propeller turbines, and jet engines with particular attention devoted to present limitations on efficiency and output.

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.

Aeronautical Engineering Continued

16·56. Jet Propulsion Engines (A). Review of the general principles of jet propulsion devices followed by a consideration of compressors, combustion chambers and turbines, which leads to evaluation of a jet power plant.

16·57. Rockets (A). Principles of operation of rockets. Combustion and thermodynamical equilibrium. Solid rocket propellants. Fundamentals of solid propellant rocket and its design. Liquid rocket propellants. Liquid propellant rocket and its design. Rocket trajectory, principles of its calculation. Long-range rockets, multi-step rockets.

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. Recommended for all graduate students in aeronautical engineering.

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. Class discussions emphasizing solution of special problems in the wind tunnel and flight.

16·70. Aircraft Drafting. Aircraft drafting room practice. Preparation of airplane assembly, sub-assembly, and detail part drawings.

16·71. Detail Design of Aircraft. Lectures and drafting room exercises covering airplane graphics, airframe detail design, power plant installation, landing gear and control system mechanisms, hydraulic systems, lofting, and preparation of weight estimates and balance diagram for a complete airplane.

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.

16·78. Human Factors in Aircraft Design (A). Quantitative data on human limitations affecting aircraft design; use of this information in evaluating engineering design requirements; discussion of importance relative to other design considerations.

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.

16·91. Aero-Elasticity and Structural Dynamics (A). Dynamics of elastic structures; air forces under unsteady conditions; flutter.

16·92. Advanced Aero-Elasticity (A). Advanced aspects of aero-elasticity: corrections for finite span and compressibility in flutter calculations; study of wing divergence and aileron reversal.

16·93. Aero-Elasticity and Structural Dynamics Laboratory (A). Experimental study of problems in strucural dynamics and aero-elasticity.

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

17·22. Building Construction. Construction of Third Class Buildings, with particular reference to the residence. Assembly of various materials commonly used in such construction discussed together with proper relationship and sequence ordinarily used in the field. Consideration of the use of new materials. Class discussions and problem analysis in drafting room. Dietz, *Dwelling House Construction.*

17·31. Building Construction. Second Class Buildings, including combinations of wood and masonry, or exposed steel, wood and masonry, in semi-fireproof or heavy timber construction. Foundation problems, exterior walls, interior frames and floor systems, and an integration of all factors into the finished building, studied same as in 17·22. Staley, *Semi-Fireproof Construction.*

17·32. Building Construction. Construction of First Class buildings, special reference to those with reinforced concrete and structural steel frames. Heavy foundations, shoring, relation of frame to exterior walls, floor arches, interior partitions, mechanical equipment, electrical services and architectural balance studied same as in previous courses in Building Construction. Voss, *Fireproof Construction.*

17·33. Building Construction. Continuation of Third Class buildings, and application of Second Class construction to light construction. Building and zoning codes and their restrictions upon Housing studied and more rational approaches to flexible public controls for low-cost construction discussed and analyzed. Modern systems, materials, and services for home construction coordinated with economic effects. Costs as affected by labor policies and field procedures analyzed. Twentieth Century Fund, *American Housing.*

17·34. Building Construction. Application of principles of mass production to Housing. Various proposals for low-cost housing analyzed and possibilities for development of mass production procedures using structural and wall and floor panels explored. Development of plans on a modular basis with maximum of interchangeability and demountability. Effects of materials on details and methods. Twentieth Century Fund, *American Housing.*

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.*

Building Engineering and Construction Continued

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.*

17·45. 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.

17·52. Structural Problems. First part: establishment of a connection by graphical and analytical methods between the study of applied mechanics and structural theory. 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 wood floor- and roof-framing, wood trusses using timber connectors, columns, trussed girders, and other details common to heavy timber construction. Design of wood rigid frames using laminated construction, design of built-up plywood girders, design of concrete forms. Hansen, *Modern Timber Design; Departmental Notes.*

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.*

17·531. 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.*

17·542. 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.

17·56. Structural Design. Structural design of simplified frames in steel and reinforced concrete. Design of slabs, beams, columns and footings, etc. Abbreviation of work given in 17·53 and 17·54. Peabody, *Design of Reinforced Concrete Structures;* Grover, *Manual of Design for Arc Welding Steel Structures by Air Reduction;* A.I.S.C., *Steel Construction Manual; Departmental Notes.*

17·71. Materials. Mechanical and physical properties of wood in relation to growth, major and minor-structure and other characteristics which influence its use in the construction and engineering fields. Volume changes, moisture content, preservative treatment, wood products, identification, and selection of species for various uses. Fundamental properties and uses of plastics, and basic characteristics of paints and fabrics used in construction. *Wood Handbook;* Dietz, *Construction Materials;* A.S.T.M., *Selected Standards for Students in Engineering; Departmental Notes.*

17·72T. Materials. Geological origin, sources, and composition of masonry materials together with their conversion into usable building forms. Fundamental properties of clays and clay products, cements and lime, concrete 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.*

17·722. Materials. Laboratory testing of masonry materials. For those students in architecture who have completed 17·72 and have not taken the laboratory work for 17·72T. A.S.T.M., *Selected Standards for Students in Engineering; Departmental Notes.*

17·73. Materials. Alloy diagrams and their interpretation. Consideration of the more important non-ferrous alloys and a more detailed discussion of ferrous metals, their properties and heat treatment. Chemistry of corrosion and welding theory and practice. Williams and Homerberg, *Principles of Metallography;* A.S.T.M., *Selected Standards for Students in Engineering; Departmental Notes.*

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.*

17·75T. Materials. Portions of 17·71, 17·72T, 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 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 17·72T. 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.*

Building Engineering and Construction Continued

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.

METEOROLOGY

Subjects 19·00 to 19·99

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 Instrumbnts (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.

19·30. General Climatology. Distribution of radiation, temperature, pressure and wind, hydrometeors and air masses and fronts at the surface of the earth and aloft and of the physical factors determining this distribution. Climatic zones and types. Microclimatology. Effect of climate on human life. Climatic changes. Hauritz and Austin, *Climatology.*

19·31. Regional Climatology. 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.*

19·43. Synoptic Meteorology I. Principles of weather map analysis: the meteorological elements and their conservatism, classification of air masses, North American air mass properties, formation and characteristics of fronts, frontal disturbances, basis of upper air analysis, tropical hurricanes. Required reference reading.

19·44. Synoptic Meteorology II. 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 III (A). Analysis of the field of motion with reference to divergence, convergence and vertical motion; fronts and frontogenesis; cyclone waves and structure of moving cyclones; survey of quantitative methods for the construction of surface and upper air prognostic charts. Petterssen, *Weather Analysis and Forecasting.*

19·50. Introductory Meteorology Laboratory. Explanation of international weather symbols and airways teletype code; decoding and plotting of daily weather reports; identification of cloud types; elementary principles of weather map analysis.

19·51. Synoptic Laboratory I. Analysis of weather maps. Application of practical rules for extrapolating the movement and development of pressure systems. Practice forecasting for selected stations.

19·52. Synoptic Laboratory II. Analysis of weather maps and practice weather forecasting for selected stations, together with practice in special airways forecasting, utilizing the teletype line sequences.

19·53. Synoptic Laboratory III (A). Continuation of 19·52. Advanced methods of analysis and forecasting with special emphasis on the use of aerological diagrams, cross sections, upper air charts, etc.

19·60. 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.

19·61. 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.*

Meteorology Continued

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. Detailed study of energy transformations in the atmosphere.

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, 19·92. Meteorological Seminar I, II (A). Weekly reviews and discussions by staff members and students, of recent meteorological contributions published in current periodicals, and of original research.

19·911, 19·912. Meteorological Seminar I, II (A). Same as 19·91.

19·95. Special Problems in Meteorology (A). Reading, consultation and original investigation on meteorological problems.

FOOD TECHNOLOGY

Subjects 20·00 to 20·99

20·01, 20·02. Technology and Chemistry of Food Supplies. Chemical composition, production, consumption, statistics, and methods of treatment of food materials. General commercial methods of production and handling of raw foods, such as milk, eggs, meats, cereals and other vegetable food supplies, and their preparation for commercial distribution or for later manufacturing processes. Fundamental principles involved in physical processes such as refrigeration, dehydration, and salting, and the microbiology and chemistry of the processes. Laboratory work including numerous exercises involving the chemical analysis of various foods and food products. Prescott and Proctor, *Food Technology;* Woodman, *Food Analysis.*

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). Anatomy and physiology of taste and odor. Relationships between chemistry, physics and psychology and taste and odor. Natural and synthetic chemicals associated with taste and odor. Classification of and theories concerning taste and odor. Organoleptic technics. Natural and synthetic flavors, their preparation, composition and use in food products. Abnormal flavors. Foreign tastes and odors in foods. Lecture demonstrations.

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.

20·34. Applied Nutrition (A). Nutrient requirements of man and animals; laboratory and clinical methods for determining requirements and nutritional status; techniques for measuring adequacy of dietaries; genetic and environmental factors influencing nutrient content of foods; food habits; population feeding programs; school lunches; communal feeding, etc.; international nutrition problems.

20·36. Advanced Nutrition (A). Digestion of food and metabolism of nutrients, including: occurrence of nutrients in plant and animal products; stability of essential nutrients during plant growth, harvesting, storage, manufacture, and preparation for serving; influence of diet on intestinal synthesis of vitamins; synergistic action of nutrients; absorbability of nutrients from alimentary tract; endocrines and nutrition; dynamics of body constituents; isotopic and radioactive techniques; measurement of food proteins; amino acid analysis; methods of research with animals.

20·38. Nutritional Evaluation of Food Processes (A). Consideration of losses or gains in nutritional values of foods and food products during transit, treatment and storage. Discussion of the effects of the following operations: harvesting, transportation, refrigeration, freezing, concentrating, dehydration, bleaching, refining, blanching, canning, pickling, salting, brewing, fermenting, baking, steaming, boiling, frying, roasting, and toasting. Procedures for minimizing these losses in vitamins, minerals, amino acids and other nutrients are suggested.

20·41. Bacteriology. Biology, physiology, biochemistry and biophysics of bacteria. Pure culture studies, identification of unknown bacteria, effects of physical and chemical agents on bacteria, food intoxication and infection, anaerobiosis,

Food Technology Continued

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. Clayton, *Colloid Aspects of Food Chemistry and Food Technology.*

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–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:* Constructions and properties of plane curves, composition and resolution of vectors, graphical integration, simple empirical curves. *Space Graphics:* Drawing in orthographic projection, pictorial views, sectional views, dimensioning, conventional representation, freehand sketches and working drawings of machine parts. Rule and Watts, *Notes on Graphics; A. S. A. Drafting Room Practice.*

D12. Descriptive Geometry. Fundamental concepts of descriptive geometry, including reference systems, representation of point, line and plane; fundamental problems of position, of perpendicularity and of measurement. Solutions of 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 method of solving equations in three or more variables and its application to scientific and engineering data. Functional scales, network charts, simple nomographic relationships derived from plane geometry. Douglass and Adams, *Elements of Nomography.*

ECONOMICS AND SOCIAL SCIENCE

Subjects Ec1 to Ec99

Ec11. 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.

Ec111, Ec112. 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.

Ec12. Economic Principles II. Continuation of Ec11 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.

Ec13. 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.

Ec15. 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 co-operation, etc.

Ec16. 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 only.)

Ec17, Ec18. Economic Analysis (A). Interdependent growth of theory and fact, general theory of equilibrium under competition and monopoly. Findings revalued under conditions which more closely approach reality.

Ec19. Mathematical Approach to Economics (A). Use of mathematical methods in all fields of economics.

Ec21. 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.

Ec22. 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.

Ec23. National Income. Economic problems involved in maintaining national income and employment.

Ec24. Schools of Economic Thought (A). Economic ideas developed by different groups of economists in recent times.

Ec26. Business Cycles (A). Statistical, historical, and theoretical examination of determinants of income, production and employment. Modern methods of analysis, forecasting, and control.

Ec27. Economics of Patents and Invention. Discussion of the process of research, invention and technical innovation and the operation of the patent system, also comparison with patent systems of other countries. Emphasis on the role of inventions in different types of industries. Cases used for illustrative purposes. (Not offered 1949–50.)

Ec28. Economics of Patents and Invention. Designed for students who hope to be inventors or technical innovators, or to participate in the launching of a scientific enterprise. Inventors and directors of research invited to lead some of the class discussions. (Not offered 1949–50.)

Ec35. Elementary Statistics. Elementary probability, prediction, and inference, applied to economic, industrial, and scientific investigation. Averages and variations of measurable and classifiable observations: correlation; random and representative sampling.

Ec352. Elementary Statistics. Abridged form of Ec35, with emphasis on applications in the social sciences.

Ec36. Industrial Quality Control. Methods and feasibility of controlling variation in manufactured parts and product. Efficient sample inspection of incoming and in-process material. Quality standards and tolerances, their significance and interrelationship.

Ec37, Ec38. Theoretical Statistics (A). Comprehensive course in statistical theory. The principal topics are: (1) nature of a chance variable, (2) exact probability distributions, (3) limit theorems in the theory of probability, (4) theory of statistical estimation, (5) theory of testing statistical hypotheses, (6) introduction to multivariate analysis.

Ec39. Economic Statistics (A). Special topics in economic statistics, varying from year to year and including correlation analysis and time series.

Ec49. Public Finance. Examination of expenditures and revenue systems of federal and local governments in the United States, and a study of effects of various fiscal policies and methods upon social and economic development.

Ec50. Money and Banking. Survey of the financial organization of society: the money-banking system, credit institutions, capital markets, fiscal policy, international financial relations.

Ec52. Comparative Political and Economic Systems. Analysis of the governmental systems of the United States, Great Britain, U.S.S.R., and other leading nations — a comparative study of capitalism, socialism and communism — economic and political problems arising out of the changing relation of government to private enterprise.

Ec54. Corporations. For students whose professional interest may be in scientific or engineering fields, but who desire some knowledge of corporate organization and finance and social and political problems of business. (Not open to Course XV students.)

Ec56. Problems in Industrial Economics (A). Small and large enterprises in the American economy; market structures; degrees of monopoly and competition; requisites of public policy.

Ec571, Ec572. International Problems. Graduate course dealing with the major problems of current international relations. Particular emphasis laid upon situations involving the Great Powers, the United Nations organization, international control of atomic energy and international economic affairs. (Open to graduate students only.)

Ec57, Ec58. International Relations. Basic factors in world politics, foundations of national power; influence of geography; relative power positions of the Great Powers; formation and execution of foreign policy; conduct of international affairs; plans for settlement of the war and establishment of a new world organization; and relationship of technology and international affairs.

Ec591, Ec592. 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.

Economics and Social Science Continued

Ec595. Technology and International Relations. Seminar on the more significant relationships between recent developments in technology and contemporary international relations — problems arising from changes in communications and transportation, in production and economic status, in military science and national power, and the control of atomic energy.

Ec60. 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.

Ec65. 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.

Ec66. Seminar in Industrial Relations (A). Constructive participation in developing "situational thinking" as a distinctive approach to industrial relations.

Ec67. Seminar in Labor Problems (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.

Ec68. Seminar in Labor Problems (A). Public policy on labor relations: 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.

Ec691, Ec692. Seminar in Personnel Administration (A). Objectives and methods of personnel administration.

Ec70. Introductory Psychology. Use of basic psychological concepts drawn from everyday life to give the student a practical understanding of the behavior of people in organizations. Examination of principles underlying leadership, management, organized group effort, cooperation, morale.

Ec701. Psychological Concepts. Consideration of theoretical and experimental bases for a systematic approach to the psychology of social human behavior. Emphasis on the relevance to everyday problems of human relations in industrial situations, education, group leadership, family living. Stress on primary group relationships as the critical unit in all types of social organization. (Open to graduate students only.)

Ec711. Human Relations Seminar (A). Consideration of theoretical and experimental bases for a systematic approach to the psychology of social human behavior. Stress on the primary group as the critical unit, and study of relationships within such groups.

Ec712. Human Relations Seminar (A). Analysis of the dynamics of human relationships. Derivation of a systematic frame of reference for these problems.

Ec721, Ec722. Social Psychology of Industry (A). Consideration of theoretical and experimental bases for a systematic approach to the social psychology of industry. Analysis of experimental approaches to productivity, morale, and organizational development in primary groups. Planning and performing of relatively simple experiments.

Ec723. Techniques of the Management of People. Laboratory subject designed to give the student a practical understanding of methods for getting changes in the behavior of people in face-to-face group contacts. (Primarily for students in Course XIV.)

Ec724. Theory of the Management of People. Systematic examination of the basic requirements for directing and coordinating the activities of people. Continuation of Ec70 into the specialized problems involved in getting work done by others. (Primarily for students in Course XIV.)

Ec725. Comparative Contemporary Cultures. Comparative study of contemporary cultures and sub-cultures. The influence of national, ethnic, and class membership on individual development and behavior. The role of culture in setting norms of behavior, standards of judgment, and patterns of social interaction. Case study of dynamics of selected social movements.

Ec73. Advanced Psychology. Analysis of factors in personal development and in the structure of the social and physical environment which determine the way in which we perceive, interpret, and react to events and persons. Study of the sources and types of bias or error in perceiving, judging, acting. Techniques of achieving objectivity in assuring that action is based on social and physical reality.

Ec731, Ec732, Ec733, Ec734. Methods in Human Relations (A). Laboratory courses in the methodology of human relations. Study of, and participation in the dynamics of primary groups. The role of the leader stressed, with emphasis placed upon problems such as those of the staff advisor, conference leader, line supervisor, teacher, etc. Each student expected to carry on actual work with some group. (Not offered 1949–50.)

Ec741, Ec742. Psychology of Industrial Management (A). Analysis of the major problems involved in directing the activities of people in industrial organizations. Development and application of techniques in policy areas such as wage administration, promotion and layoff, training, etc. (Not offered 1949–50.)

Ec751, Ec752, Ec753, Ec754. Research Seminar in Human Relations (A). Weekly seminar given by staff and graduate students to discuss current research and research problems in the area of human relations. (Ec752, Ec753, Ec754 not offered 1949–50.)

Ec761, Ec762. Reading Seminar in Human Relations (A). Reading and discussion of special topics in the field of human relations. Open to advanced graduate students by arrangement with individual members of the staff.

Ec77. 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 only.)

Ec82. Government Regulation of Industry (A). Follows Ec56. Development of anti-trust policy, generally and in specific cases. "Public utility" price fixing, government ownership as alternative.

Ec88. Building Economics. Social, political, industrial, and economic factors affecting the location, construction, financing, and marketing of buildings — with emphasis on low-cost housing.

Ec91, Ec92. Economics Seminar (A). Special social problems or economic problems of particular industries. (Open to graduate students only.)

Ec93, Ec94. Industrial Economics Seminar (A). Readings, discussions, reports on such topics as industrial price policies, government regulation of industry, competitive practices and other phases of industrial economics.

Ec95, Ec96. Social Science Seminar (A). Reading, discussion, and case work relating to non-economic aspects of human behavior and human relations in the perspective of modern social and industrial conditions.

Ec97, Ec98. 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.

ENGINEERING PRACTICE SCHOOLS

Subjects EPS1 to EPS99

EPS1–EPS3. 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.

ENGLISH AND HISTORY

Subjects E1 to E99

E1. Entrance English.

E11. English Composition. Principles of effective written and oral communication. Particular attention to logical organization of papers and talks and to precise and coherent expression of facts and opinions. Numerous papers and speeches required.

E12. English Composition. Continuation of E11.

E21, E22. History. Two options are provided, as follows:

A. The United States in World History. Historical development of the modern world, stressing the growth of the United States as a member of a general western civilization; evolution of governmental, social, and economic organization, intellectual trends, and influence of science and technology; experiences of the United States and other countries in dealing with related problems compared and contrasted. The first term covers the period from 1500 to 1870; the second term, 1870 to the present.

B. The Growth of Democratic Thought. Critical study of democratic thought and institutions and the forces which have shaped them, directed toward an understanding of contemporary American civilization and its problems. Emphasis upon America as part of the western world and upon ideas in relation to the other forces in history. Topical organization, with readings in political, social, and economic theory, religion and philosophy, and literature. The first term covers the period from 1500 to 1870; the second term, 1870 to the present.

E25. English Composition. Students who in the collective judgment of members of the Department of English and History have failed in E22 to meet certain standards of expression and therefore have received a Composition D required to take this subject. It may be prescribed at any time for juniors and seniors whose use of English in their professional courses is unsatisfactory. Instruction carried on in frequent group meetings and in individual conferences, at hours to be determined by the instructor. No credit given for this subject.

E35T. 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.

E401. History of Philosophy. How and why philosophical questions arose. Greek and Christian thought. The great philosophical systems.

E402. Problems of Modern Philosophy. Philosophical questions subjected to modern analysis to show which problems still subsist, which ones can and cannot be answered by science; the meaning of the latter today.

E41, E42. History of Ideas. Lectures, discussions, readings in works of outstanding thinkers, illustrating problems such as these: How do thoughts and actions influence each other? How do old ideas acquire new significance? How do patterns of thinking in one field — government, science, economics, philosophy, religion — shape ideas in another? How did genuinely new thoughts come into being? What are the most vital problems of thought today? First term: Antiquity to eighteenth century. Second term: From "Age of Reason" to the present day.

E411, E412. Problems in Philosophy. Discussion of the fundamental philosophical problems present in modern civilization. Problems examined systematically; reading concentrated on a few major philosophers.

E43, E44. Books and Men; Discussions in Literature. Material selected from significant whole books and plays in the range of time from classic Greece to contemporary America. Discussion of several meanings of the things read — emotional, social, and philosophic — and the relevance of these to our times.

E431, E432. Reading Seminar in Famous Books. Books chosen so far as possible to meet the interests and needs of the students, discussed in small groups. Purpose of course is to give some grasp of human relationships and our social, philosophic, and artistic traditions as reflected in great literature.

E45. Introduction to Music. Designed to make students more familiar with the language of music and its universal literature including contemporary music. Rudiments of harmony and ear-training, and an outline of the terminology and history of music. Detailed analysis of masterpieces by various composers through lectures, demonstrations, and outside listenings. Reading assignments required. For students with no or little knowledge of music.

English and History Continued

E46. Music Through the Ages. Survey of the history of music with emphasis on musical examples from the Middle Ages, the Renaissance, the Baroque, and the Classic Era. Detailed analysis of the master works of Bach, Mozart, Beethoven. The Romantic Age and contemporary music, as well as a short historical analysis of opera. Lectures, demonstrations, outside listening, and reading assignments.

E47, E48T. Books and Men; Discussions in Literature. Continuation of E43 and E44.

E51. Modern Industrial Society. Survey and synthesis of the problems of industrial society from 1750 to the present. Particular emphasis laid upon the nature of industrialism as the central factor in modern social experience. Contemporary problems selected for study in the light of their origins and development.

E511, E512. Economic and Industrial History. Historical study of the economic concepts and institutions which have governed the production and distribution of goods since the Middle Ages. Particular attention given to the evolutionary character of economic institutions and to the development of modern industrial organizations.

E61. History of Early Mathematics. Ancient mathematics of the Egyptians and Babylonians followed by a discussion of Greek mathematics with special emphasis on Euclid, Archimedes, Apollonius and Ptolemy. Greek and Oriental influences in Arabic science, which in turn influences early European mathematics. Development of algebra in the sixteenth century. Struik, *Concise History of Mathematics I.*

E62. History of Modern Mathematics. Introduction dealing with the incubation period of modern mathematics (from Descartes to Leibniz): study of the development of analysis and dynamics in the eighteenth century (Euler): discussion of the main trends in nineteenth century mathematics, connected with such figures as Gauss, Poncelet, Gaolis, Riemann, Klein and Poincaré. (Not offered 1949–50.)

E67. Debate and Discussion. Discussion of the fundamentals of argumentation and debate. Study of important economic and political questions. Practice and training for those interested in becoming intercollegiate debaters in the Debating Society. Oral presentation of conclusions. Open to all students interested in debating and public speaking.

HUMANITIES AND SOCIAL SCIENCES

DURING each regular academic year, in addition to required courses in mathematics, science, engineering and modern languages, undergraduate students are expected to carry one course in the general field of the humanities and social sciences. In the second half of the third year and in the fourth year a limited number of options are permitted. The list of options may be modified or extended from year to year.

FOR UNDERGRADUATES AND GRADUATES

HUMANITIES I

First Year

First Term	E11	English Composition	3–5
Second Term	E12	English Composition	3–5

HUMANITIES II

Second Year

First Term	E21	History	3–5
Second Term	E22	History	3–5

HUMANITIES III

Third Year

First Term	Ec11	Economic Principles I	3–5
Second Term	Ec12	Economic Principles II	3–5
(Choice of	Ec60	Labor Relations	3–5
one)	Ec70	Psychology, Introductory	3–5

HUMANITIES IV

Fourth Year

First Term	(1) Ec57	International Relations	3–5
(Choice of	(2) E41	History of Ideas	3–5
one)	(3) E43	Books and Men: Discussions in Literature	3–5
	(4) E45	Music, Introduction	3–5
Second Term	(1) Ec58	International Relations	3–5
(Choice of	(2) E42	History of Ideas	3–5
one)	(3) E44	Books and Men: Discussions in Literature	3–5
	(4) E46	Music Through the Ages	3–5

FOR GRADUATE STUDENTS ONLY
ELECTIVES IN HUMANITIES

The subjects listed below are offered for those graduate students who are required to extend their studies in Humanities and for those who desire to broaden their general education.

First Term	Ec111	Current Economic Problems	3–6
	Ec571	International Problems	3–6
	Ec701	Psychological Concepts	3–6
	E411	Problems in Philosophy	3–6
	E431	Reading Seminar in Famous Books	3–6
	E511	Economic and Industrial History	3–6
Second Term	Ec112	Current Economic Problems	3–6
	Ec572	International Problems	3–6
	Ec702	Psychological Concepts	3–6
	E412	Problems in Philosophy	3–6
	E432	Reading Seminar in Famous Books	3–6
	E512	Economic and Industrial History	3–6

Effective participation is a requirement for continuation in any of these seminars. Although no formal grades will be given, satisfactory work (recorded as "N") will be accepted for reduction of deficiencies in Socio-Humanistic subjects.

MODERN LANGUAGES

SUBJECTS L1 TO L99

ELEMENTARY and intermediate courses are offered in German, French, Spanish, and Russian. At the elementary level a careful foundation is laid for reading, writing, speaking, and hearing the foreign language. Great care is taken to secure a good pronunciation, a mastery of the working essentials of grammar, and a reasonable vocabulary for the expression of common ideas. At the intermediate level, there is continued work in the spoken language with training of the ear and the development of a broad reading vocabulary. The reading texts include scientific matter, fiction, drama, historical or descriptive works of a nature to open up to the student the genius, institutions and social organization of the country studied. Part of the work consists of assignments for written translation of articles from recent foreign journals selected by each student according to his individual interests and needs. Spanish is taught with the primary aim of developing ability to understand the spoken language and to speak correctly and intelligibly.

Special courses in scientific German, French, and Russian, open to graduate students only, are offered in addition to the above. As opposed to the cultural objective of the undergraduate courses, these have a narrowly limited purpose; namely, to prepare each student to read technical and scientific material in his own field.

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, and individual written translations from recent scientific works. Texts (subject to modification): Curts, *Basic German;* Kästner, *Die Verschwundene Miniatur;* Lenz, *Scientific German.*

L111. ELEMENTARY GERMAN. Special one-semester subject in reading Chemical Engineering German. Primarily intended for Course X. No previous preparation required. Text (subject to modification): Osborn, *German for Science Students.*

L13, L14. INTERMEDIATE GERMAN. Systematic review of grammar, miscellaneous prose and individual written translations from recent scientific works. Trains students to read understandingly any ordinary newspaper or magazine article of a literary or scientific nature. Texts (subject to modification): Richter, *German Readings in Science;* De Vries, *A Contemporary Scientific German Reader;* Wizinger, *German Science Readings.*

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.)

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; also individual written translations from recent scientific works. Hendrix and Meiden, *Beginning French;* Heath, Chicago, *French Readers I–V.*

L53, L54. INTERMEDIATE FRENCH. Continuation of pronunciation and practice in conversation, reading of matter dealing with France, some standard modern authors, reading of scientific French, individual written translations from recent scientific works.

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.)

L81, L82. ELEMENTARY SPANISH. Emphasis on spoken Spanish, pronunciation, intonation, vocabulary building, and essentials of grammar. Leslie, *Spanish for Conversation;* Castillo and Sparkman, *Graded Spanish Readers.*

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.*

L91, L92. ELEMENTARY RUSSIAN. Elementary grammar; practice in reading 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. Text (subject to modification): Znamensky, *Conversational Russian.*

L93, L94. INTERMEDIATE RUSSIAN. Continuation of pronunciation and practice in conversation, reading of matter dealing with Russia, some standard modern authors, reading of scientific Russian, individual written translations from recent scientific works.

L97. SCIENTIFIC RUSSIAN. Intensive preparation for graduate language requirement in Russian. No previous study of Russian required. Group meetings for discussion of ways to facilitate comprehension of grammatical and syntactical difficulties. Section meetings by Courses for reading material in the field of the student. (Open to graduate students only.)

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.

M11. CALCULUS. Fundamental ideas of calculus. Differentiation and graphical representation of algebraic, trigonometric, logarithmic and exponential functions. Integration of simple algebraic and transcendental functions. Maxima and minima applications to problems in geometry and mechanics, such as determination of velocity, acceleration, area, volume and pressure. Discussion of the analytic geometry of the straight line, and the conic sections.

Mathematics Continued

M112. Mathematics (College Transfer). For college transfer students who have taken calculus prior to their transfer but whose preparation is not sufficient to cover first year requirements. (Not offered 1949–50.)

M12. Calculus. Parametric representation of curves, polar coordinates. Methods of integration including approximate integration. Further applications of derivatives and integrals, including arc length, curvature, surface area, center of gravity and moment of inertia. Average values. Elementary vector analysis in the plane, vector velocity and acceleration.

M21. Calculus. Partial differentiation. Infinite series. Complex numbers. Surfaces and vectors in three-dimensional space. Dot and cross products of vectors and their applications. Multiple integration and geometrical and physical applications.

M22. Differential Equations. Treatment of ordinary differential equations including principal types of first- and second-order equations, simultaneous equations, and linear equations with constant coefficients. Illustrated by numerous applications to geometry, chemistry, physics, and mechanics. Phillips, *Differential Equations, Third Edition.*

M31. Differential Equations. Complex numbers, Fourier series, partial differentiation, systems of ordinary differential equations and some simple partial differential equations with applications to the long line and heat flow. Laplace transforms. Franklin, *Differential Equations for Electrical Engineers.*

M32. Elementary Statistics. General survey of 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. Mathematical Theory of Statistics. Thorough discussion of the mathematical theory and modern techniques of the design and analysis of complex experiments. Practical applications of Latin squares and their variations, factorial design, split plot experiments, compounding and partial compounding, etc. Hypothesis testing, multiple and partial correlation, orthogonal polynomials, applied matrix algebra Emphasis on the underlying logic of statistical methodology, and on efficient computational procedures. R. A. Fisher, *Statistical Methods for Research Workers*; R. A. Fisher, *Design of Experiments.*

M332. Mathematical Theory of Statistics. Rigorous development of mathematical statistics, including such topics as distribution functions, sampling theory, maximum likelihood statistics, confidence intervals, hypothesis testing, regression theory, and an introduction to multivariate statistical analysis. S. S. Wilks, *Mathematical Statistics.*

M341, M342. Modern Statistical Theory. First term: theory of probability and statistics from the point of view of real variables, discussion of the necessary real variable theory, generalized distribution functions, characteristic functions, statistical inference, sampling distributions, tests of significance, theory of estimation. Second term: topics varying from year to year. Discussion of papers taken from recent journals and the solutions of industrial and scientific problems. Opportunity for students to participate by preparing papers for discussion. H. Cramer, *Mathematical Methods of Statistics.* (M342 not offered 1949–50.)

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). Complex numbers, partial differentiation, analytic functions of a complex variable, contour integration, Gamma and Beta functions. Franklin, *Methods of Advanced Calculus.*

M37. Advanced Calculus (A). Vector analysis, line, surface and volume integrals, second-order linear differential equations, Legendre and Bessel functions, partial differential equations, Fourier series, calculus of variations. Franklin, *Methods of Advanced Calculus.*

M371, M372. Operations Research. Two-term course designed for the fourth year and graduate student who wishes to become familiar with the operational methods developed particularly in the armed services during World War II. Both terms commencing with the development of the philosophy and the mathematical methods necessary for the applications which will follow. 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, conjugate functions, integrals and products, entire functions, Bessel functions, Fourier transforms in complex domain. Knopp, *Function Theory.*

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. Poiseville flow. Stokes' flow. Boundary layer theory.

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. (Not offered 1949–50.)

M441. Projective Geometry. Homogeneous coordinates. Point, line, and plane coordinates. Ranges and pencils. Principle of duality. Curves and surfaces of second order and of second class. Linear transformations. Projective measurement. Non-Euclidean geometry. Pentaspherical and Plücker co-ordinates. F. S. Woods, *Higher Geometry.* (Not offered 1949–50.)

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. Graustein, *Differential Geometry.*

M451, M452. Fourier Series and Integrals (A). First term: Methods of complex variables in the theory of Fourier series. Second term: elementary theory of Fourier series and integrals as developed along modern lines. Stress on practical applications and development of the necessary analysis from the beginning.

M461. Seminar in Applied Mathematics (A). Mathematical discussion of linear and non-linear problems arising in the field of mechanics of a continuum. (Not offered 1949–50.)

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,

Mathematics Continued

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). Poincare-Alexander duality theorems, and other selected topics in algebraic Topology.

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.

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.*

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: Analysis in the large, topological methods in analysis. Content varying from one year to another, so that graduate students taking the course for successive years can have an introduction to several important chapters of the theory of functions.

M561, M562. Functions of a Complex Variable (A). First term: Geometric aspects of function theory, many-valued analytic functions, Riemann surfaces. 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. Poincaré-Liapounoff stability theory. Periodic orbits. Limit cycles. Perturbation methods.

M581, M582. Continuous Groups (A). Basic concepts of group-theory, such as group, sub-group, invariant sub-group, finite and infinitesimal transformations; one-parameter groups and their applications to differential equations and geometry; r-parameter groups, structure constants, the fundamental theorems of Lie; invariant theories associated with continuous groups; differential invariants and applications to systems of partial differential equations. (Not offered 1949–50.)

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. (M592 not offered 1949–50.)

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. (Not offered 1949–50.)

M62. Modern Algebra. Polynomials, determinants, linear equations, linear transformation, matrices, linear independence, introduction to groups. Birkhoff and MacLane, *A Survey of Modern Algebra.*

M63. Algebra (A). Groups, rings and fields including algebraic and transcendental field extensions. Ideal theory and its relation to algebraic number theory, including the factorization of ideals. Introduction to valuation theory.

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.

M64. Group Representations (A). Introduction to the theory and applications of representations of groups by linear transformations. Finite groups. Peter-Weyl theory of compact groups with emphasis on the explicit study of the representations of such groups as the group of rotations. Applications to Fourier analysis and quantum mechanics. Commutative groups and their characters, including the Pontrjagin duality theorem. (Not offered 1949–50.)

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 1949–50.)

M65. Operator Theory in Hilbert Space and Foundations of Quantum Mechanics (A). Operator theory in Hilbert space with discussions of the mathematics foundation of quantum mechanics. Spectral theory and decomposition of self-adjoint Hermitian operators — theory of symmetrical integral equations (Hilbert and Carleman). Material in von Neumann's *Mathematischen Grundlagen der Quantenmechanik.* Ergodic theory.

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 1949–50.)

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.

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 1949–50.)

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.*

M691, M692. Characteristic Value Problems (A). Linear algebra, orthogonal functions, linear integral equations; characteristic value problems of mathematical physics; applications of the calculus of variations; special functions defined by characteristic value problems. Courant-Hilbert, *Methoden der Mathematischen Physik*, Vol. I; or Margenau and Murphy, *The Mathematics of Physics and Chemistry.* (Not offered 1949–50.)

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.)

M731, M732. Mechanics. Statics; point kinematics with applications to linkwork and mechanism; polar diagrams of velocity and acceleration; kinematics and dynamics of rigid bodies in three dimensions; dynamics of mechanisms; impact, theory of the gyroscope, with applications; Lagrange's equations; Hamilton's principle; theory of vibrations, with applications to engineering problems. (Not offered 1949–50.)

Mathematics Continued

M76. Theory of Probability (A). Permutations and combinations. Elementary principles of theory of probabilities. Bernoulli's Theorem. Bayes' theorem. Distributive functions and continuous variables. Averages. Curve fitting. H. Levy and L. Roth, *Elements of Probability;* T. C. Fry, *Probability and Its Engineering Uses.*

M77. Vector Analysis. Treatment of vector functions and operations required in theoretical work on electricity. Phillips, *Vector Analysis.*

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. (Not offered 1949–50.)

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.

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, 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

Subjects MS11 to MS99

MS11, MS12. Military Science. (Required in all Courses.) Drill, military organization, military policy of the United States, evolution of warfare, maps and aerial photographs, military psychology and personnel management, first aid and hygiene, geographical foundations of national power, military problems of the United States, and military mobilization and demobilization.

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 Department. Drill; the role of ordnance; automotive materiel; small arms materiel; ammunition materiel; artillery materiel; fire control materiel.

MS215, MS225. Air Force. Drill; evolution of air power including principles of war, history of warfare, and development of the United States Air Force; introduction to aeronautics including aerodynamics and propulsion, weather, and navigation; application of air power (weapons and concepts); administration of air power including organization of the USAF, executive procedures, and logistics.

MS216, MS226. Chemical Corps. Drill; organization and function of the Chemical Corps; chemical agents; protection, individual; Chemical Corps materiel; 4.2 inch mortar gunnery; M-2 smoke generator operation.

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.

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. Military Science. Corps of Engineers, Advanced. Military leadership, psychology, and personnel management; leadership, drill, and exercise of command; military law and boards; organization of engineer units; bridge design and classification; military roads; engineer reconnaissance; organization of the ground and field fortifications.

MS313. Military Science. Signal Corps, Advanced. Military leadership, psychology, and personnel management; leadership, drill and exercise of command; military law and boards; signal communication for all arms and services; organization and missions of the Signal Corps; communication security; the place of the Signal Corps in the military team; signal corps photography.

MS314. Military Science. Ordnance Department, Advanced. Military leadership, psychology, and personnel management; leadership, drill and exercise of command; military law and boards; ammunition materiel; ammunition supply; automotive materiel; small arms materiel.

MS315. Military Science. Air Force, Advanced. Military leadership, psychology, and personnel management;

Military Science Continued

leadership, drill and exercise of command; military law and boards; history of the Air Force; organization of the Air Force; air force training; air force inspection systems.

MS316. Military Science. Chemical Corps, Advanced. Military leadership, psychology, and personnel management; leadership, drill and exercise of command; military law and boards; chemical agents; chemical warfare materiel; cloud behavior; maps and aerial photographs.

MS317. Military Science. Army Security Agency, Advanced. Military leadership, psychology and personnel management; leadership, drill and exercise of command; military law and boards; organization and operational methods of Army Security Agency; communication security and signal intelligence.

MS318. Military Science. Quartermaster Corps, Advanced. Military leadership, psychology and personnel management; leadership, drill and exercise of command; military law and boards; depot supply I; organization and functions of the Quartermaster Corps; organization for supply in the army; property accountability and responsibility; station supply I.

MS322. Military Science. Corps of Engineers, Advanced. Military problems of the United States; leadership, drill, and exercise of command; job management; the place of engineers in the military team, engineer combat principles; camouflage; explosives and demolitions.

MS323. Military Science. Signal Corps, Advanced. Military problems of the United States; leadership, drill and exercise of command; organization of the infantry division and its signal and communication components; message center and signal center procedure; field wire communication fundamentals; field radio communication fundamentals.

MS324. Military Science. Ordnance Department, Advanced. Military problems of the United States; leadership, drill and exercise of command; organization of the Ordnance Department; the place of ordnance in the military team; maintenance and supply procedures; artillery materiel; fire control materiel.

MS325. Military Science. Air Force, Advanced. Military problems of the United States; leadership, drill and exercise of command; air force statistical control methods; guided missiles; air intelligence and combat orders; air force supply; transportation; navigation; aeronautics; air operations; communications.

MS326. Military Science. Chemical Corps, Advanced. Military problems of the United States; leadership, drill and exercise of command; chemical warfare materiel; motor vehicles and motor maintenance; defense against chemical attack; signal communications; tactical employment of chemicals; organization and functions of Chemical Corps and chemical corps units.

MS327. Military Science. Army Security Agency, Advanced. Military problems of the United States; leadership, drill and exercise of command; communication security and signal intelligence.

MS328. Military Science. Quartermaster Corps, Advanced. Military problems of the United States; leadership, drill and exercise of command; depot supply I, organization and functions of the Quartermaster Corps; organization for supply in the army; property accountability and responsibility; station supply I.

MS412. Military Science. Corps of Engineers, Advanced. Military teaching methods; geographical foundation of national power; military mobilization and demobiliza tion; leadership, drill, and exercise of command; engineer combat principles; engineer estimates and orders; engineer signal communcations; water supply.

MS413. Military Science. Signal Corps, Advanced. Military teaching methods; geographical foundation of national power; military mobilization and demobilization; leadership, drill and exercise of command; wire communication; radio communication.

MS414. Military Science. Ordnance Department, Advanced. Military teaching methods; geographical foundation of national power; military mobilization and demobilization; leadership, drill and exercise of command; maintenance and supply procedure; ammunition materiel; ammunition supply; artillery materiel.

MS415. Military Science. Air Force, Advanced. Military teaching methods; geographical foundation of national power; military mobilization and demobilization; leadership, drill and exercise of command; tactics and technique of air force communications.

MS416. Military Science. Chemical Corps, Advanced. Military teaching methods; geographical foundation of national power; military mobilization and demobilization; leadership, drill and exercise of command; chemical agents; chemical warfare materiel; cloud behavior; chemical intelligence and preparation of reports; defense against chemical attack.

MS417. Military Science. Army Security Agency, Advanced. Military teaching methods; geographical foundation of national power; military mobilization and demobilization; leadership, drill and exercise of command; communication security; signal intelligence; radio intercept and military cryptography.

MS418. Military Science. Quartermaster Corps, Advanced. Military teaching methods; geographical foundation of national power; military mobilization and demobilization; leadership, drill and exercise of command; depot supply II; the military team; unit and organization supply; fiscal procedures and procurement methods; station supply II.

MS422. Military Science. Corps of Engineers, Advanced. Command and staff; psychological warfare; leadership, drill and exercise of command; airborne and amphibious operations; construction and utilities; engineer reconnaissance, river crossing operations.

MS423. Military Science. Signal Corps, Advanced. Command and staff; psychological warfare; leadership, drill and exercise of command; applied signal communication; signal supply and repair; higher echelon signal communication and equipment.

MS424. Military Science. Ordnance Department, Advanced. Command and staff; psychological warfare; leadership, drill and exercise of command; automotive materiel; small arms materiel; fire control materiel.

MS425. Military Science. Air Force, Advanced. Command and staff, psychological warfare; leadership, drill and exercise of command; tactics and technique of air force communications.

MS426. Military Science. Chemical Corps, Advanced. Command and staff; psychological warfare; leadership, drill and exercise of command; supply and field service; history of chemical corps units in World War II; tactical employment of chemicals; maps and aerial photographs; organization and duties of chemical corps staff section in the field; signal communication; the place of the Chemical Corps in combat and service functions of the military team.

MS427. Military Science. Army Security Agency, Advanced. Command and staff; psychological warfare; leadership, drill and exercise of command; radio intercept; military cryptography and the development of cryptographic devices and systems.

MS428. Military Science. Quartermaster Corps, Advanced. Command and staff; psychological warfare, leadership, drill and exercise of command; depot supply II; the military team; unit and organization supply; fiscal procedures and procurement methods.

SUBJECTS OF INSTRUCTION TABULATED

The information below is necessarily subject to change. The list of subjects actually to be given will be published with the Class Schedule prior to the beginning of each term.

The number at the left is the subject number.

The numbers following the names of subjects indicate the prerequisite subjects (those in italics may be taken simultaneously).

To the right of the prerequisites are noted the year and term and the Professional Courses in which the subjects are required.

(A) following the year indicates that the subject is primarily for Graduate students. (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 credit for a subject is the sum of the units allotted to Exercise (Recitation, Lecture, Laboratory, Drawing or Fieldwork), and Preparation. One unit of Recitation or Lecture credit is equivalent to one semester hour. Two units of Drawing or Laboratory credit are equivalent to one semester hour.

At the extreme right is given the name of the Instructor in charge of the subject.

CIVIL AND SANITARY ENGINEERING—1·00-1·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
1·00	Surveying	D12	2	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 or 1·055	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
1·055	Surveying	D12	2	S	——	4	10	0	Shea
1·06	Photogrammetry	1·03 or 1·05	4	2	Elective	2	2	4	Shea
1·07	Geodetic Surveying	1·03	4	S	Elective	4	20	0	Shea
1·071	Geodetic Surveying	1·055	—	S	——	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 or 1·055	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	1·21	4	1	Elective	3	—	3	Bone
1·301	Railway Transport., Adv.	1·272	G(A)	1	Elective	2	—	4	Babcock
1·302	Railway Transport., Adv.	1·301	G(A)	2	Elective	2	—	4	Babcock
1·311	High. Transport., Adv.	1·272 or 1·28	G(A)	1	Elective	2	—	4	Bone
1·312	High. Transport., Adv.	1·311	G(A)	2	Elective	2	—	4	Bone
1·32	Airport Design	——	G(A)	2	Elective	0	6	0	Bone
1·35	Soil Mech. & Found. Eng.	2·04	4	1	I_1	3	3	6	D. W. Taylor
1·351	Soil Mech. & Found. Eng.	2·04	4	1	$I_{2,3}$,$XVII_1$	2	2	4	D. W. Taylor
1·361	Soil Mechanics	2·04	G(A)	1	Elective	3	—	6	D. W. Taylor
1·362	Soil Mechanics	1·361	G(A)	2	Elective	3	—	6	D. W. Taylor
1·37	Soil Mech. Lab.	*1·35, 1·351* or *1·361*	G(A)	1	Elective	0	3	3	Lambe
1·38	Soil Eng. Spec. Studies	*1·361*	G(A)	1 or 2	Elective		★		D. W. Taylor
1·40	Structures	2·04	3	2	I	3	3	6	Fife
1·401	Structures	2·04	3	2	XVII	3	—	6	Fife
1·41	Structures	1·40 or 1·401	4	1	I, $XVII_1$	3	—	6	Mirabelli
1·42	Structures	1·41	4	2	$I_{1,3}$, $XVII_1$	3	—	6	Norris
1·43	Reinforced Concrete Design	*1·40*	3	2	I	0	6	0	Mirabelli
1·441	Structural Design	*1·41*	4	1	$I_{1,3}$	0	6	0	Mirabelli
1·442	Bridge Design	1·441	4	2	I_1	0	6	0	Mirabelli
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, 1·43	G(A)	1	Elective	2	4	0	Mirabelli
1·542	Reinf. Conc. Des., Adv.	1·541	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	Wilbur
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	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
1·61	Fluid Mechanics	2·01	3	1	I	3	—	6	Daily
1·62	Fluid Mechanics	1·61	3	2	I(1)	2	—	4	Daily
1·63	Fluid Mechanics	2·01	3	2	XV-A	2	—	4	Ippen, Daily
1·64	Fluid Mechanics	2·01	3	2	$VI\text{-}A(A)_1$	3	—	6	Ippen, Daily
			4	1	VI_1				
			4	2	$VI\text{-}A(B)_1$				
1·641	Fluid Mechanics	2·01	G	2	Elective	3	—	6	Daily
1·65	Applied Hydromechanics	1·62 or 1·641	G(A)	1	Elective	3	—	6	Daily
1·66	Free Surface Flow	1·62	G(A)	2	Elective	2	—	4	Ippen
1·67	Hydromechanics, Seminar	1·62	G(A)	2	Elective	1	—	2	Ippen, Daily
1·681	Exp. Hydromechanics	1·62	G(A)	1	Elective	2	—	4	Ippen
1·682	Exp. Hydromechanics	1·681	G(A)	2	Elective	0	9	0	Ippen, Daily
1·683	Exp. Hydromechanics	1·641, 1·65	G(A)	2	Elective	0	6	0	Ippen
1·69	Rivers & Harbors	1·66 or 1·681	G(A)	2	Elective	2	—	4	Ippen
1·70	Hydrology & Flood Control	1·62	4	1	Elective	3	3	6	Gifford
1·701	Hydrology & Flood Control	—	4	1	Elective	3	—	6	Gifford
1·71	Water Power Eng.	1·40, 1·43, 1·70	4	2	Elective	3	3	3	Gifford
1·711	Water Power Eng.	1·61 or 1·64; 1·70 or 1·701	4	2	Elective	3	—	3	Gifford
1·72	Hydrol. & Water Power Eng.	1·61 or 1·64; 2·04	4	1	I_2	3	—	3	Gifford
1·731	Water Power Eng., Adv.	1·42, 1·71, *1·741*	G(A)	1	Elective	3	—	6	Gifford
1·732	Water Power Eng., Adv.	1·731, *1·742*	G(A)	2	Elective	3	—	6	Gifford
1·741	Water Power Des., Adv.	*1·731*	G(A)	1	Elective	0	8	0	Gifford
1·742	Water Power Des., Adv.	*1·732*, 1·741	G(A)	2	Elective	0	8	0	Gifford
1·75	Water Supply & Purif.	1·61	4	1	Elective	3	3	6	Stanley,A.A.Thomas
1·76	Sewer. & Sew. Treatment	1·61	4	2	Elective	3	3	3	Stanley,A.A.Thomas
1·77	Water Sup. & Sewerage	1·61	4	2	I_2	3	—	3	Eliassen
1·771	Sanitation	—	3	1	IV-A, IV-B	2	—	4	Stanley,A.A.Thomas
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	Stanley
1·812	Sanitary Eng., Adv.	*1·76*	G(A)	2	Elective	3	—	6	Stanley
1·821	Sanitary Eng. Lab.	*1·75, 1·831*	G(A)	1	Elective	2	3	4	Sawyer,A.A.Thomas
1·822	Sanitary Eng. Lab.	*1·76, 1·831*	G(A)	2	Elective	2	3	4	Sawyer,A.A.Thomas
1·831	Sanitary Chemistry	5·02	G	1	Elective	2	4	4	Sawyer
1·832	Chem. & Indus. Waste Treat.	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	Sanitary Science, Prin.	*1·84*	G(A)	1	Elective	3	—	6	Horwood
1·871	Pub. Health Admin. Prac.	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
1·891	San. Eng. Seminar	*1·811* or *1·812*	G(A)	1	Elective	1	—	2	Stanley
1·892	San. Eng. Seminar	*1·811* or *1·812*	G(A)	2	Elective	1	—	2	Stanley
1·90	Conservation, Prin.	—	3	2	I(2)	3	—	6	Shea
1·91T	Eng. Construction	—	3	1	I	3	—	3	Babcock
1·92T	Constr. Equip. & Methods	1·91T	3	2	I(3)	2	—	4	Babcock
1·94	Professional Prob.	—	4	2	I	2	—	4	Wilbur

MECHANICAL ENGINEERING — 2·00–2·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2·00	Statics	8·02, M12	2	1	I, II, VI, XIII, XIV (a, b), XVI XVII, XIX	3	—	5	Den Hartog
2·01	Dynamics	2·00	2	2	I, II, VI, XIII, XIV (a, b) XVI, XVII, XIX	3	—	5	Den Hartog
2·011	Statics & Dynamics	8·02, M12	2	1	III, IV-A, XV-A, XVIII	3	—	5	Sloane
			2	2	X, XIII-C				

Mechanical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2·04	Strength of Materials	2·01 or 2·011	2	2	III, IV-A, XV-A	3	—	6	MacGregor
			3	S	II-B, VI-A(A), XVI-B				
			3	1	I, II, VI, VI-A(B), IX-B, X, XIII, XIII-C, XIV(a, b), XVI, XVII				
2·046	Strength of Mat. & Dynamics	——	G	S	XIII-A	4	2	8	MacGregor
2·06	Dynamics	2·04	3	1	II-B(B)	3	—	6	Adkins
			3	2	II, II-B(A)				
			4	2	XIV(a)				
2·062	Strength of Mat. & Dynamics	2·04	3	2	XIII	3	—	6	Adkins
2·07	Dynamics	2·04	3	2	VI (1, 4), VI-A(A)$_{1,4}$	3	—	6	Hrones
			4	S	VI-A(B)$_{1,4}$				
2·081	Strength of Materials	2·04	4	1	II, (II-B Not '49–'50)	3	—	6	Den Hartog
			G	1	XIII-A				
2·082	Mech. Eng. Problems	2·081, 2·252, 2·43	4	2	II, (II-B Not '49–'50)	3	—	6	Soderberg
2·10	Ordnance Engineering	2·04	4	1	Elective	3	—	6	Holmes
2·11	Industrial Plant Eng.	2·04	4	2	Elective	4	—	5	Holmes
2·121	Photoelasticity	2·04	4	1 or 2	Elective	1	2	3	Murray
2·125	Res. in Exp. Stress Anal.	2·121 or 2·126 or 2·128	G(A)	1 or 2	Elective		★		Murray
2·126	Exp. Stress Analysis	2·081	4	2	Elective	2	3	4	Murray
2·128	Exp. Stress Analysis	2·081	4	2	Elective	2	6	4	Murray
2·211	Mechanics, Adv.	2·081	G(A)	1	Elective	3	—	9	Den Hartog
2·212	Mechanics, Adv.	2·211	G(A)	2	Elective	3	—	9	Den Hartog
2·213	Gas Turbines	2·082	G(A)	1	Elective	3	—	9	Soderberg
2·214	Gas Turbines	2·213	G(A)	2	Elective	3	—	9	Soderberg
2·215	Relaxation Methods	2·06 or 2·07; M22	G(A)	1	Elective	3	—	6	Allen
2·221	Plasticity	2·081	G(A)	1	Elective	3	—	9	MacGregor
2·222	Plasticity Prob., Adv.	2·221	G(A)	2	Elective	3	—	9	MacGregor
2·223	Plasticity Research	2·221	G(A)	1 or 2	Elective		★		MacGregor
2·231	Elasticity, Theory	2·081	G(A)	1	Elective	3	—	9	Adkins
2·232	Elasticity, Theory	2·231	G(A)	2	Elective	3	—	9	Adkins
2·251	Fluid Mechanics	2·01, M22	3	1	II, II-B(B), XIII, XIX	3	—	6	Shapiro
			3	2	II-B(A)				
			4	1	VI$_4$, VI-A(A)$_4$, XIV(a)				
			4	2	VI-A(B)$_4$				
2·252	Fluid Mechanics	2·251	3	2	II	2	—	4	Shapiro
			4	S	(II-B Not '49–'50)				
			4	2	XIV(a)				
2·256	Fluid Mechanics	2·046 or 2·06; 2·40 or 2·402	G	1	Elective	3	—	6	Shapiro
			G	2	XIII-A				
2·261	Lubrication & Friction	2·252	4	2	Elective	2	—	4	Burwell
2·262	Lubrication, Research	2·261	G(A)	1 or 2	Elective		★		Burwell
2·263	Lubrication and Friction	2·252 or 2·261	G(A)	1	Elective	3	—	6	Burwell
2·271	Hydromechanics	2·252	G(A)	1	Elective	3	—	9	Rightmire
2·28	Fluid Machinery	2·271 or 2·491	G(A)	2	Elective	3	—	9	Shapiro
2·34	Mech. Prop. of Metals	2·37, 3·12	4	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	Test. Materials Lab.	2·04, 3·11	3	1	II-B(B)	2	2	4	MacGregor
			3	2	II, II-B(A)				
2·371	Test. Materials Lab.	*2·04*	3	1	I, XVI	0	2	2	MacGregor
			3	2	XVII				
			4	1	III$_4$, XIII				
2·40	Heat Engineering	8·02, M21	3	S	II-B, VI-A(A)$_4$	4	—	5	Svenson
			3	1	II, VI(1), VI-A(B)$_4$, IX-B, XIII, XIII-C, XIV(a, b), XVI, XVI-B(B), XIX				
			3	2	XVI-B(A)				
2·401	Heat Engineering	8·02, M21	3	1	——	4	—	5	Svenson
2·402	Heat Engineering	——	G	1	XIII-A	4	2	7	Keenan
2·41	Heat Engineering	8·02, M21	3	1	XVII	4	—	5	Svenson
			3	2	I(1), XV-A				
2·42	Heat Engineering	2·40	3	1	II-B(B)	3	—	6	Svenson
			3	2	II, II-B(A), VI(1), VI-A(A)$_4$, IX-B, XIII, XIV(a,b), XVI				
			4	S	VI-A(B)$_4$, XVI-B				

★ Time specially arranged.

Mechanical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2·422	Heat Engineering	2·402	G	2	XIII-A	2	—	4	Keenan
2·43	Heat Engineering	2·251, 2·40	4	1	II, (II-B Not '49–'50)	3	—	6	Kaye
2·44	Heat Engineering	2·42	4	1	Elective	3	—	6	Stever
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
2·46	Eng. App. of Kinetic Th.	2·44	G(A)	2		3	—	9	Kaye
2·48	Gas Turbines	2·42	4	2	Elective	3	—	6	Neumann
2·491	Flow of Compressible Fluids	2·252 or 16·02; 2·42; *M36*	G(A)	1	Elective	3	—	9	Shapiro
2·492	Flow of Compressible Fluids	2·491	G(A)	2	Elective	3	—	9	Shapiro
2·50	Heat Measurements	8·04	3	2	III	1	2	1	Wilkes
2·51	Heat Measurements, Adv.	8·04	G	1	——	1	4	4	Wilkes
2·521	Heat Transfer, Adv.	2·43, M36	G(A)	1	Elective	3	3	6	Rohsenow
2·522	Heat Transfer, Adv.	2·43, M36	G(A)	2	Elective	3	—	9	Rohsenow
2·53	Heat Measurements	2·50	4	1 or 2	Elective		★		Wilkes
2·56	Power Plant Eng.	2·43; 2·680 or 2·681	4	2	II_1, ($II\text{-}B_1$ Not '49–'50)	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	Elective	3	—	6	Svenson
2·641	Refrigeration Eng.	2·42, 2·43	G(A)	2	Elective	3	—	6	Svenson
2·642	Low Temp. Refrigeration	2·42, 2·43	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 2·41	4	1	Elective	3	—	6	Hesselschwerdt
2·664	Refrigeration, App.	2·663	4	2	Elective	2	—	4	Hesselschwerdt
2·665	Refrigeration, App	2·40	3	2	XIII-C	2	1	4	Hesselschwerdt
2·671	Air Conditioning, Adv.	2·663	G(A)	1	Elective	3	—	9	Hesselschwerdt
2·680	Engineering Lab.	2·40 or 2·41 or 10·29	4	1	II_1, ($II\text{-}B_1$ Not '49–'50)	1	3	4	Holt
			4	2	II_2, ($II\text{-}B_2$ Not '49–'50)				
2·681	Engineering Lab.	2·40 or 2·41 or 10·29	4	1	II_3, ($II\text{-}B_3$ Not '49–'50), VI_1, VI-A(A)$_1$	0	3	3	Holt
			4	2	VI-A(B)$_1$				
			5	1	XIII-C				
2·683	Engineering Lab.	2·40	4	1	XIII	0	4	4	Holt
2·687	Hydraulic Lab.	1·62	4	1	I_1	0	2	2	Holt
2·693	Ref. & Air Cond. Lab.	*2·621;* 2·663; 2·680 or 2·681	4	2	Elective	0	3	6	Hesselschwerdt
2·701	Machine Drawing	D12	2	1	II	0	6	0	Lent
2·730	Machine Design	*2·01*, D12	3	S	II-B	1	3	2	Sloane
			3	1	II				
2·731	Machine Design	2·04, 2·730, 3·11	3	2	II	2	3	4	Hrones
			4	S	(II-B Not '49–'50)				
2·732	Machine Design	2·731	4	1	II_2, ($II\text{-}B_2$ Not '49–'50)	2	2	4	Arnold
2·733	Machine Design	2·732	4	2	Elective	0	9	3	Arnold
2·751	Machine Design	2·731	G(A)	1	Elective	2	4	4	Hrones
2·78	Hydraulic Machinery, Des.	2·251	4	2	Elective	2	3	4	Hrones
2·783	Control Prob. in Mech. Eng.	2·082, 2·43	G(A)	2	Elective	3	—	9	Hrones
2·79	Int. Comb. Eng., Elem.	2·04; 2·40 or 2·41 or 10·29	4	1	Elective	3	—	6	Rogowski
2·791	Internal Combustion Eng.	2·04, 2·42	4	1	II_3, ($II\text{-}B_3$ Not '49–'50)	3	—	6	Rogowski
2·792	Internal Combustion Eng.	2·791	4	2	II_3, ($II\text{-}B_3$ Not '49–'50)	3	—	6	Rogowski
2·7941	Int. Comb. Eng. Lab.	*2·791*	4	1	II_3, ($II\text{-}B_3$ Not '49–'50)	0	2	1	Ku
2·7942	Int. Comb. Eng. Lab.	2·7941, 2·792	4	2	II_3, ($II\text{-}B_3$ Not '49–'50)	0	2	1	Ku
2·796	Int. Comb. Eng. Des.	2·06, 2·791	4	2	Elective	3	—	6	Rogowski
2·797	Int. Comb. Eng. Des.	2·792	G(A)	1	Elective	3	3	6	C. F. Taylor
2·798	Int. Comb. Eng. Des.	2·797	G(A)	2	Elective	3	3	6	C. F. Taylor
2·799	Automotive Dynamics	2·082, 2·792	G(A)	1 or 2	Elective	3	—	9	Den Hartog
2·801	Spec. Prob. in Int. Comb. Eng.	2·48 or 2·792	G(A)	1	Elective		★		C. F. Taylor, E. S. Taylor
2·802	Spec. Prob. in Int. Comb. Eng.	2·48 or 2·792	G(A)	2	Elective		★		C. F. Taylor, E. S. Taylor
2·851	Machine Tool Lab.	——	2	1	II, VI, XIII, XIII-C, XIV(a, b), XV-A, XIX	0	4	0	P. A. Smith
			2	2	XII, XVI				
			4	1	III_1				

★ Time specially arranged.

Mechanical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2·852	Machine Tool Practice	2·851	2	2	II, XIII	0	4	0	P. A. Smith
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	Elective	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	Elective	3	—	6	Schwarz
2·904	Textile Manufact., Prin.	2·903	4	2	Elective	3	—	6	Schwarz
2·905	Textile Tech. Anal.	8·04	G(A)	1	Elective	3	—	6	Schwarz
2·906	Textile Tech. Anal.	2·905	G(A)	2	Elective	3	—	6	Schwarz
2·907	Textile Microscopy	8·04	G(A)	1	Elective	2	3	2	Schwarz
2·908	Textile Microscopy	2·907	G(A)	2	Elective	2	3	2	Schwarz
2·911	Textile Testing Lab.	2·905	G(A)	1	Elective	0	6	2	Finch
2·912	Textile Research Lab.	2·906	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
2·991	Mechanical Eng. Seminar	——	G(A)	1	Elective	2	—	2	Soderberg
2·992	Mechanical Eng. Seminar	——	G(A)	2	Elective	2	—	2	Soderberg

METALLURGY — 3·00–3·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
3·01	Metallurgical Eng. I	5·61	3	2	III	4	—	4	Schuhmann
3·02	Metallurgical Eng. II	3·01	4	1	III	3	4	6	Schuhmann
3·03	Metallurgical Eng. III	3·02, 3·81	4	2	III_2	2	—	4	Schuhmann
3·06	Non-Ferrous Met., Adv.	3·02	G(A)	1	Elective	2	—	6	Hayward
3·08	General Metallurgy, Adv.	3·02	G(A)	2	Elective	2	—	6	Hayward
3·10	Metal. Plant Visits	——	4	S	III	0	3	1	Floe
3·11	Engineering Metals	——	2	1	XVI	4	1	4	Wulff, Bartholomew
			2	2	II, XIII				
			3	1	XV-A				
			3	2	XIV(a, b)				
3·12	Metal Processing	3·11 or *3·32*	3	2	III(1), XV-A	2	2	4	H. F. Taylor
			4	1	II, (II-B Not '49–'50)				
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	Peterson
3·16	Powder Metallurgy	3·11 or 3·32	4	1	Elective	2	—	4	Wulff
3·161	Powder Metallurgy Lab.	3·11 or 3·32	4	1	Elective	0	4	2	Wulff
3·18	Mech. Behavior of Metals	*3·12*	4	1	Elective	2	—	4	Shaler
3·20	Metal. Thermodynamics	5·62	4	1	III	4	—	4	Chipman, Bever
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)	1	Elective	2	—	4	Mellgren
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	Floe, Bever
3·33	Physical Metallurgy III	3·32	4	2	III_1	2	4	4	Homerberg, Floe
3·331	Industrial Phys. Met.	3·11	4	1	XV-A	1	3	2	Homerberg, Floe
3·34	Physical Metal., Adv.	3·20; 3·30 or 3·32; 3·50	G(A)	1	Elective	2	—	4	M. Cohen
3·35	Physical Metal., Adv.	3·20; 3·30 or 3·32; 3·50	G(A)	2	Elective	2	—	4	M. Cohen
3·38	Physical Metal., Adv.	——	G	1	Elective	0	3	3	Homerberg
3·39	Physical Metal., Adv.	3·38	G	2	Elective	2	3	3	Homerberg
3·391	Properties of Metals	——	G	1	XIII-A	2	1	3	R. S. Williams
3·392	Properties of Metals	3·391	G	2	XIII-A	2	1	3	Homerberg
3·41	Light Alloys	3·11 or 3·31	4	1 or 2	Elective	2	—	4	R. S. Williams
3·42	Electrochemistry, App.	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

★ Time specially arranged.

Metallurgy Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec.	Lab. Lec.	Draw.	Prep.	Instructor in Charge
3·53	X-ray Metallurgy, Adv.	3·50	G(A)	2	Elective		★			J. T. Norton
3·61	Magnetic Properties of Metals & Alloys	3·50, 3·51	G(A)	1	Elective	2	—		4	Kaufmann
3·62	Sp. Prob. in Metallurgy	——	G(A)	1	Elective		★			——
3·63	Sp. Prob. in Metallurgy	——	G(A)	2	Elective		★			——
3·70	Ceramics	5·02, 8·04	4	2	III$_2$	2	3		4	Vinal
3·71	Ceramics Seminar	3·70	G(A)	1	Elective	1	—		2	Vinal
3·72	Ceramics Seminar	3·70	G(A)	2	Elective	1	—		2	Vinal
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	Vinal
3·78	Ceramics Lab., Adv.	3·70	G(A)	2	Elective	0	5		4	Vinal
3·81	Mineral Engineering I	8·04, *12·011*	3	1	III	2	2		4	Gaudin
3·82	Mineral Engineering II	3·81	3	2	III(2)	2	4		4	Spedden
3·83	Mineral Engineering III	3·82	4	1	III$_2$	2	2		4	Spedden
3·85	Mineragraphy	3·82	4	1 or 2	Elective	1	3		2	Spedden
3·86	Quantitative Mineragraphy	3·83	G(A)	1 or 2	Elective		★			Spedden
3·87	Ore Testing	3·83	4	1	Elective	0	10		0	Spedden
3·89	Mineral Dressing Design	3·83	G(A)	1 or 2	Elective		★			Gaudin
3·90	Mineral Dressing, Adv.	3·83	G(A)	1 or 2	Elective	2	—		4	Gaudin
3·901	Mineral Dressing Lab., Adv.	3·83	G(A)	1 or 2	Elective		★			Gaudin

ARCHITECTURE AND PLANNING — 4·00–4·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec.	Lab. Lec.	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, Ec11	4	1	IV-B	2	—		4	Rodwin
			5	1	IV-A					
4·14	Land Economics	4·13	4	2	IV-B	3	—		6	Rodwin
4·451	Hist. of Architecture	E22	5	1	IV-A	3	—		6	H. R. Hitchcock
4·452	Hist. of Architecture	4·451	5	2	IV-A	3	—		6	H. R. Hitchcock
4·50	Office Practice	——	4	S	IV-B	40 h.p.w.				F. J. Adams
4·52	Office Practice	4·50	G(A)	1	Elective	0	30		0	F. J. Adams
4·541	Housing Seminar	4·683 or 4·751	G(A)	1	Elective	2	—		4	Rodwin
4·542	Housing Seminar	4·541	G(A)	2	Elective	2	—		4	Rodwin
4·59	Govt. & Public Admin.	——	3	1	IV-B	3	—		6	Shurtleff
			4	1	I$_2$					
4·60	Plan. Legis. & Admin.	4·59	4	2	IV-B	2	—		4	Shurtleff, Kelly
4·62	Site Plan. & Const.	4·681	4	1	IV-B	0	9		3	Bender
4·621	Site Plan. & Const.	4·741	5	1	IV-A	0	9		3	Bender
4·63	Prin. of Regional Planning	——	4	1	I$_2$	2	—		4	Greeley
4·641	City Planning, Principles	——	2	2	IV-B	2	—		4	Shurtleff
			3	2	IV-A					
4·651	City Plan., Th. & Prac.	4·641	3	1	IV-B	3	—		6	F. J. Adams
4·652	City Plan., Th. & Prac.	4·651	3	2	IV-B	3	—		6	F. J. Adams
4·661	City Planning Research	4·683	G(A)	1	Elective	2	—		4	F. J. Adams
4·662	City Planning Research	4·661	G(A)	2	Elective	2	—		4	F. J. Adams
4·681	City & Regional Planning	4·722	3	1	IV-B	0	12		6	Greeley
4·682T	City & Regional Planning	4·681	3	2	IV-B	0	12		9	Greeley

★ Time specially arranged.

Architecture and Planning Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
4·683	City & Regional Planning	4·682T	4	1	IV-B	0	9	3	Adams, Greeley
4·691	City & Reg. Plan., Adv.	4·683	G(A)	1	Elective	0	30	0	F. J. Adams
4·692	City & Reg. Plan., Adv.	4·691	G(A)	2	Elective	0	30	0	F. J. Adams
4·721	Architectural Design	—	2	1	IV-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
4·732T	Architectural Design	4·731	3	2	IV-A	0	12	6	Anderson
4·741	Architectural Design	4·732T, 4·811, 4·812	4	1	IV-A	0	12	6	Anderson
4·742T	Architectural Design	4·741	4	2	IV-A	0	12	6	Anderson
4·751	Architectural Design	4·742T	5	1	IV-A	0	9	3	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	XVII	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	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
5·00	Chemistry, Entrance	—	–	–	—	3	3	6	Young
5·01	Chemistry, General	—	1	1	All courses	4	3	4	Beattie
5·02	Chemistry, General	5·01	1	2	All courses	4	3	4	Beattie
5·061	Inorganic Chem., Adv.	5·13T	4	1	V	2	—	4	Schumb
5·062	Inorganic Chem., Adv.	5·061	4	2	V	2	—	4	Schumb
5·066	Structural Chem., Adv.	5·061	G(A)	2	Elective	2	—	4	Coryell
5·071	Sp. 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	Young
5·09	Radiochemistry	5·061, 5·12	G(A)	1	Elective	3	—	3	Coryell, Irvine
5·091	Radiochemistry Lab.	5·061, 5·12	G(A)	1	Elective	0	3	0	Coryell, Irvine
5·10T	Qualitative Analysis	5·02	2	1	V	3	8	3	Simpson
5·11	Qualitative Analysis	5·02	2	1	III, VII, VIII, X, XII, XIV(c), XV-B, XX	3	4	3	Simpson
5·12	Quantitative Analysis	5·10T or 5·11	2	2	III, VII, X, XIV(c), XV-B, XX	3	4	3	Simpson
5·13T	Quantitative Analysis	5·10T	2	2	V	4	8	4	Simpson
5·15	Instrumental Analysis	5·42; 5·62 or 5·64	4	1, 2	Elective	2	4	2	Hume, Rogers
5·192	Analytical Chemistry, Adv.	5·13T	G(A)	2	Elective	2	—	4	Hume, Rogers
5·193	Analytical Chemistry, Adv.	5·13T	G(A)	1	Elective	2	—	4	Hume, Rogers
5·194	Analytical Chemistry, Adv.	5·13T	G(A)	2	Elective	2	—	4	Hume, Rogers
5·41	Organic Chemistry I	5·12, 8·04	3	S	VII, XX	4	—	4	Sheehan
			3	1	V, IX-A, X, XIV(c), XV-B				
5·412	Organic Preparations I	*5·41*	3	S	VII, XX	0	10	0	Ashdown
5·414	Organic Preparations I	5·12, *5·41*	3	1	V	0	9	0	Swain
5·416	Organic Preparations I	5·12, *5·41*	3	1	X	0	6	0	Swain
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, IX-A, X	4	—	4	Roberts
5·424	Org. Prep. II & Anal.	5·414	3	2	V	0	9	0	Roberts
5·426	Qual. Org. Anal.	5·416	3	2	X	0	6	0	Roberts
5·43	Organic Chemistry III	5·42	4	1	V	2	—	4	Roberts
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
5·53	Organic Chem.: Iden., Adv.	5·44	G(A)	2	Elective	2	—	4	Huntress
5·54	Phys. Org. Chem., Adv.	5·43	G(A)	2	Elective	2	—	4	Swain
5·582	Organ Lab.: Iden., Adv.	5·53	G(A)	2	Elective	0	6	0	Huntress
5·61	Physical Chem. I	5·12, 8·03, M21	3	1	III, VII, X, XII(1), XIV (c), XV-B, XX	4	—	4	Millard
5·611	Physical Chem. Lab. I	*5·61* or *5·63*	3	1	V, VII, XX	0	4	0	Amdur
5·612	Physical Chem. Lab. I	*5·61*	3	1	X	0	2	0	Amdur
5·62	Physical Chem. II	5·61	3	2	III, VII, X, XII(1), XIV (c), XV-B, XX	4	—	4	Millard
5·621	Physical Chem. Lab. II	5·611; *5·62* or *5·64*	3	2	V, VII, XX	0	4	0	Amdur

★ Time specially arranged.

Chemistry Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
5·622	Physical Chem. Lab. II	5·612, *5·62*	3	2	X	0	2	0	Amdur
5·63	Physical Chemistry I	5·12, 8·04, M22	3	1	V	4	—	6	Stockmayer
5·64	Physical Chemistry II	5·63	3	2	V	4	—	6	Stockmayer
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	Elective	2	—	4	Lord
5·68	Kin. of Chem. Reactions	5·62 or 5·64	4	2	Elective	2	—	4	Amdur
5·70‡	Physico-Chem. Exp. Tech.	5·71	G(A)	1	Elective	0	4	2	Beattie
5·71	Chem. Thermodynamics I	5·62 or 5·64	G(A)	1	Elective	2	—	4	Beattie
5·72	Chem. Thermodynamics II	5·71, *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; M36	G(A)	2	Elective	2	—	4	Stockmayer
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		★		Huntress
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	5·13T	G(A)	1	Elective	1	—	2	Rogers
5·916	Anal. Chem. Seminar	5·13T	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.	5·13T	G(A)	1	Elective	1	—	2	Rogers
5·952	Res. Conf. Anal. Chem.	5·13T	G(A)	2	Elective	1	—	2	Rogers
	Research	——	G(A)	1, 2	Elective		★		Huntress
	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	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6·00	Elec. Eng., Prin.	8·03, *M22*	2	2	VI, VIII	4	—	8	Guillemin
6·002	Elec. Eng., Prin.	8·03, *M22*	2	2	——	2	—	4	Guillemin
6·01	Elec. Eng., Prin.	6·00	3	S	VI-A	3	—	6	Kingsley
	(Mag. Cir. & Trans.)		3	1	VI				
6·02	Elec. Eng., Prin.	6·00	3	1	VI-A, VIII	3	—	6	R. Taylor
	(Eng. Electronics)		3	2	VI				
6·031	Elec. Eng., Prin.	6·01	3	2	VI, VI-A(A)	2	1	6	Kingsley, Kusko
			4	S	VI-A(B)				
6·032	Elec. Eng., Prin.	6·031	4	S	VI-A(A)	3	—	6	Kingsley
			4	1	VI, VI-A(B)				
6·04	Elec. Eng., Prin.	6·032	4	1	$VI-A(A)_1$	3	—	6	Dwight
	(Elec. Power Trans.)		4	2	VI_1, $VI-A(B)_1$				
6·05	Elec. Eng., Prin.	*8.03*	2	1	VI	2	1	5	Fano, R. Taylor
6·16	Electricity	8·03	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	3	1	II, II-B(B), III, XIV(a,b), XV-A	3	1	6	Fitzgerald, Kusko
			3	2	I, II-B(A), XIV(c), XV-B				
			4	1	X, X-B, XIII, XVI, XVI-B				
			5	1	XIII-C				
6·19	Industrial Electronics	6·18 or 6·40	3	2	XIV(a, b), XV-A	3	1	6	Fitzgerald, Kusko
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				

‡ Not offered 1949–50. ★ Time specially arranged.

Electrical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6·202	Electronic Control & Meas.	6·20	4	2	Elective	3	—	6	Gray
6·211	App. Elec. to Industry	6·02	4	1	Elective	3	—	6	Dawes
6·212	App. Elec. to Industry	6·032	4	2	Elective	3	—	6	Dawes
6·213	Ind. App. of Servomechanisms	6·01 or 6·18 or 6·40; M22	4	2	XIV(b)	3	—	6	D. P. Campbell
6·221	Elect. Power Syst.	2·42	4	1	Elective	3	—	6	Balsbaugh
6·222	Elect. Power Syst.	6·032	4	2	XIV(b)	3	—	6	Balsbaugh
			4	2	Elective				
6·223	Power Frequency App. Eng.	6·031	4	1	Elective	3	—	6	Powel
6·224	Power Frequency App. Eng.	6·031	4	2	Elective	3	—	6	Powel
6·23	Electrical Implementation	6·02	4	1	VI-A(A)$_1$	3	—	6	Frazier
			4	2	VI$_4$, VI-A(B)$_1$				
6·241	Case Studies in Elec. Eng. Prac.	6·031	4	1 or 2	Elective	3	—	6	Boyajian
6·251	Elec. Mach. Design	*6·032*	4	1	Elective	3	—	6	Dwight
6·252	Elec. Mach. Design	6·032	4	2	Elective	3	—	6	Dwight
6·26	Insulators & Semi-Conductors	8·04	4	1	Elective	3	—	6	von Hippel
6·271	Illum. Eng., Prin.	8·04	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
6·291T	Radar, Prin.	6·20 or 6·311	4	1	Elective	3	—	6	Reintjes
6·292T	Radar, Prin.	6·291T	4	2	Elective	3	—	6	Reintjes
6·30	Elec. Com., Prin.	6·00	3	2	VI(3), VI-A(A)$_3$	3	—	6	Guillemin
			4	S	VI-A(B)$_3$				
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.	6·311	4	2	Elective	3	—	6	Arguimbau
6·321T	Elec. Com., Prin.	8·04, M22	3	2	VI-A(A)$_3$	3	—	6	Getting
			4	S	VI-A(B)$_3$				
			4	1	VI$_3$				
6·322T	Elec. Com., Prin.	6·321T	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
6·37	Television, Prin.	6·311	4	1	Elective	3	—	6	Arguimbeau
6·40	Elec. Eng., Elem.	*8·04*	3	1	XVII	4	—	6	Hudson
			3	2	IX-B				
6·43	Electrical Eng.	—	G	1	XIII-A	3	—	6	Kingsley
6·44	Electrical Eng.	6·43	G	2	XIII-A	3	1	7	Kingsley
6·45	Electrical Eng.	6·44	G	1	XIII-A	3	1	7	Kingsley
6·46	Electrical Eng.	6·45	G	2	—	3	1	7	J. G. Linvill
6·47	App. Elec. in Industry	6·18 or 6·40	4	1	XIV(b)	3	—	6	Dawes
			4	2	Elective				
6·501	Elec. Eng. Seminar	6·04 or 6·321T	G(A)	S	VI-A(A)	2	—	10	Fitzgerald
			G	1	VI-A(B)				
6·502	Elec. Eng. Seminar	6·501	G(A)	2	Elective	2	—	2	Fitzgerald
6·511	Elec. Power Circuits	6·04	G(A)	1	Elective	3	—	6	Wildes
6·512	Elec. Power Circuits	6·04	G(A)	2	Elective	3	—	6	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	6·04	G(A)	2	Elective	3	2	6	Fitzgerald
6·521	A-c. Machinery, Adv.	6·032, M31	G(A)	1	Elective	3	—	6	Lyon
6·522	A-c. Machinery, Adv.	6·04, M31	G(A)	2	Elective	3	—	6	Lyon
6·561	Network Theory, Adv.	6·30	G(A)	1	Elective	3	—	6	Guillemin
6·562	Network Theory, Adv.	6·561	G(A)	2	Elective	3	—	6	Guillemin
6·563	Optimum Linear Syst.	6·561 or 6·581	G(A)	1 or 2	Elective	3	—	6	Lee
6·581	Trans. in Linear Systems	6·00; 2·07 or 8·13; M31	G(A)	1	Elective	3	—	6	Gardner
6·582	Trans. in Linear Systems	6·04 or 6·321T; 6·581	G(A)	2	Elective	3	—	6	Gardner
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
6·59	Communications Lab.	6·332	G(A)	1 or 2	Elective		★		Radford
6·601	Machine Computation	M22	G(A)	1	Elective	3	4	6	Kopal
6·602	Machine Computation	6·601	G(A)	2	Elective	3	4	6	S. H. Caldwell

★ Time specially arranged.

Electrical Engineering Continued

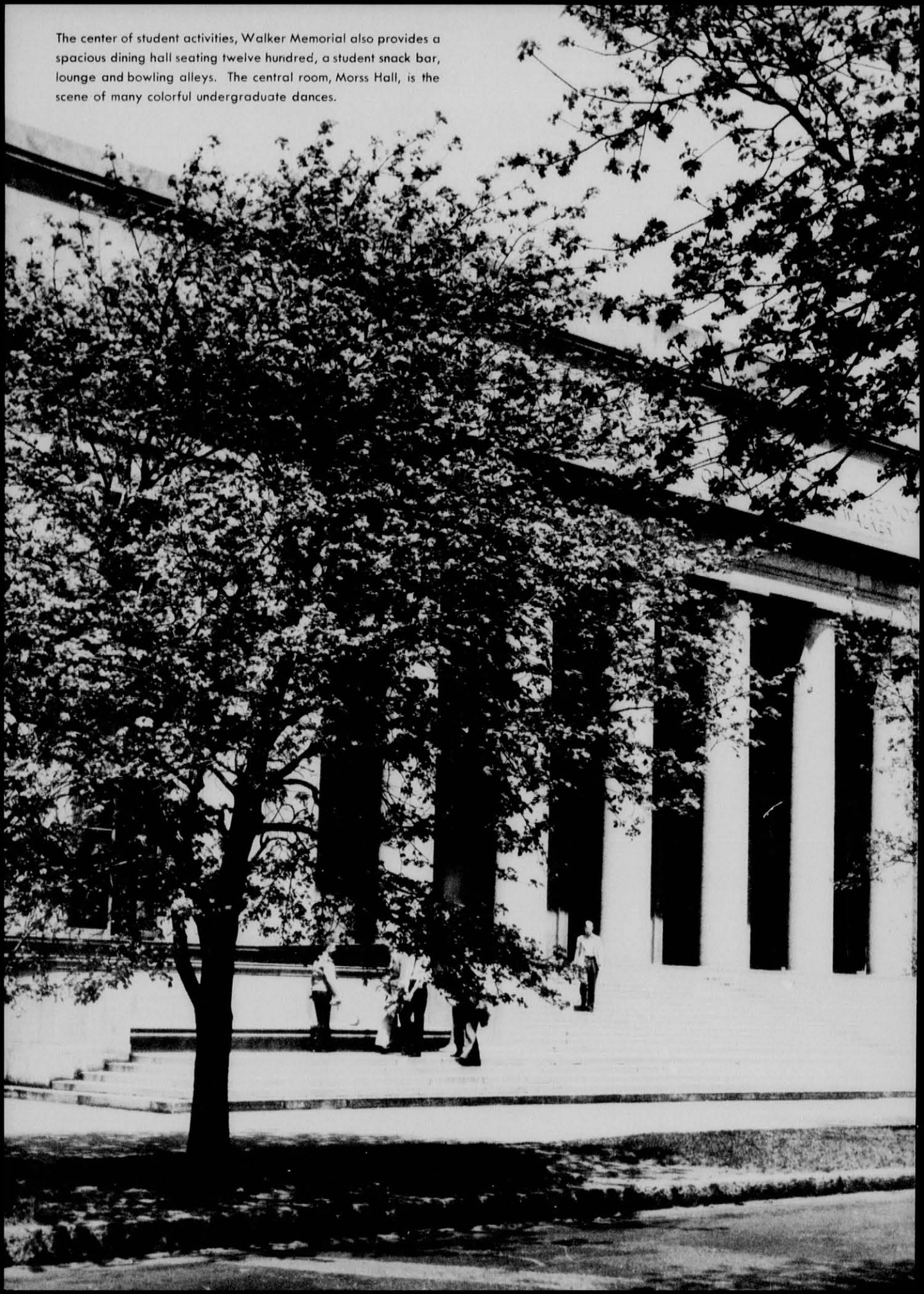
No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6·605	Servomechanisms	6·213 or 6·63; M22	G(A)	1	Elective	3	—	6	G. S. Brown
6·606	Servomechanisms	6·605	G(A)	2	Elective	3	3	6	G. S. Brown
6·607	Servomechanisms Lab.	6·605	G(A)	2	Elective	0	12	0	G. S. Brown
6·608	Servomechanisms	6·605	G(A)	2	Elective	3	—	6	G. S. Brown
6·609	Des. Auto. Cont. Syst. Aircr.	2·07, 6·605	G(A)	1 or 2	Elective	3	—	6	A. C. Hall
6·61	Eng. of High Volt. & Part. Accelerators	6·04	G(A)	2	Elective	3	—	6	Trump
6·621	Microwave Circuits	6·322T	G(A)	1	Elective	3	—	6	Fano
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
6·624	Electrodyn. of Particles	6·321T or 6·322T or 8·462	G(A)	2	Elective	3	—	6	Getting
6·625	Mod., Noise and Trans. Inf.	6·30, 6·311	G(A)	1	Elective	3	—	6	Wiesner
6·626	Freq. Modulation, Prin.	6·311	G(A)	1, 2	Elective	3	—	6	Arguimbau
6·631	Gaseous Electronics, Prin. & App.	8·07, 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	6·20 & 6·202; or 6·311 & 6·312	G(A)	1 or 2	Elective	3	—	6	Coate
6·64	Dielectric Phen. and Mat.	8·04	G(A)	2	Elective	3	—	6	von Hippel
6·651	Elect. Power Syst.	6·04	G(A)	1	Elective	3	—	6	Balsbaugh
6·652	Elect. Power Syst.	6·04	G(A)	2	Elective	3	—	6	Balsbaugh
6·661	Elec. Mach. Dev., Prin.	6·032	G(A)	1	Elective	3	1	6	Dwight
6·662	Elec. Mach. Dev., Prin.	6·032	G(A)	2	Elective	3	1	6	Dwight
6·68	Sp. Prob. in Elec. Eng.	—	G(A)	1 or 2	Elective		★		Hazen, Gardner
6·681	Spec. Prob. in Fire Control	6·606	G(RA)	1	—	6	—	12	Hazen
6·691	Acoustics, Advanced	8·13	G(A)	1	Elective	3	—	6	Beranek
6·692T	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	Sp. 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		★		R. Taylor
6·74	Elec. Mach. Lab., Adv.	6·04, 6·79	G(A)	1 or 2	Elective		★		C. E. Tucker
6·75	Elec. Meas. Lab.	*6·01*, 6·05	3	S	VI-A(A)	1	3	5	R. Taylor
			3	1	VI, VI-A(B)				
6·756	Elec. Meas. Lab.	—	3	1 or 2	—		★		R. Taylor
6·76	Eng. Electronics Lab.	*6·02*, 6·75	3	1	VI-A(B), VIII	1	2	3	R. Taylor
			3	2	VI, VI-A(A)				
6·78	Elec. Mach. Lab.	6·031	4	1	VI_1, $VI\text{-}A(A)_1$	1	3	4	C. E. Tucker
			4	2	$VI\text{-}A(B)_1$				
6·781	Elec. Mach. Lab.	6·031	4	1	$VI\text{-}A(A)_{3,4}$	1	2	3	C. E. Tucker
			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	C. E. Tucker
			4	2	VI_1, $VI\text{-}A(B)_1$				
6·80	Elec. Meas. Lab.	6·76	4	1 or 2	Elective		★		R. Taylor
6·83	Electronic Eng. Lab.	6·76	4	1	VI_4, $VI\text{-}A(A)_4$	1	2	3	Van Rennes
			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	C. E. Tucker
6·86	Elec. Mach. Lab.	6·01 or 6·18 or 6·40	4	1 or 2	Elective		★		C. E. Tucker
6·89	Elec. Eng. Lab.	6·40	3 or 4	1 or 2	Elective	0	2	2	C. E. Tucker
6·901	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)				

★ Time specially arranged.

The Massachusetts Institute of Technology Symphony Orchestra under the direction of Klaus Liepmann, Assistant Professor of Music, rehearses in Walker Memorial.

Intercollegiate dinghy 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 collegiate sailing fleet in the world. Every student is eligible to participate, and it is by far the most popular recreational activity.

Of the seventeen intercollegiate sports at Massachusetts Institute of Technology, field and track attract the greatest number of participants. Briggs Field House and the Rockwell Athletic Cage, located on the West Campus across Massachusetts Avenue from the main educational buildings, provide modern facilities for this and other field sports.



The center of student activities, Walker Memorial also provides a spacious dining hall seating twelve hundred, a student snack bar, lounge and bowling alleys. The central room, Morss Hall, is the scene of many colorful undergraduate dances.

Electrical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
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)				
6·941	Bell System Com. Prac.	—	3	S	VI-A(B)	40 h.p.w.			Boehne
			3	1	VI-A(A)				
6·942	Bell System Com. Prac.	—	3	2	VI-A(B)	40 h.p.w.			Boehne
			4	S	VI-A(A)				
6·943	Bell System Com. Prac.	—	4	1	VI-A(B)	40 h.p.w.			Boehne
			4	2	VI-A(A)				
6·944	Bell System Com. Prac.	—	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)				

BIOLOGY — 7·00–7·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
7·01	General Biology I	—	2	1	VII, XX	3	3	4	Johnson
7·02	General Biology II	7·01	2	2	VII, XX	3	3	4	Johnson
7·03	Genetics	7·02	4	2	VII, VII-A	2	—	4	Blake
7·11	Embryology	7·02	3	2	VII	2	6	4	Loomis
7·12	General Cytology	7·19, 7·20	G(A)	2	Elective	2	4	4	Waugh
7·14	Comparative Anatomy	7·02	3	1	VII	2	6	4	Blake
7·19	General Physiology I	5·62, 7·80	4	1	VII, VII-A	2	—	4	Waugh
7·20	General Physiology II	7·19	4	2	VII, VII-A	2	—	4	Schmitt
7·211	Gen. Physiol. Lab. I	*7·19*	4	1	VII, VII-A	0	4	0	Waugh
7·212	Gen. Physiol. Lab. II	7·211	4	2	VII, VII-A	0	4	0	Sizer
7·80	Biochemistry	5·41	4	1	XX, XX-A	2	6	4	Gould
			3	1	VII				
7·81T	Enzymology	*7·19*	G(A)	1	XX-A	2	—	4	Sizer
7·811	Enzymology Lab.	*7.81T*	G(A)	1	Elective	0	4	2	Sizer

Biology Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
7·82	Biochemistry, Adv.	*7·20*, 7·80	G(A)	2	Elective	2	4	4	Gould
7·831	Biochem. of Micro-organisms.	7·80	4	1	VII-A	3	4	4	Gould, Johnson
7·832	Biochem. of Micro-organisms.	7·831	G(A)	2	Elective	0	6	0	Gould
7·85	Biophysics I	*7·19*, 8·04	G(A)	1	VII-A	2	2	4	Bear
7·86	Biophysics II	8·04	G(A)	2	VII-A	2	—	4	Loofbourow
7·87	Spectr. of Biol. Materials	8·04	G(A)	1	Elective	2	—	2	Loofbourow
7·871	Spectr. of Biol. Mater. Lab.	*7·87*	G(A)	1	Elective	0	4	0	Loofbourow
7·882	Biophysics Lab.	8·04	G(A)	2	VII-A	0	4	0	Loofbourow
7·91	Instrument. in Biol. I	*7·19*	G(A)	1	VII-A	4	4	8	Lion
7·92	Instrument. in Biol. II	7·91	G(A)	2	VII-A	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	G(A)	2	Elective	3	—	6	C. E. Hall
7·96	Electron Microscopy Lab.	7·95	G(A)	2	Elective	0	4	2	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
7·99	Biol. Effects of Rad.	7·19 or 8·06	G(A)	1	Elective	2	—	4	Loofbourow

PHYSICS — 8·00–8·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
8·00	Physics, Entrance	——	—	S	——	2	—	5	——
8·001	Physics	——	—	1	——	3	—	6	——
8·01	Physics (Mechanics)	——	1	1	All courses	4	2	5	Sears
8·02	Physics (Mech. and Heat)	8·01	1	2	All courses	4	2	5	Sears
8·03	Physics (Electricity)	8·01, M12	2	1	All courses	4	1	5	Duntley, Frisch
			G.	S	XIII-A				
8·04	Physics (Elec., Optics and Modern Physics)	8·03	2	2	All courses except IV-A	4	1	5	Duntley, Frisch
			G.	S	XIII-A				
8·05	Atomic Physics	8·04	3	1	VIII	4	—	6	Zacharias
			4	1	VII-A				
8·06	Nuclear Physics	8·05	4	2	VII-A	4	—	6	Deutsch
8·07	Thermo. & Statist. Mech.	8·04	3	1	VIII, IX-A, XII(2), XVIII	4	—	5	Herlin
8·071	Thermo. & Statist. Mech.	8·04	3	S	VI-A(A)$_{3,4}$	4	—	5	Sears
			3	1	VI(3,4), VI-A(B)$_{3,4}$				
8·08	Electronics	8·04	3	2	VI(3,4), VI-A(A)$_{3,4}$ VIII, IX-A, XII(2)	4	—	5	A. G. Hill
			4	S	VI-A(B)$_{3,4}$				
8·09	Experimental Physics I	8·04	3	1	VIII, XII(2)	0	3	2	Stockbarger
			4	2	VII-A				
8·10	Experimental Physics II	8·05, *8·08*, 8·09	3	2	VIII	0	6	6	Buechner, Kip
8·101	Experimental Physics	8·05	4	2	Elective	0	3	3	Buechner, Kip
8·11	Experimental Physics	8·10	4	1	VIII	2	6	4	S. C. Brown
8·13	Vibration and Sound	8·04, M22	4	2	Elective	3	—	6	Bolt
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
8·135	Sp. 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	8·04	3	2	Elective	3	—	6	Hardy
8·17	Color Measurements	8·04	4	2	Elective	0	3	2	Hardy
8·18	Sp. 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	S. C. Brown
8·232‡	Elec. Discharges in Gases, Th.	8·231, *8·72*	G(A)	2	Elective	3	—	6	Allis
8·25	Sp. Prob. in Electronics	8·08, *8·21*	G(A)	1 or 2	Elective		★		Nottingham
8·27	X-rays & Crystal Physics	8·04, M22	4	1	Elective	3	1	6	Warren
8·28	X-ray Diffraction	8·27	G(A)	2	Elective	3	—	6	Warren
8·30	Sp. Prob. in Crystal Phys.	8·27	G(A)	1 or 2	Elective		★		Warren

★ Time specially arranged. ‡ Not offered 1949–50.

Physics Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
8·32	Line Spectra	8·05	G(A)	2	Elective	3	—	6	Harrison
8·34	Sp. Prob. in Spectroscopy	8·32	G(A)	1 or 2	Elective		★		Harrison
8·361	Quantum Th. of Matter	3·51 or 5·67 or 5·75 or 8·05	G(A)	1	Elective	3	—	6	Slater
8·362	Statistical Th. of Matter	5·61 or 5·63 or 8·07; 8·361	G(A)	2	Elective	3	—	6	Slater
8·39	Macro. Prop. of Matter I	8·72	G(A)	2	Elective	3	—	6	Mueller
8·40‡	Macro. Prop. of Matter II	8·72	G(A)	2	Elective	3	—	6	Mueller
8·411T	Statistical Thermodynamics	8·731	G(A)	1	Elective	3	—	9	Tisza
8·412T	Quantum Theory of Solids	8·411T	G(A)	2	Elective	3	—	9	Tisza
8·42T	Low Temperature Physics	8·07	G(A)	2	Elective	3	—	6	Herlin
8·43T	Microwave Physics	8·72	G(A)	1	Elective	3	2	6	Strandberg
8·45T	Sp. Prob. in Solid State Phys.	8·362 or 8·412T	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	0	3	3	M. Deutsch
8·52T	Nuclear Physics III	8·512	G(A)	2	Elective	3	—	6	R. D. Evans
8·541	Selected Topics in Nuclear Phys. I	8·06	G(A)	1	Elective	2	—	4	Zacharias
8·542	Selected Topics in Nuclear Phys. II	8·06	G(A)	2	Elective	2	—	4	Zacharias
8·55T	Nuclear Structure, Theory	8·732	G(A)	1	Elective	3	—	9	Weisskopf
8·56T	Cosmic Rays & High Energy Phenomena	8·71, 8·72	G(A)	2	Elective	3	—	6	Rossi
8·57	Int. to Nuclear Engineering	8·06	G(A)	1	Elective	3	—	6	Goodman
8·60T	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	4	1	VIII (XII_2, Not '49–'50)	4	—	8	Feld
8·72	Int. to Th. Physics II (Electromagnetic Theory)	M352 or M37	4	2	VIII (XII_2, Not '49–'50)	4	—	8	Feld
8·731	Int. to Quantum Th. I	8·71, 8·72	G(A)	1	Elective	3	—	9	Frank
8·732	Int. to Quantum Th. II	8·731	G(A)	2	Elective	3	—	9	Feshbach
8·79	Methods of Theoret. Phys.	8·71, 8·72	G(A)	1	Elective	3	—	9	Feshbach
8·80	Advanced Mechanics	8·71, 8·72	G(A)	2	Elective	3	—	9	Harvey
8·82	Relativity	8·71, 8·72	G(A)	2	Elective	3	—	9	Morse
8·84‡	Electromag. Wave Theory	8·72	G(A)	2	Elective	3	—	9	Stratton
8·85‡	Microwave Electronics	8·43T, 8·71	G(A)	2	Elective	3	—	6	Slater
8·86	Adv. Quantum Mechanics	8·732	G(A)	2	Elective	3	—	9	Weisskopf
8·90	Sp. Prob. Theoret. Phys.	8·79	G(A)	1 or 2	Elective		★		Frank

CHEMICAL ENGINEERING — 10·00–10·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
10·17	Industrial Chemistry	5·41, 5·61	3	2	X, XIV(c), XV-B	3	—	4	Addoms
10·18	Industrial Chemistry	5·62, 10·17	4	1	X, X-B, XIV(c), XV-B	3	—	6	Broughton
10·21	Industrial Chemistry	10·18	4	2	X	3	—	6	Michaels
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	Broughton
10·27	Chemical Eng. Lab.	10·17	4	1	X	0	10	0	Pohlenz
10·28	Chemical Eng.	*5·61*	3	1	X, XIV(c), XV-B	4	—	6	Mickley
10·29	Chemical Eng.	10·28	3	2	X	4	—	6	Mickley
10·30	Eng. Equipment	10·32	4	2	X-B	0	6	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	4	—	6	McAdams
10·311	Heat Transfer	——	G	1	XIII-A	3	—	3	McAdams
10·32	Chemical Eng.	10·31	4	1	X-B	4	—	6	McAdams
			4	2	X, XIV(c), XV-B				
10·33	Anal. Treat. of Chem. Eng. Processes	5·62, M22	G(A)	2	Elective	3	—	6	Mickley
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	—	3	Gilliland
10·46	Absorption & Extraction	10·32	G(A)	2	Elective	3	—	6	G. C. Williams
10·50	Heat Transmission	10·31	G(A)	2	Elective	2	—	4	McAdams

★ Time specially arranged. ‡ Not offered 1949–50.

Chemical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
10·52	Chemical Eng. II	10·32	G(A)	1	Elective	3	—	6	G. C. Williams
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, 2	Elective	3	—	6	Satterfield
10·63	Industrial Chemistry II	10·661	G(A)	1	Elective	3	—	6	Meissner
10·65	Catal. & High Pres. Proc.	5·62, 10·29	G(A)	2	Elective	3	—	6	Gilliland
10·661	Colloid Chem., Int.	5·42, 5·62	G(A)	1	Elective	3	—	6	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		★		Whitman
10·911	Research Conf.	5·42, 5·62	G(A)	1	Elective	1	—	2	Weber
10·912	Research Conf.	10·911	G(A)	2	Elective	1	—	2	Whitman
10·991	Seminar Chem. Eng.	10·32	G(A)	1	Elective	2	—	4	Gilliland
10·992	Seminar Chem. Eng.	10·32	G(A)	2	Elective	2	—	4	Gilliland

GEOLOGY — 12·00–12·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
12·011	Mineralogy	5·02, *12·20*	2	1	XII	0	3	1	
			3	1	III				
12·012	Mineralogy	12·011	2	2	XII	0	4	2	
12·04	X-ray Mineralogy	12·012, 12·20	4	1	XII, (XII, Not '49–'50)	1	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
12·15	Petrography	12·231	3	2	XII(1)	0	6	2	Fairbairn
12·16	Petrology Seminar	12·15	G(A)	1	Elective	2	—	4	Fairbairn
12·17	Petrology Laboratory	12·15	G(A)	1	Elective	0	4	1	Fairbairn
12·20	Elem. Crystallography	M12	2	1	XII	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(1)	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	2	XII, (XII, Not '49–'50)	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	3	3	3	Morris
			3	2	III(2)				
12·302	Historical Geology	12·301	3	1	XII	3	4	3	Shrock
12·303	Geological Surveying	12·301	3	S	XII	0	5	0	Parks
12·304	Field Investigations and Reports	12·301	3	S	XII	0	15	0	Staff
12·321	Engineering Geology	—	2	2	I, IV-B	2	2	4	Mead
12·322	Engineering Geology	—	G	2	Elective	2	—	4	Mead
12·35	Glacial Geology	12·302	4	1	Elective	3	—	6	Morris
12·37	Geomorphology	12·301	3	2	XII	2	—	4	Morris
12·38	Geomorphology, Adv.	12·37	G(A)	2	Elective	3	—	6	Morris
12·39	Regional Geomorphology of the Earth	12·37	4	1 or 2	Elective	2	—	4	Morris
12·40	Mineral Deposits	12·012, 12·302	4	1	XII	3	—	6	Hurley

★ Time specially arranged.

Geology Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
12·41	Mineral Deposits Lab.	*12·40*	4	1	XII, (XII_1 Not '49–'50)	0	6	0	Hurley
12·42	App. Econ. Geol.	12·40	4	2	Elective	3	—	6	Mead, Whitehead
12·432	Mineral Dep. Lab., Adv.	12·41	G(A)	2	Elective	0	4	1	Hurley
12·433	Mineral Deposits Sem.	12·40	G(A)	1	Elective	2	—	4	Hurley
12·434	Mineral Deposits Sem.	12·433	G(A)	2	Elective	2	—	4	Hurley
12·44	Mineral Fuels	12·302, 12·702	4	2	XII, (XII_1 Not '49–'50)	2	—	4	Whitehead
12·45	Laboratory Methods	12·15, 12·581	4	2	XII, (XII_1 Not '49–'50)	0	6	0	Shrock, Fairbairn
12·461	Geology of Petroleum and Coal	12·44, 12·581	G(A)	1	Elective	3	—	6	Whitehead
12·462	Geology of Petroleum, Adv.	12·461	G(A)	2	Elective	3	—	6	Whitehead
12·511	Paleontology	12·302	4	1	Elective	1	6	2	Shrock
12·512	Paleontology	12·511	4	2	Elective	1	6	2	Shrock
12·52	Paleontology, Adv.	12·512	G(A)	2	Elective		★		Shrock
12·53	Index Fossils	12·512	G(A)	2	Elective		★		Shrock
12·581	Sedimentology	12·301	3	1	XII(1)	2	1	4	Shrock
			4	1	XII				
12·582	Sedimentology, Adv.	12·581	G(A)	2	Elective	2	2	4	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	0	4	0	Whitehead
12·702	Structural Geology	12·701	3	2	XII(1)	3	—	6	Mead
12·71	Structural Geology, Adv.	12·702	G(A)	2	Elective	3	—	6	Mead
12·721	Tectonics Seminar	12·702	G(A)	1	XII	2	—	4	Whitehead
12·722	Tectonics Seminar	12·15, 12·721	G(A)	2	XII	2	—	4	Whitehead, Fairbairn
12·73	Regional Geology	12·302, 12·702	4	1	Elective	2	—	4	Whitehead
12·83	Geophysics Laboratory	12·302	4	1	Elective	0	3	2	J. Adkins
			4	1	(XII_2 Not '49–'50)				
12·86	Elements of Seismology	M22	4	2	Elective	2	—	4	J. Adkins
12·87	Int. Geophysics	12·302	4	1	XII	2	—	4	J. Adkins
12·881	Geophysics, Adv.	12·87	G(A)	1	Elective	3	—	6	J. Adkins
12·882	Geophysics, Adv.	12·881	G(A)	2	Elective	3	—	6	J. Adkins
12·91	Mining, Elements	12·40	4	[illegible]	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	III_2, XII, (XII_1 Not '49–'50)	2	—	4	Parks
12·95	Mine Valuation	12·92	G(A)	2	Elective	3	—	6	Parks
12·96	Mineral Econ. Sem.	12·94	G(A)	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	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
13·01	Statics of Ship Design	8·01, M21	3	1	XIII, XIII-C	3	—	6	Manning
			G	1	XIII-A				
13·02	Dynamics of Ship Design	2·251	3	2	XIII	3	—	6	Manning
		or 2·256; 13·01	G	2	XIII-A				
13·021	Ship Propulsion & Maneuver.	13·01	3	2	XIII-C	2	—	4	Manning
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)	2	Elective	0	8	0	Manning
13·04	Ship Design, Advanced	13·03	G(A)	2	Elective		★		Manning
13·12	Warship General Arrangements	13·01	G(R)	2	XIII-A	2	—	4	Farrin
13·13	Warship Structure, Theory I	2·046	G(RA)	1	——	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	Cochrane
13·16	Warship Basic Design II	13·15	G(RA)	2	——	3	—	6	Farrin
13·17	History of Warships	——	G	1	XIII-A	3	—	4	Farrin
13·20	Ship Design, Elem.	——	G	S	XIII-A	1	4	0	Robertson
13·21	Warship Form Design	——	G(R)	1	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
13·25	Warship Structure, Design II	13·14, 13·24	G(RA)	1	——	0	5	0	J. H. Evans
13·26	Preliminary Design of Warships	13·15	G(RA)	2	XIII-A	0	8	0	Cochrane

★ Time specially arranged.

Naval Architecture and Marine Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
13·34	Ship Construction	——	3	1	——	3	—	3	Burtner
			3	2	XIII				
13·40	Ship Construction, Elementary	——	2	1	XIII	2	3	2	Manning
13·401	Ship Construction, Elementary	——	2	1	XIII-C	2	—	2	Manning
13·42	Ship Hull Design	13·01	3	1	XIII	0	6	0	Manning
13·45	Ship Structures, Design	2·04, 13·42	4	1	XIII	3	3	3	Manning
13·46	Ship Design	13·02, 13·45	4	2	XIII	1	6	1	Manning
13·47	Ship Design	13·021, 13·34	5	1	——	1	6	1	Robertson
13·47T‡	Ship Design	13·021	5	1	XIII-C	2	6	2	Robertson
13·52	Marine Engineering	2·40	3	2	XIII, XIII-C	3	—	6	Burtner
13·54	Marine Engineering Dynamics	2·062, 13·52	4	1	XIII	2	—	4	F. M. Lewis
			G	1	XIII-A				
13·55	Marine Engineering	2·42, 13·52	4	2	XIII	2	—	4	Burtner
13·56†	Marine Engineering Economics	13·52	5	1	XIII-C	3	—	6	Chapman
13·61	Marine Engineering Design	2·04, 2·40, 13·52	4	1	XIII	1	5	1	Burtner
13·62	Marine Engineering Design	13·61	4	2	XIII	1	5	1	Burtner
13·71 ¶	Ship Propulsion I	13·54, 13·55	G(A)	1	Elective	3	—	6	Burtner
13·711¶	Ship Machinery Design I	13·54, 13·55	G(A)	1	Elective	0	2	0	Burtner
13·72 ¶	Ship Propulsion II	13·71	G(A)	2	Elective	2	—	4	Burtner
13·721¶	Ship Machinery Design II	13·711	G(A)	2	Elective	0	4	0	Burtner
13·73	Mechanical Vibration	2·046 or 2·06 or 2·062	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	—	6	Chadwick
13·751	Warship Machinery Design I	2·422, 10·311	G(RA)	1	XIII-A	0	2	0	Chadwick
13·76	Warship Propulsion II	13·75	G(RA)	2	XIII-A	2	—	4	Chadwick
13·761	Warship Machinery Design II	13·751	G(RA)	2	XIII-A	0	4	0	Chadwick
13·78	Propeller Theory & Exp. Res.	13·02	G(A)	2	Elective	2	—	4	F. M. Lewis
13·79	Propeller Design	13·02	G(A)	1	Elective	2	1	2	Powell
13·81†	Ship Operation	13·021, 13·52, 13·84	5	1	XIII-C	3	—	6	Chapman
13·82†	Ship Operation	13·81	5	2	XIII-C	2	—	4	Chapman
13·83	Ports and Port Facilities	——	3	1	XIII-C	2	—	4	Chapman
13·84	Cargo Handling and Stowage	13·01, 13·83	3	2	XIII-C	3	2	3	Chapman
13·85‡	Cargoes in World Trade	——	3	1	XIII-C	3	—	6	Sherrill
13·86	Steamship Management	13·81, 13·84	5	2	XIII-C	3	—	6	Sherrill

BUSINESS AND ENGINEERING ADMINISTRATION — 15·00–15·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
15·11	Bus. Manage., Int.	Ec11	3	2	XX	3	—	6	Swope
			4	1	Elective				
			4	2	XIII				
15·18	Accounting, Production, & Marketing	——	G	S	——	5	—	10	Tallman
15·30	Personnel Administration	15·70	2	2	XV-A, XV-B	3	—	5	Pigors
15·301	Personnel Administration	*Ec111*	G	1	Elective	3	—	5	Pigors
15·41	Finance	15·50, Ec11	4	1	XV-A, XV-B	3	—	6	R. E. Freeman
15·411	Finance	15·501	G	S	Elective	3	—	6	R. E. Freeman
15·42	Financial Institutions	15·41	4	2	Elective	3	—	6	D. S. Tucker
15·46	Fin. Adm. of Industry	15·41	G(A)	2	Elective	3	—	6	R. E. Freeman, D. S. Tucker
15·50	Accounting	*Ec11*	3	1	XV-A	3	2	4	Beckett
			3	2	I(3), XIII-C, XIV, XV-B				
			4	2	XVII				
15·501	Accounting	*Ec111*	G	1	Elective	3	2	4	Beckett
15·51	Indust. Accounting	15·50	4	1, 2	Elective	3	2	4	T. M. Hill
15·55	Prob. in Account. Policy	15·41	G(A)	1	Elective	3	—	6	Robnett
15·58	Prob. in Account. Control	15·51	G(A)	2	Elective	3	—	6	Robnett
15·61	Business Law	*Ec11*	3	2	XV-A, XV-B	3	—	6	MacMillan
			4	2	$XVII_2$				
			5	2	XIII-C				
15·611	Business Law	*Ec111*	G	1	Elective	3	—	6	——
15·64	Patent Law	15·61	4	2	Elective	3	—	6	Berle

†Open only to students in Course XIII-C who have had one year's practical work with a Steamship Company with nine months spent at sea.
¶Approximately one year's practical experience with Marine Engineering Plants essential. Experience to be evaluated prior to acceptance of enrollment.
‡Not offered 1949–50.

Business and Engineering Administration Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
15·65	Labor Law	15·61	4	2	Elective	3	—	6	Jacks
15·66	Fund. Legal Principles	15·92	G(A)	1	Elective	3	—	6	Wyzanski
15·70	Production	——	2	1	XV-A, XV-B	3	—	6	Clark
			3	1	XIV(1)				
			3	2	Elective				
			4	1	$XVII_2$				
15·701	Production	——	G	1	Elective	3	—	6	Clark
15·71	Production Management	15·70	4	1, 2	Elective	3	—	6	Boyan
15·72	Tech. of Exec. Control	15·70	4	2	Elective	3	—	6	C. J. Brown
15·73	Management Lab.	15·70	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	15·92	G(A)	1	Elective	3	—	6	Ritchie
15·76	Mass Production Methods	2·851, 15·70	4	1, 2	Elective	3	—	6	Clark
15·81T	Marketing	*Ec11*	3	1	XV-A, XV-B	3	—	6	Cross
			3	2	Elective				
			4	1	$XVII_2$				
15·811T	Marketing	*Ec111*	G	1	Elective	3	—	6	Cross
15·82	Sales Promotion: Strategy & Methods	15·81T	4	2	Elective	3	—	6	Cunningham
15·83	Marketing Research: Field Surveys	15·81T	4	1	Elective	3	—	6	Cunningham
15·84	Marketing Research: Sales Anal. & Poten.	15·81T	4	2	Elective	3	—	6	Cunningham, Tallman
15·86	New Prod. Appraisal & Development	15·82 or 15·83 or 15·84	G(A)	1	Elective	3	—	6	Cunningham, Tallman
15·88	Industrial Marketing Seminar	15·82 or 15·83 or 15·84	G(A)	2	Elective	3	—	6	Cunningham, Cross
15·92	Industrial Problems	15·30, 15·41, 15·61, 15·70, 15·81T	4	2	XV-A, XV-B	3	—	6	Boyan
15·93	Organization	15·92	G(A)	1	Elective	3	—	6	Schell
15·94	Contemp. Prob. Seminar	15·92	G(A)	2	Elective	3	—	6	Schell
15·951	Sp. Prob. in Management	——	G(A)	1	Elective		★		Robnett
15·952	Sp. Prob. in Management	——	G(A)	2	Elective		★		Robnett
15·96	Adm. Th. & Practice	15·92	G(A)	2	Elective	3	—	6	Schell
15·97	Public Relations Seminar	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	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
16·01	Aero. Mech., Int.	M22	3	S	XVI-B	4	2	6	Rauscher
			3	1	XVI				
16·02	Aero. Mech., Int.	16·01	3	1	XVI-B(B)	4	2	6	Rauscher
			3	2	XVI, XVI-B(A)				
16·03	Aerodyn.—Non-Viscous Fluids	16·02	G(A)	1	Elective	3	—	6	Rauscher
16·04	Aerodyn.—Viscous Fluids	16·02	G(A)	2	Elective	3	—	6	Bicknell
16·051	Aerodynamics — Compressible Fluids I	16·03 or M351, M352	G(A)	2	Elective	3	—	9	——
16·052	Aerodynamics-Compressible Fluids II	16·051	G(A)	1	Elective	3	—	9	——
16·07	Aerodyn.-Kinetics of Gases	2·40, 16·02	G(A)	1	Elective	2	—	4	Stever
16·10	Applied Aerodynamics	16·01, 16·82	3	2	XVI	4	—	8	Ober
			4	S	(XVI-B Not '49–'50)				
16·105	Applied Aerodynamics	16·10	G(A)	1 or 2	Elective	3	—	6	Ober
16·13	Airpl. Stab. & Control	16·10	4	1	XVI, (XVI-B Not '49–'50)	3	—	6	Koppen
16·14	Airpl. Design Prob.	16·13, 16·17	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)	2	Elective	3	—	6	Stever
16·20	Structures	2·04	3	1	XVI-B(B)	3	—	6	Newell
			3	2	XVI, XVI-B(A)				

★ Time specially arranged.

Aeronautical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
16·21	Structures	16·20	4	1	XVI, (XVI-B Not '49–'50)	3	—	6	Newell
16·22	Aircraft Structures	16·21	4	2	Elective	3	2	6	Newell
16·25	Aircraft Struct., Adv.	16·21	G(A)	1	Elective	3	—	6	Newell
16·30	Aircraft Instruments	8·04, M22	4	2	Elective	3	2	6	McKay
16·31	Inst. & Control, Prin.	2·06 or 2·07 or 6·02 or 16·02	G(A)	1	Elective	3	—	9	Draper
16·32	Inst. & Auto. Control Sys. for Aircraft	16·31	G(A)	2	Elective	3	—	9	McKay
16·33	Inst. & Cotrol Lab.	*16·31*	G(A)	1	Elective	0	3	6	Forbes
16·34	Aircr. Flight Test Inst. & Control Syst.	16·30 or 16·31	G(A)	2	Elective	3	3	6	McKay
16·35	Special Problems in Aircraft Instrumentation	16·32 or 16·34 or 16·36	G(A)	1 or 2	Elective		★		McKay
16·36	Vibration Measurements	2·06 or 2·07 or 8·13 or 13·73; 16·31	G(A)	2	Elective	2	3	6	Forbes
16·37	Inst. & Control Syst. Des. Prac.	16·31	G(A)	1	Elective	2	6	2	McKay
16·38	Inst. & Control Syst. Des. Prac.	16·37	G(A)	2	Elective	2	6	2	McKay
16·39	Automatic Control Equipment for Aircraft	16·13, *16·31*	G(A)	1	Elective	3	—	6	Seamans
16·40	Vector Kin. & Gyr. Inst. Th.	16·31 or 16·41	G(A)	2	Elective	3	—	6	Weems
16·41	Fire Control Instruments, Int.	2·06	G(RA)	1	——	3	—	6	Draper
16·42	Fire Cont. Instr., Adv.	16·41	G(RA)	2	——	4	—	8	Draper
16·43	Fire Control Instr. Lab.	16·41	G(RA)	1	——	0	3	5	Amara
16·44	Fire Cont. Instr., Adv.	16·41	G(RA)	2	——	4	—	8	Draper
16·45	Fire Cont. Instr., Adv.	16·42 or 16·44	G(RA)	1	——	4	—	8	Draper
16·46	Fire Cont. Instr. Lab., Adv.	16·42 or 16·44	G(RA)	2	——	0	3	5	Amara
16·50	Rotating Wing Aircraft	16·10	4	1	Elective	3	—	6	Miller
16·501	Rotating Wing Aircraft	16·10	G(A)	1	Elective	3	—	6	Miller
16·52	Aircraft Propeller Des.	16·10, 16·20	G(A)	2	Elective	2	3	4	Ober
16·53	Aircraft Power Plants, Prin.	2·42; 2·06 or 16·02	4	2	XVI, (XVI-B Not '49–'50)	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 2·48	G(A)	2	Elective	3	—	9	E. S. Taylor, Hawthorne
16·57	Rockets	16·02, *M351*	G(A)	1	Elective	3	—	6	——
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, (XVI-B Not '49–'50)	2	2	4	Ober
16·63	Aerodynamic Lab.	16·62	4	2	Elective	2	2	5	Ober
16·70	Aircraft Drafting	D12	2	2	XVI	0	6	0	Bentley
16·71	Detailed Design of Aircraft	2·701 or 16·70	3	1	XVI, XVI-B(B)	0	6	0	Koppen
			3	2	XVI-B(A)				
16·72	Airplane Design Practice	16·10, 16·13, 16·71	4	2	XVI, (XVI-B Not '49–'50)	0	9	0	Miller
16·74	Airplane Design, Adv.	16·105, 16·13, 16·72	G(A)	1	Elective	2	6	4	Miller
16·78	Human Factors in Aircraft Des.	16·02, *16·72*	G(A)	2	Elective	3	—	6	Ober
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	2	XVI	3	—	1	Markham
16·91	Aero-Elasticity & Struct. Dyn.	16·02	G(A)	1 or 2	Elective	3	—	6	Rauscher
16·92	Aero-Elasticity, Adv.	16·91	G(A)	2	Elective	3	—	9	Rauscher
16·93	Aero-Elasticity & Struct. Dyn. Lab.	*16·91*	G(A)	1	Elective	2	2	2	Rauscher
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	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
17·22	Building Construction	D12	2	1	XVII	2	3	4	Staley
17·31	Building Construction	17·22	3	1	XVII(1)	2	3	4	Staley

★ Time specially arranged.

Building Engineering and Construction Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
17·32	Building Construction	17·31	3	2	XVII(1)	2	3	4	Staley
17·33	Building Construction	17·22	3	1	XVII(2)	2	3	4	Voss
17·34	Building Construction	17·33	3	2	XVII(2)	2	3	4	Voss
17·40	Estimating & Job Manage.	17·32 or 17·34	4	2	XVII	2	3	4	Voss
17·401	Job Management, Adv.	17·40	G(A)	1	Elective	3	—	6	Voss
17·41	Building Management	17·40, 17·73	G(A)	1	Elective	3	—	6	Voss
17·42	Building Management	17·41	G(A)	2	Elective	3	—	6	Voss
17·45	Construction Problems	17·32 or 17·34	4	1 or 2	Elective		★		Voss
17·52	Structural Problems	2·04	3	2	XVII	3	3	6	Simpson
17·53	Structural Design	17·52	4	1	$XVII_1$	3	3	6	Simpson
17·531	Reinf. Concrete Des., Adv.	1·42 or 17·53	G(A)	1	Elective	3	—	6	Simpson
17·532	Reinf. Concrete Des., Adv..	17·531	G(A)	2	Elective	3	—	6	Simpson
17·54	Structural Design	17·53	4	2	$XVII_1$	3	3	6	Simpson
17·542	Structural Steel Des., Adv.	1·42 or 17·54	G(A)	2	Elective	3	—	6	Simpson
17·56	Structural Design	17·52	4	1	$XVII_2$	3	3	6	Simpson
17·71	Materials	5·02, 8·02	2	2	IV-A, XVII	3	—	4	Dietz
17·72T	Materials	17·71	3	2	XVII	4	2	4	J. A. Murray
			4	2	IV-A				
17·722	Materials	17·72	4	2	—	1	2	0	J. A. Murray
17·73	Materials	17·72T	4	1	IV-A, XVII	3	—	4	Dietz
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
17·75T	Materials	5·02, 8·02	3	1	I	4	2	6	Voss
17·76	Res. in Organic Struct. Mat.	17·742	G(A)	1 or 2	Elective		★		Dietz
17·771	Cementitious Materials	17·72T or 17·75T	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

METEOROLOGY — 19·00–19·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
19·01	Descriptive Meteorol. I	8·02, M12	3	1	XIX	3	—	6	Willett
19·012	Des. Meteorol. (Coll. Trans.)	8·02, M12	3	2	—	3	—	6	Willett
19·02	Descriptive Meteorol. II	19·01	3	2	XIX	3	—	6	Willett
19·14	Long Range Weather Fore.	19·02, 19·45, 19·53, 19·61	G(A)	1	Elective	3	8	6	Willett
19·21	Meteorological Observations	8·02, M12	3	1	XIX	1	3	2	Keily
19·22	Meteorological Inst.	19·21, 19·43, 19·51	G(A)	2	Elective	2	4	6	Keily
19·30	General Climatology	19·01	3	2	XIX	2	—	4	Malone
19·31	Regional Climatology	19·02, 19·30, *19·51*	4	1	Elective	2	—	4	Austin
19·43	Synoptic Meteorol. I	19·01	4	1	XIX	3	—	6	Malone
19·44	Synoptic Meteorol. II	19·43, 19·51, 19·61	4	2	XIX	3	—	6	Austin
19·45	Synoptic Meteorol. III	19·44	G(A)	1	Elective	3	—	6	Austin
19·50	Meteorol. Lab., Int.	*19·01*	3	2	XIX	0	9	3	Malone
19·51	Synoptic Lab. I	19·50	4	1	XIX	0	15	0	Malone
19·52	Synoptic Lab. II	19·51	4	2	XIX	0	15	0	Malone
19·53	Synoptic Lab. III	19·43, 19·52	G(A)	1 or 2	Elective	0	15	0	Austin
19·60	Thermodyn. of Atmos.	8·02, M22	3	1	Elective	3	—	6	Houghton
			3	2	XIX				
19·61	Dynamic Meteorol. I	19·60	4	1	XIX	2	—	4	Starr
19·62	Dynamic Meteorol. II	19·61	4	2	XIX	3	—	6	Starr
19·64	Dynamic Meteorol. III	19·62	G(A)	1 or 2	Elective	3	—	9	Starr
19·65	Dynamic Meteorol. IV	19·62	G(A)	2	Elective	3	—	6	Abdullah
19·70	Phys. of Atmos., Elem.	19·01	3	2	XIX	2	—	4	Houghton
19·71	Radar Meteorology	19·43, 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	*19·43, 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
19·92	Meteorol. Seminar II	19·91	G(A)	2	Elective	2	—	4	Houghton
19·95	Sp. Prob. in Meteorol.	19·44, 19·62	G(A)	1 or 2	Elective		★		Staff

★ Time specially arranged.

FOOD TECHNOLOGY — 20·00–20·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
20·01	Tech. & Chem. Food Supplies	5·41, *20·41*	3	1	XX	2	4	2	Lockhart
20·02	Tech. & Chem. Food Supplies	*20·42*	3	2	XX	2	4	4	Lockhart
20·04	Chemistry of Foods	5·12	3	2	Elective	2	4	2	R. S. Harris
20·11	Tech. Food Products	20·02	4	1	XX, XX-A	2	4	4	Proctor
20·12	Tech. Food Products	20·11	4	2	XX, XX-A	2	4	4	Proctor
20·13	Chem. Eng. Food App.	5·61	4	1	XX, XX-A	4	—	6	Bauer
20·14	Chem. Eng. Food App.	20·13	4	2	XX, XX-A	4	—	6	Bauer
20·21	Flavor Evaluation	20·12, 20·32	G(A)	1 or 2	Elective	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
20·34	Applied Nutrition	20·32	G(A)	2	Elective	2	2	4	R. S. Harris
20·36	Nutrition, Adv.	20·32	G(A)	2	Elective	2	4	2	R. S. Harris
20·38	Nutr. Eval. of Food Proc.	20·12, 20·32	G(A)	1 or 2	Elective	2	—	4	R. S. Harris
20·41	Bacteriology	7·02	3	1	XX	2	4	2	Dunn
20·42	Industrial Microbiol.	20·41	3	2	XX	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	Proctor
20·51	Food Technology, Adv.	20·12	G(A)	1	XX-A	2	6	4	Proctor
20·52	Food Technology, Adv.	20·51	G(A)	2	XX-A	2	4	4	Proctor
20·61	Food Technology Sem.	20·12	G(A)	1	XX-A	2	—	2	Proctor
20·62	Food Technology Sem.	20·61	G(A)	2	XX-A	2	—	2	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	Staff

ATHLETIC PROGRAM — A1–A99

No.	Subject	Prerequisite	Year	Term	Taken by	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	Taken by	Rec. Lec	Lab. Draw.	Prep.	Instructor in Charge
D11	Engineering Drawing	—	1	1	All courses	0	6	0	Rule
D12	Descriptive Geometry	D11	1	2	All courses	0	6	0	Rule
D31	Nomography	D12, M12	2, 3	1, 2	Elective	2	—	4	D. P. Adams

ECONOMICS AND SOCIAL SCIENCE — EC1–EC99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
Ec11	Economic Principles I	E12	2	1	XIV	3	—	5	Bishop
			3	S	VI-A(A)				
			3	1	All except II-B(A), VI-A(A), XIV, and XVI-B(A)				
			3	2	II-B(A), XVI-B(A)				
Ec111	Current Economic Problems	—	G	1	Elective	3	—	6	R. E. Freeman
Ec112	Current Economic Problems	—	G	2	Elective	3	—	6	R. E. Freeman
Ec12	Economic Principles II	Ec11	2	2	XIV(2)	3	—	5	E. C. Brown
			3	2	Elective				

★ Time specially arrauged

Economics and Social Science Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
Ec13	Prices & Production	Ec12	4	1	XIV_2	3	—	6	Bishop
Ec15	Econ. & Labor Rel., Prin.	E12	G	2	Elective	4	—	8	R. E. Freeman
			G	2	XIII-A				
Ec16	Econ., Finance & Statistics	—	G	S	—	4	—	9	Samuelson
Ec17	Economic Analysis	Ec50	G(A)	1	Elective	3	—	6	Samuelson, Bishop
Ec18	Economic Analysis	Ec17	G(A)	2	Elective	3	—	6	Samuelson, Bishop
Ec19	Math. Approach to Econ.	Ec18	G(A)	1	Elective	3	—	6	Samuelson
Ec21	Econ. of Invent. & Innova.	Ec27	G(A)	1	Elective	3	—	6	Maclaurin
Ec22	Ec. of Invent. & Innova. Sem.	Ec21	G(A)	2	Elective	3	—	6	Maclaurin
Ec23	National Income	Ec12	4	1	Elective	3	—	6	E. C. Brown
Ec24	Schools of Econ. Thought	Ec50	G(A)	2	Elective	3	—	6	Bishop
Ec26	Business Cycles	Ec50	G(A)	2	Elective	3	—	6	Samuelson
Ec27‡	Econ. of Patents and Invention	Ec11	4	1	Elective	3	—	6	Maclaurin
Ec28‡	Econ. of Patents and Invention	15·64 or Ec27	4	2	Elective	2	—	4	Maclaurin
Ec35	Statistics, Elem.	M12	2	1	IV-B	3	—	6	H. A. Freeman
			4	1	XV-A				L. C. Young
Ec352	Statistics, Elem.	M12	3	2	I(2), XIV	2	—	4	H. A. Freeman
									L. C. Young
Ec36	Indust. Quality Control	Ec35	4	2	Elective	3	—	6	L. C. Young
Ec37	Statistics, Theoretical	Ec35, M22	G(A)	1	Elective	3	—	6	H. A. Freeman
Ec38	Statistics, Theoretical	Ec37	G(A)	2	Elective	3	—	6	H. A. Freeman
Ec39	Economic Statistics	Ec35	G(A)	1	Elective	3	—	6	Samuelson
Ec49	Public Finance	Ec11	4	1	IV-B	2	—	4	E. C. Brown
Ec50	Money and Banking	Ec11	4	1	Elective	2	—	4	R. E. Freeman
			3	1	XIV(2)				
Ec52	Comp. Polit. & Ec. Systems	Ec11	4	2	Elective	3	—	6	—
Ec54	Corporations	Ec11	5	2	XIII-C	2	—	4	D. S. Tucker
Ec56	Industrial Econ., Prob.	Ec13	G(A)	1	Elective	3	—	6	Adelman
Ec57	International Relations	Ec11	4	1	Elective	3	—	5	Padelford
Ec571	International Problems	—	G	1	Elective	3	—	6	Padelford
Ec572	International Problems	—	G	2	Elective	3	—	6	Padelford
Ec58	International Relations	Ec57	4	2	Elective	3	—	5	Padelford
Ec591	International Economics	Ec50	G(A)	1	Elective	3	—	6	Kindleberger
Ec592	International Economics	Ec591	G(A)	2	Elective	3	—	6	Kindleberger
Ec595	Tech. & Internat. Rel.	Ec58	4	1	Elective	2	—	4	Padelford
Ec60	Labor Relations	Ec11	3	2	XIV	3	—	5	Myers
			3	2	Elective				
Ec65	Industrial Relations	15·30 or Ec60	4	1	XIV_1	3	—	6	D. V. Brown
			4	1	Elective				
Ec66	Seminar in Indust. Rel.	Ec65	G(A)	2	Elective	3	—	6	Pigors
Ec67	Seminar in Labor Probs.	Ec65	G(A)	1	Elective	3	—	6	D. V. Brown, Myers
Ec68	Seminar in Labor Probs.	Ec67	G(A)	2	Elective	3	—	6	D. V. Brown, Myers
Ec691	Personnel Admin., Sem.	Ec65	G(A)	1	Elective	3	—	6	Pigors
Ec692	Personnel Admin., Sem.	Ec691	G(A)	2	Elective	3	—	6	Pigors
Ec70	Introductory Psychology	—	2	2	XIV(1)	3	—	5	—
			3	1	XIV(2)				
			3	2	Elective				
Ec701	Psychological Concepts	—	G	1	Elective	3	—	6	Bavelas
Ec711	Human Relations Sem.	—	G(A)	1	Elective	3	—	6	—
Ec712	Human Relations Sem.	Ec711	G(A)	2	Elective	3	—	6	—
Ec721	Soc. Psych. of Industry	—	G(A)	1	Elective	3	—	6	Bavelas
Ec722	Soc. Psych. of Industry	Ec711	G(A)	2	Elective	3	—	6	Bavelas
Ec723	Manage. of People, Tech.	Ec70	3	1	XIV(1)	0	4	0	Krulee
Ec724	Manage. of People, Th.	Ec723, Ec725, Ec73	4	2	XIV_1	2	—	4	Scanlon
Ec725	Comp. Contemp. Cultures	Ec11	3	1	XIV	2	—	4	—
Ec73	Psychology, Adv.	Ec70	4	1	XIV_1	3	—	6	Frost
Ec731‡	Methods in Human Rel.	Ec711, Ec721	G(A)	1	Elective	3	—	6	—
Ec732‡	Methods in Human Rel.	Ec711, Ec721	G(A)	2	Elective	3	—	6	—
Ec733‡	Methods in Human Rel.	Ec711, Ec721	G(A)	1	Elective	3	—	6	—
Ec734‡	Methods in Human Rel.	Ec711, Ec721	G(A)	2	Elective	3	—	6	—
Ec741‡	Psych. of Ind. Manage.	Ec731	G(A)	1	Elective	3	—	6	—
Ec742‡	Psych. of Ind. Manage.	Ec741	G(A)	2	Elective	3	—	6	—
Ec751	Res. Sem. in Hum. Rel.	Ec711, Ec721	G(A)	1	Elective	3	—	6	Bavelas
Ec752‡	Res. Sem. in Hum. Rel.	Ec711, Ec721	G(A)	2	Elective	3	—	6	Bavelas
Ec753‡	Res. Sem. in Hum. Rel.	Ec711, Ec721	G(A)	1	Elective	3	—	6	Bavelas
Ec754‡	Res. Sem. in Hum. Rel.	Ec711, Ec721	G(A)	2	Elective	3	—	6	Bavelas

‡ Not offered 1949–50.

Economics and Social Science Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
Ec761	Reading Sem. in Hum. Rel.	Ec711, Ec721	G(A)	1	Elective		★		Bavelas
Ec762	Reading Sem. in Hum. Rel.	Ec711, Ec721	G(A)	2	Elective		★		Bavelas
Ec77	Human Rel. & Labor Rel.	——	G	S	——	4	—	8	Myers
Ec82	Govt. Regulation of Industry	Ec56	G(A)	2	Elective	3	—	6	Adelman
Ec88	Building Economics	Ec11	4	2	XVII$_2$	2	—	4	D. S. Tucker
			5	2	IV-A				
Ec91	Economics Seminar	Ec17	G(A)	1	Elective	3	—	6	R. E. Freeman
Ec92	Economics Seminar	Ec91	G(A)	2	Elective	3	—	6	R. E. Freeman
Ec93	Ind. Econ. Seminar	Ec56	G(A)	1	Elective	3	—	6	Scanlon
Ec94	Ind. Econ. Seminar	Ec93	G(A)	2	Elective	3	—	6	Scanlon
Ec95	Social Science Seminar	Ec711	G(A)	1	Elective	3	—	6	——
Ec96	Social Science Seminar	Ec95	G(A)	2	Elective	3	—	6	——
Ec97	Read. Sem. in Econ.	Ec17	G(A)	1	Elective		★		——
Ec98	Read. Sem. in Econ.	Ec17	G(A)	2	Elective		★		——

ENGINEERING PRACTICE SCHOOLS — EPS1–EPS99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
EPS1	Eng. Prac. School at Oak Ridge	——	G(A)	1 or 2	Elective	0	12	0	Vivian
EPS2	Eng. Prac. School at Oak Ridge	EPS1	G(A)	1 or 2	Elective	0	12	0	Vivian
EPS3	Eng. Prac. School at Oak Ridge	EPS2	G(A)	1 or 2	Elective	0	12	0	Vivian

ENGLISH AND HISTORY — E1–E99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
E1	English, Entrance	——	—	S	——	2	—	5	——
E11	English Composition	——	1	1	All courses	3	—	5	Urbach
E12	English Composition	E11	1	2	All courses	3	—	5	Urbach
E21	History								
	U. S. in World History	——	2	1	All courses	3	—	5	Rae
	Growth of Dem. Thought	——	2	1	All courses	3	—	5	Edgerly
E22	History								
	U. S. in World History	——	2	2	All courses	3	—	5	Rae
	Growth of Dem. Thought	——	2	2	All courses	3	—	5	Edgerly
E25	English Composition	——	3, 4	1 or 2	Elective		★		Urbach
E35T	Reports	E22	3	1	XV-A, XV-B	1	—	4	Ulman
			3	2	Elective				
E36	Seminar in Technical Writing	E22	3, 4	1 or 2	Elective	2	—	4	Ulman
E37	Public Speaking	——	2	1	IV-B	3	—	3	Marsh
E38	Public Speaking	——	2	2	Elective	3	—	3	Marsh
E401	History of Philosophy	E22	3,4	1	Elective	3	—	5	Wiener
E402	Problems of Mod. Phil.	E22	3,4	2	Elective	3	—	5	de Santillana
E41	History of Ideas	E22	4	1	Elective	3	—	5	Deutsch
E411	Problems in Philosophy	——	G	1	Elective	3	—	6	de Santillana
E412	Problems in Philosophy	——	G	2	Elective	3	—	6	de Santillana
E42	History of Ideas	E22	4	2	Elective	3	—	5	Deutsch
E43	Books and Men	E22	4	1	Elective	3	—	5	Greene
E431	Read. Sem. in Famous Books.	——	G	1	Elective	3	—	6	Greene, Morison, Urbach
E432	Read. Sem. in Famous Books.	——	G	2	Elective	3	—	6	Greene, Morison, Urbach
E44	Books and Men	E22	4	2	Elective	3	—	5	Greene
E45	Music, Int.	——	4	1	Elective	3	—	5	Liepmann
E46	Music Through the Ages	E45	4	2	Elective	3	—	5	Liepmann
E47	Books and Men	E43, E44	4	1	Elective	3	—	5	Wood
E48T	Books and Men	E43, E44	4	2	Elective	3	—	5	Wood
E51	Mod. Industrial Society	E22	4	2	Elective	3	—	6	Ballantine
E511	Economic & Industrial History	——	G	1	Elective	3	—	6	Deutsch

★ Time specially arranged.

English and History Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
E512	Economic & Industrial History	—	G	2	Elective	3	—	6	Deutsch
E61	History of Early Math.	—	4	2	Elective	3	—	6	Struik
E62‡	History of Modern Math.	—	4	2	Elective	3	—	6	Struik
E67	Debate and Discussion	—	—	1	Elective	3	—	3	Marsh

MODERN LANGUAGES — L1–L99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
L11	German, Elem.	—	—	1	Elective	3	—	5	Condoyannis
			2	1	XIX				
L111	German, Elem.	—	2	1	Elective	3	—	5	Condoyannis
L12	German, Elem.	L11	—	2	Elective	3	—	5	Condoyannis
			2	2	XIX				
L13	German, Int.	L12, or Elem. Entrance German	—	1	Elective	3	—	5	Klugman
L14	German, Int.	L13	—	2	Elective	3	—	5	Steinmetz
L17	Scientific German	—	G	1	Elective	3	—	6	Raven
L51	French, Elem.	—	—	1	Elective	3	—	5	Locke
L52	French, Elem.	L51	—	2	Elective	3	—	5	Locke
L53	French, Int.	L52 or Elem. Entrance French	—	1	Elective	3	—	5	Locke
L54	French, Int.	L53	—	2	Elective	3	—	5	Locke
L57	Scientific French	—	G	2	Elective	3	—	6	Locke
L81	Spanish, Elem.	—	—	1	Elective	3	—	5	Koch
L82	Spanish, Elem.	L81	—	2	Elective	3	—	5	Raven
L83	Spanish, Int.	L82	—	1	Elective	3	—	5	Azuola
L84	Spanish, Int.	L83	—	2	Elective	3	—	5	Azuola
L91	Russian, Elem.	—	—	1	Elective	3	—	5	Znamensky
L92	Russian, Elem.	L91	—	2	Elective	3	—	5	Znamensky
L93	Russian, Int.	L92	—	1	Elective	3	—	5	Znamensky
L94	Russian, Int.	L93	—	2	Elective	3	—	5	Znamensky
L97	Scientific Russian	—	G	2	Elective	3	—	6	Znamensky

MATHEMATICS — M1–M99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
M1	Algebra, Entrance	—	—	S	—	2	—	5	—
M3	Solid Geom., Entrance	—	—	S	—	2	—	5	—
M4	Trigonometry, Entrance	—	—	S	—	2	—	5	—
M10	Calculus	—	—	1	—	3	—	6	Phillips
M11	Calculus	Entrance Algebra, Solid Geometry, Trigonometry	1	1	All courses	3	—	6	Douglass
M112‡	Mathematics (College Transfer)	—	1	1	—	3	—	6	Douglass
M12	Calculus	M11	1	2	All courses	3	—	6	Douglass
M21	Calculus	M12	2	1	All courses 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	3	—	6	Wadsworth
			3	1	XIX				
M331	Math. Th. of Statistics	M22, M32	3	1	Elective	3	—	6	Wadsworth
M332	Math. Th. of Statistics	M22, M32	3	2	Elective	3	—	6	Wadsworth
M341	Modern Statistical Th.	M332	4	1	Elective	3	—	6	Wadsworth
M342‡	Modern Statistical Th.	M332 or M341	4	2	Elective	3	—	6	Wadsworth
M351	Adv. Calculus for Engineers	M22	G(A)	1	Elective	3	—	6	Hildebrand
M352	Adv. Calculus for Engineers	M351	G(A)	2	Elective	3	—	6	Hildebrand

‡ Not offered 1949–50.

Mathematics Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
M36	Advanced Calculus	M22	G(A)	1	Elective	3	—	6	Douglass
			3	1	IX-A, XII(2)				
			3	2	VI-A(B)				
			4	2	VI-A(A)				
			G	1	XIII-A				
M37	Advanced Calculus	M22	G(A)	2	Elective	3	—	6	Douglass
			3	2	VIII, IX-A XII(2)				
			G	S	VI-A(B)				
			G	2	XIII-A				
M371	Operations Research	M36 or M77 or M831	G	1	Elective	3	—	6	Wadsworth
M372	Operations Research	M371	G	2	Elective	3	—	6	Wadsworth
M381	Theory of Functions	M352 or M831	G(A)	1	Elective	3	—	9	Thomas
M382	Theory of Functions	M381	G(A)	2	Elective	3	—	9	Franklin
M42	Hydromechanics, Int.	M351 or M36 or M37	4	2	Elective	3	—	6	Lin
M421‡	Theoretical Hydromechanics	M352 or M381	G(A)	1	Elective	3	—	9	Lin
M422‡	Theoretical Hydromechanics	M352 or M381	G(A)	2	Elective	3	—	9	Lin
M441‡	Projective Geometry	M22	3	1	Elective	3	—	6	Struik
M442	Diff. Geometry, Elem.	M22	4	1	Elective	3	—	6	Struik
M451	Fourier Series & Integrals	M382, M551	G(A)	1	Elective	3	—	9	Salem
M452	Fourier Series & Integrals	M381 or M831	G(A)	2	Elective	3	—	9	Wiener
M461‡	Seminar in App. Math.	M352 or M37 or M381 or M832	G(A)	2	Elective	3	—	9	Lin, Reissner
M481	Topology	M62; M381 or M831	G(A)	1	Elective	3	—	9	Ambrose
M482	Topology	M481	G(A)	2	Elective	3	—	9	Ambrose
M483	Advanced Topology	M482	G(A)	1	Elective	3	—	9	Hurewicz
M52	Topics in the Th. of Numbers	M381	G(A)	1	Elective	3	—	9	Apostol
M54	Mathematical Lab.	M22	3	2	Elective	3	—	6	Douglass
M551	Funct. of Real Variable	M381 or M831	G(A)	2	Elective	3	—	9	Hurewicz
M552	Funct. of Real Variable	M551	G(A)	1	Elective	3	—	9	Browder
M561	Functions of a Complex Var.	M382, M481	G(A)	2	Elective	3	—	9	Mautner
M562	Functions of a Complex Var.	M382	G(A)	2	Elective	3	—	9	Springer
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	M22	G(A)	1	Elective	3	—	9	Zeldin
M582‡	Continuous Groups	M581	G(A)	2	Elective	3	—	9	Zeldin
M591	Partial Differential Equations	M351 or M36 or M381 or M831	G(A)	1	Elective	3	—	9	Lin
M592‡	Partial Differential Equations	M591	G(A)	2	Elective	3	—	9	Lin
M61†	Math. Logic	M381 or M62	G(A)	1	Elective	3	—	9	Pitts
M62	Modern Algebra	M22	3	1 or 2	Elective	3	—	6	I. S. Cohen
M63	Algebra	M62	G(A)	1	Elective	3	—	9	G. W. Whitehead
M631	Integral Equations	M22	G(A)	2	Elective	3	—	9	Crout
M64‡	Group Representations	M381 or M831; M62	G(A)	2	Elective	3	—	9	Mautner
M641	Tensor Calculus	M22	G(A)	2	Elective	3	—	9	Struik
M642‡	Tensor Calculus	M641	G(A)	2	Elective	3	—	9	Struik
M65	Operator Th. in Hilbert Sp. & Found. Quant. Mech.	M551 or M591 or M691	G(A)	1	Elective	3	—	9	Pitts
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	Pitts
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	Thomas
M691‡	Charact. Value Prob.	M351 or M36 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
M731‡	Mechanics	M22	3	1	Elective	3	—	6	Crout
M732‡	Mechanics	M731	3	2	Elective	3	—	6	Crout
M76	Th. of Probability	M21	G(A)	2	Elective	3	—	9	Struik
M77	Vector Analysis	*M22*	3	1	Elective	3	—	6	Crout
M78‡	Th. of Elasticity, Int.	M351 or M36 or M37	4	1	Elective	3	—	6	Reissner

‡ Not offered 1949-50.

Mathematics Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
M791	Th. & App. Elasticity	M351 or M36 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	3	1	XVIII	3	—	9	Coddington
M832	Analysis	M831	3	2	XVIII	3	—	9	Coddington
M833	Analysis	M831	4	1	Elective	3	—	6	Hurewicz
M84	Complex Variables & App., Int.	M351 or M36 or M37 or M831	4	2	Elective	3	—	6	Lin
M90	Math. Reading	——	G(A)	1 or 2	Elective		★		Martin

MILITARY SCIENCE — MS1–MS99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
MS11	Military Science	——	1	1	All courses	2	1	0	Bearce
MS12	Military Science	——	1	2	All courses	2	1	0	Bearce
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	Bruce
MS213	Signal Corps	MS11, MS12	2	1	All courses	2	1	0	Foster
MS214	Ordnance Department	MS11, MS12	2	1	All courses	2	1	0	Crossman
MS215	Air Force	MS11, MS12	2	1	All courses	2	1	0	Lineham
MS216	Chemical Corps	MS11, MS12	2	1	All courses	2	1	0	Fitzpatrick
MS217	Army Security Agency	MS11, MS12	2	1	All courses	2	1	0	Bearce
MS218	Quartermaster Corps	MS11, MS12	2	1	All courses	2	1	0	Varner
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	Bruce
MS223	Signal Corps	MS213	2	2	All courses	2	1	0	Foster
MS224	Ordnance Department	MS214	2	2	All courses	2	1	0	Crossman
MS225	Air Force	MS215	2	2	All courses	2	1	0	Lineham
MS226	Chemical Corps	MS216	2	2	All courses	2	1	0	Fitzpatrick
MS227	Army Security Agency	MS217	2	2	All courses	2	1	0	Bearce
MS228	Quartermaster Corps	MS218	2	2	All courses	2	1	0	Varner
MS312	Corps of Engineers, Adv.	MS222	3	1	All courses	3	0	1	Bruce
MS313	Signal Corps, Adv.	MS223	3	1	All courses	3	0	1	Foster
MS314	Ordnance Department, Adv.	MS224	3	1	All courses	3	0	1	Crossman
MS315	Air Force, Adv.	MS225	3	1	All courses	3	0	1	Lineham
MS316	Chemical Corps, Adv.	MS226	3	1	All courses	3	0	1	Fitzpatrick
MS317	Army Security Agency, Adv.	MS227	3	1	All courses	3	0	1	Bearce
MS318	Quartermaster Corps, Adv.	MS228	3	1	All courses	3	0	1	Varner
MS322	Corps of Engineers, Adv.	MS312	3	2	All courses	3	0	1	Bruce
MS323	Signal Corps, Adv.	MS313	3	2	All courses	3	0	1	Foster
MS324	Ordnance Department, Adv.	MS314	3	2	All courses	3	0	1	Crossman
MS325	Air Force, Adv.	MS315	3	2	All courses	3	0	1	Lineham
MS326	Chemical Corps, Adv.	MS316	3	2	All courses	3	0	1	Fitzpatrick
MS327	Army Security Agency, Adv.	MS317	3	2	All courses	3	0	1	Bearce
MS328	Quartermaster Corps, Adv.	MS318	3	2	All courses	3	0	1	Varner
MS412	Corps of Engineers, Adv.	MS322	4	1	All courses	3	0	1	Bruce
MS413	Signal Corps, Adv.	MS323	4	1	All courses	3	0	1	Foster
MS414	Ordnance Department, Adv.	MS324	4	1	All courses	3	0	1	Crossman
MS415	Air Force, Adv.	MS325	4	1	All courses	3	0	1	Lineham
MS416	Chemical Corps, Adv.	MS326	4	1	All courses	3	0	1	Fitzpatrick
MS417	Army Security Agency, Adv.	MS327	4	1	All courses	3	0	1	Bearce
MS418	Quartermaster Corps, Adv.	MS328	4	1	All courses	3	0	1	Varner
MS422	Corps of Engineers, Adv.	MS412	4	2	All courses	3	0	1	Bruce
MS423	Signal Corps, Adv.	MS413	4	2	All courses	3	0	1	Foster
MS424	Ordnance Department, Adv.	MS414	4	2	All courses	3	0	1	Crossman
MS425	Air Force, Adv.	MS415	4	2	All courses	3	0	1	Lineham
MS426	Chemical Corps, Adv.	MS416	4	2	All courses	3	0	1	Fitzpatrick
MS427	Army Security Agency, Adv.	MS417	4	2	All courses	3	0	1	Bearce
MS428	Quartermaster Corps, Adv.	MS418	4	2	All courses	3	0	1	Varner

★ 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, Teaching Fellowships 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 — full tuition, 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 March 15 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 co-operate 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 co-operating 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, 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.

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 '96 FUND (1923). Received from the Class of 1896 to found a scholarship to be awarded subject to the approval of the Secretaries of the Class. Preference in making awards will be given to descendants of members of the Class of 1896, including freshmen, and grants from this fund are to be considered as loans to be repaid by the recipients when and if able.

CLASS OF 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 $800 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.

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.

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.

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."

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 $1,000 (full tuition plus $200) 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 $800 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 $25,000 from Redfield Proctor of the Class of 1902 to found a scholarship "in memory of Vermonters who, having received their education at the Institute, served as engineers in the Armies of the Allies in the World War." The income is awarded annually "to worthy students . . . preference to any bona fide residents of Vermont doing undergraduate work at the Institute of Technology, and also Vermont students doing graduate work, or students who are graduates of or transfers from Middlebury College or Norwich University . . . who shall meet regular scholastic and other requirements."

UNDERGRADUATE SCHOLARSHIP AID FOR UPPER CLASSMEN

In addition to the Freshmen Scholarships, the Institute holds funds from the income of which awards are made to students in the upper undergraduate years. It is the policy of the Faculty Committee on Undergraduate Scholarships to assist as many well qualified students as possible by assigning, in general, amounts less than full tuition. Awards are made only to students who have completed at least a year of satisfactory work at the Institute.

In making selections, the ability of the student, as indicated by the scholastic record, is the primary consideration. However, account is also taken of the applicant's evidences of need for financial assistance, of his good character, and of his general worthiness and professional promise. Applications should, except as noted below, be made on blanks to be obtained at Room 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:

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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 Undergraduate Scholarship Committee and final approval by the American Brake Shoe Company.

AMERICAN SMELTING AND REFINING COMPANY (1946). Gift of the company to establish prize awards of $500 each to five Course III students whose academic programs emphasize pyro-metallurgy. Preference is to be accorded to men whose college studies were interrupted by military or naval duty during World War II. Recipients are to be selected by the Head of the Course in Metallurgy, subject to approval by the Faculty Committee on Undergraduate Scholarships, from among candidates who are "physically sound and in their twenties." Preference will be given to third year students in making an initial award, but fourth year students with continued good standing will be eligible for renewal of the award.

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."

HARRIET L. BROWN FUND (1932). Bequest of Harriet L. Brown "to be held in trust as a scholarship . . . the income to be given to such needy and deserving young women desiring to become students at M. I. T., as would otherwise be unable to attend; and in case of two or more applicants of equal merit, preference shall be given to a native of either Massachusetts or New Hampshire."

MABEL BLAKE CASE (1920). Bequest of $25,000 from Caroline S. Freeman to be "known as Mabel Blake Case Fund, income to be used to aid deserving students (preferably women) who are in need of assistance."

NINO TESHER CATLIN (1926). Gift from Maria T. Catlin to establish a fund in memory of her son, Nino T. Catlin of the Class of 1918, the income "to be awarded to needy and deserving students."

LUCIUS CLAPP (1905). Gift from Lucius Clapp to form a fund "to aid worthy students who may not be able to complete their studies without help."

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."

LUCRETIA CROCKER (1916). By the will of Matilda H. Crocker, the Institute was made the residuary legatee of her estate "for the establishment of one or more scholarships for women in memory of my sister, Lucretia Crocker . . . the income to aid one or more young women in need of pecuniary assistance in obtaining instruction at said Institute."

ISAAC W. DANFORTH (1903). Bequest of $5,000 from James H. Danforth for scholarship purposes as a memorial to his brother, Isaac Warren Danforth.

ANN WHITE DICKINSON (1898). Bequest of $40,000 from Ann White Dickinson "to establish free scholarships in M. I. T. . . . such persons enjoying benefit . . . shall be worthy young men of American origin."

DORMITORY (1903). Raised by miscellaneous subscriptions and formerly known as Students' Aid Fund.

THOMAS MESSINGER DROWN (1928). Bequest of $50,000 from Mary Frances Drown, "to be used to establish scholarships for deserving undergraduate students, to be known as the Thomas Messinger Drown Scholarships."

FRANCES AND WILLIAM EMERSON FUND (1930). Awards not exceeding $600 to students in the School of Architecture. Applications should be made directly to the Dean of the School of Architecture.

FARNSWORTH (1889). Founded by Mrs. Mary E. Atkins of Boston with a gift of $5,000.

CHARLES LEWIS FLINT (1889). Bequest of $5,000 from Charles L. Flint, for the "support of some worthy student, preference to be given to some graduate of the English High School, Boston."

SARAH S. FORBES (1913). Originally a fund of $2,800 given in trust in 1868 by Sarah S. Forbes to William Barton Rogers and Henry S. Russell, trustees, and transferred in 1913 to the Institute, "for the maintenance and education of a scholar in M. I. T."

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 1896, "for the aid of deserving students . . . of insufficient means, said fund, together with any other sums which said institution may receive under this will, to be known as the James H. Haste Fund."

GEORGE HOLLINGSWORTH (1916). Bequest of $5,000 from Rose Hollingsworth to found the George Hollingsworth Scholarship.

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."

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 Dean of Students.

RUPERT ANDERSON MARDEN (1933). Established by an anonymous gift "toward a memorial to be known as the Rupert Anderson Marden Scholarship Fund, income available annually to aid a worthy student at M. I. T. — Protestant and of American origin — preference to a student taking the Cooperative Course in Electrical Engineering."

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. . . ."

NICHOLS (1895). Bequest of $5,000 from Mrs. Betsy F. W. Nichols to constitute The Nichols Scholarship in memory of her son William Ripley Nichols of the Class of 1869, for sixteen years Professor of General Chemistry at the Institute. Preference is given to students in the Course in Chemistry.

CHARLES C. NICHOLS (1904). Bequest of $5,000 from Charles C. Nichols to constitute a scholarship.

JOHN FELT OSGOOD (1909). Bequest of $5,000 from Eliza B. Osgood "to establish and maintain a scholarship in Electricity in memory of my husband, John Felt Osgood."

GEORGE L. PARMELEE (1921). Bequest from George L. 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."

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 by the Scholarship Committee on recommendation of the Head of the Department of Chemical Engineering.

JOHN P. SCHENKL (1922). Bequest of $20,000 from Johanna Pauline Schenkl "to be held in trust to establish one or more scholarships in the Department of Mechanical Engineering" in memory of her father, John P. Schenkl.

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.

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 $25,000 from Redfield Proctor of the Class of 1902 to found a scholarship "in memory of Vermonters who, having received their education at the Institute, served as engineers in the Armies of the Allies in the World War." The income is awarded annually "to worthy students . . . preference to any bona fide residents of Vermont doing undergraduate work at the Institute of Technology, and also Vermont students doing graduate work, or students who are graduates of or transfer from Middlebury College or Norwich University . . . who shall meet regular scholastic and other requirements."

ANN WHITE VOSE (1896). Bequest from Ann White Vose of $25,000 "plus one half of the remainder of my estate . . . to establish free scholarships in M. I. T. . . . such persons enjoying benefit . . . shall be worthy young men of American origin."

ARTHUR M. WAITT (1925). Bequest of $10,000 from Arthur M. Waitt, for "assisting needy and deserving students in the second-, third-, and fourth-year classes of the Mechanical Engineering Course of said Institute."

GRANT WALKER FUND (1943). Bequest of $50,000 "the income to be used for scholarships for deserving students in said Institute."

JAMES WATT (1942). Bequest of Jennie A. Douglas, to establish "a scholarship in Mechanical Engineering to be known as the James Watt Scholarship."

HERMAN E. WEIHMILLER FUND (1942). Gift of H. E. Weihmiller of the Class of 1925 in memory of his late father "for aiding students or prospective students of M. I. T., who are deserving of financial aid in furtherance of, or as assistance towards, an aeronautical career at M. I. T. . . . without restriction as to sex, creed, color or nationality."

LOUIS WEISSBEIN (1915). Bequest of $4,000 from Louis Weissbein "to found a scholarship to be awarded each year to a promising student, preference to be given a Jewish boy in making the award."

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 2,800 M. I. T. students have borrowed more than $2,000,000 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 $2,400 during his undergraduate period, or $3,200 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 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.

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.

PRIZES

AMERICAN SOCIETY OF TOOL ENGINEERS (1945). Gift of the Boston Chapter of the Society. A monetary prize of $100 offered annually for the best graduation thesis on a subject related to the professional field of tool engineering.

ROBERT A. BOIT (1921). Bequest of $5,000 from Robert A. Boit, to provide annual prizes "to stimulate the interest in the best use of the English language." Awards are made to first- and second-year men on the basis of essays written on topics announced by the Department of English and History.

JAMES MEANS MEMORIAL (1925). A medal and monetary prize of $100 offered annually for the best thesis on an aeronautical subject. Joint thesis may be entered and, if successful, duplicate medals will be awarded and the prize divided. Open only to candidates for the Bachelor's degree.

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 the Graduate School 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.*, Post-doctoral 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 the Graduate School 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 the Graduate School.

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 the Graduate School.

Correspondence concerning scholarships should be addressed to the Chairman of the appropriate Departmental Committee on Graduate Students (see page 80).

ASSISTANTSHIPS AND TEACHING FELLOWSHIPS

Assistantships and Teaching Fellowships are sub-faculty staff appointments made upon recommendations of heads of departments to whom applications shall be addressed either with, or subsequent to, application for admission to the Graduate School.

A "full-time" staff appointee, if also a graduate student, may register for approximately 18 units per term of scheduled subjects (exclusive of thesis based on contract or other assigned research) toward an advanced degree; a "half-time" similar appointee may register for approximately 30 units per term; Veterans who are academically qualified are eligible for one-third time Assistantships which permit registration for 38 units per term as a graduate student. (This permits at least 12 class hours per term.)

Graduate students, whether or not they are also on the staff, may apply for financial assistance to the Technology Loan Fund Board.

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 19, 1949, unless otherwise specified.

Acoustics Laboratory

ARMSTRONG CORK COMPANY, for a graduate student whose field of specialization is under supervision of this Laboratory, primarily in last year of work for an advanced degree, tuition plus $1,200 single, $1,800 married.

Aeronautical Engineering

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 1949–50.)

GOODYEAR TIRE AND RUBBER COMPANY, for a graduate student, $1,500. (Two available for 1949–50.)

Biology

STANDARD BRANDS, INC., see Food Technology.

Business and Engineering Administration

STANDARD OIL COMPANY OF CALIFORNIA, for a graduate student whose undergraduate major was in chemistry or chemical engineering, tuition plus $1,250.

Chemical Engineering

ALLIED CHEMICAL AND DYE CORPORATION, for a U. S. citizen in final year of graduate study, tuition plus $1,200.

AMERICAN CYANAMID COMPANY, for a graduate student during his final academic year of residence in work toward an advanced degree, tuition plus $1,200.

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.

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 $1,200 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, $1,900.

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. degree, or in any year of his work toward a Doctorate, for three terms, tuition plus $1,800.

STANDARD BRANDS, INC., see Food Technology.

STANDARD OIL COMPANY OF CALIFORNIA, for a graduate student whose academic work toward an advanced degree preferably starts in 1949, tuition plus $1,250.

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.

Chemistry

ALLIED CHEMICAL AND DYE CORPORATION, for a U. S. citizen in final year of graduate study, tuition plus $1,200.

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 $1,200 single, $1,800 married.

E. I. DU PONT DE NEMOURS AND COMPANY, for advanced research (postdoctoral) in Chemistry, for 12 months, $3,000.

ARTHUR D. LITTLE, memorial fellowship for a candidate for a Doctorate in Chemistry, $2,000.

MOORE, for a graduate of the Institute for further study in residence or elsewhere, preference being given to the field of Organic Chemistry, $1,800.

UNITED STATES RUBBER COMPANY, for a candidate for a Doctorate, tuition plus $1,200 single, $1,800 married.

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.

Electrical Engineering

AIRBORNE INSTRUMENTS COMPANY, for a graduate student preferably interested in broad-band high-frequency systems, 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 the S.M. degree or a Doctorate, tuition plus $1,200 single, $1,800 married.

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, and Socony-Vacuum Laboratories.

Food Technology

BRUCE'S JUICES, INC., for a male U. S. citizen, veteran of World War II, a graduate student, not to exceed $2,000.

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.

STANDARD BRANDS, INC., for a graduate student whose thesis research is in a field applicable to the food industry, tuition plus $1,200.

Mathematics

APPLIED MATHEMATICS, for graduate students who are studying in the Department of Mathematics for careers of research or teaching in fields which involve extensive applications of mathematics, tuition plus $700.

Mechanical Engineering

E. I. DU PONT DE NEMOURS AND COMPANY, for a graduate student in any year of his work toward the S.M. degree or a Doctorate, tuition plus $1,200 single, $1,800 married.

SHELL, for a graduate student, candidate for the S.M. or Sc.D., preference to be given to doctoral candidate; renewable, tuition plus $1,200.

Metallurgy

AMERICAN BRAKE SHOE COMPANY, for a graduate student, tuition plus $1,000.

ARMOUR AND COMPANY, for a graduate student whose thesis research pertains to the field of dry cyaniding in the Department of Metallurgy, $1,100.

ARMOUR AND COMPANY, for graduate students whose thesis research is in the field of Flotation in the Department of Metallurgy. Several available for 1949–50, tuition plus up to $2,000.

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 satisfactory progress. Several available for 1949–50, tuition plus $1,200 to $2,400.

REVERE COPPER AND BRASS COMPANY, for a graduate student, tuition plus $1,200.

UNION CARBIDE AND CARBON, for a graduate student for research in the metallurgical field, tuition plus $1,200.

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.

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

GULF OIL CORPORATION, for a graduate student whose major work is in the field of petroleum physics in the Department of Physics, $1,500.

HARSHAW CHEMICAL COMPANY, for a graduate student, preferably enrolled for the Doctorate, in the field of crystals in the Department of Physics. More than one award may be made during any year; renewable. For S.M. candidate, tuition plus $600 single, $900 married; for Doctoral candidate, tuition plus $1,200 single, $1,800 married.

Textile Technology

CHICOPEE MANUFACTURING COMPANY, for a graduate student in any year of his work toward the S.M. or a Doctorate in a field of Textile Technology. Among equally qualified applicants, preference will be given to a graduate of the Lowell Textile Institute, or to a student who has had or will elect some work in Business and Engineering Administration, $1,200.

CLARK THREAD COMPANY, for graduate students in a field of textile technology whose thesis research is in that Division, three for 1949–50, tuition plus $1,200.

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 1949–50, $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.

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.

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 1949–50, $1,000.

GRADUATE SCHOLARSHIPS

Unrestricted

AUSTIN and WHITNEY FUNDS	$48,300
COLLAMORE and ROGERS FUNDS (for women)	2,000
DALTON FUND	300
SALTONSTALL FUND	475
SAVAGE FUND	585
SWETT FUND	475

In Specified Fields

F. W. CHANDLER, in City Planning, awarded upon recommendation of Head of Department. (Holders of tuition scholarships are eligible.) $450.

WILFRED LEWIS, in Mechanical Engineering. $300.

R. L. RUSSELL, in Civil Engineering. $180.

THORP FUND, for a member of previous year's graduating class of M. I. T., studying for an advanced degree in Chemical Engineering. $470.

VERGES FUND, for a graduate student whose research is related to sugar chemistry. $465.

Regional Awards

CAUCA UNIVERSITY, Colombia, tuition.

ESCUELA ESPECIAL DE INGENIEROS INDUSTRIALES, Madrid, Spain, tuition.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, London, England, tuition.

M. I. T. CLUB OF MEXICO. For a graduate student nominated by the M. I. T. club of Mexico, tuition.

NATIONAL SCHOOL OF ENGINEERS, Lima, Peru, tuition.

THEODORE B. PARKER MEMORIAL for graduates of colleges of the Tennessee Valley States, tuition.

VERMONT SCHOLARSHIP. Open to a native of Vermont or a graduate of Middlebury College or Norwich University. Undergraduate applications have preference, tuition.

APPENDIX B

DIRECTORY OF HONORARY SECRETARIES

THE Honorary Secretaries listed below are alumni "Ambassadors of Technology" in communities throughout the United States and in selected foreign centers. Prospective applicants for admission to the First-Year Class, living more than 100 miles from Cambridge, are referred to the nearest Honorary Secretary for a conference as a part of the required entrance procedure.

The Honorary Secretary is not expected to be a source of detailed information on entrance requirements, credits and the like, nor does he make, on behalf of the Institute, commitments regarding admission or the award of scholarships. All such matters should be taken up directly with the proper officers of the Institute. The function of the Honorary Secretary is to advise the student regarding his educational program and objectives, and to assist the Admissions Office in the selection of the limited number of applicants accepted each year in the entering class.

Students wishing to enter with advanced standing, or as members of the graduate school, are likewise encouraged to confer with the nearest Honorary Secretary, but are not required to do so.

ALABAMA

Birmingham — Douglas F. Elliott, '24, Alabama Power Co., 600 N. 18th St.

ARIZONA

Phoenix — Charles F. Willis, '06, 528 Title and Trust Bldg.

CALIFORNIA

Los Angeles — Ralph B. Atkinson, '29, Atkinson Laboratory, 7273 Santa Monica Blvd., Hollywood.
Kenneth C. Kingsley, '23, c/o Keyaction Corp., 1138 Mission St., So. Pasadena
Charles H. Toll, Jr., '23, 1028 Subway Terminal Bldg., 417 So. Hill St.

San Francisco — Richard L. Cheney, '27, Glass Container Mfr.'s Institute, Room 610, 110 Market St.
Allen W. Horton, Jr., '36, Standard Oil Co. of Calif., Standard Oil Bldg.
George D. Whittle, '08, Bridge Engineer, Public Roads Administration, 720 Phelan Bldg., 760 Market St.

COLORADO

Colorado Springs — Robert H. Cotton, '39, Director of Research, Holly Sugar Corp.

Denver — Alfred E. Perlman, '23, Chief Engineer, Denver & Rio Grande Western R.R., Rio Grande Bldg., 1531 Stout St.

CONNECTICUT

Bridgeport — Gilbert C. Mott, '37, 77 Rocton Ave.
Edward L. Wemple, '34, Remington Arms Co., 939 Barnum Ave.

Hartford — Thomas D. Green, '26, 38 Montclair Dr., W. Hartford.
Thomas B. Rhines, '32, Hamilton Standard Propellers, E. Hartford.

New Britain — Albert S. Redway, '23, President, The American Paper Goods Co., Kensington, Conn.

New Haven — E. B. Haskell, '26 Commercial and Industrial Manager, United Illuminating Co., 80 Temple St.

Waterbury — Harold G. Manning, '12, The Post College Bldg., 24 Central Ave.

DELAWARE

Wilmington — Walter J. Beadle, '17, DuPont Building.
C. A. Cary, '25, E. I. DuPont de Nemours Co., Rayon Department.
Pierre S. DuPont, III, '33, 13096 DuPont Bldg.

DISTRICT OF COLUMBIA

Washington — Albert F. Bird, '30, Navy Department, Bureau of Ships.
Joseph Y. Houghton, '26, 906 American Bldg., 1317 F St., N.W.
William K. MacMahon, '22, Washington Gas Light Co., 1100 H St., N.W.
Edward D. Merrill, '09, Capital Transit Co., 36th and M Sts., N.W.
George D. Mock, '28, Washington Gas Light Co., 1100 H St., N.W.
John W. Sheetz, III, '42, Dept. of the Navy, Office of Naval Research.
Robert K. Thulman, '22, Housing & Home Finance Agency, 1626 K St., N.W.

FLORIDA

Jacksonville — George W. Simons, Jr., '15, Hildebrandt Bldg.

Miami — B. Howard Brown, '30, 70 S.W. 27th Rd.
Fred E. Zurwell, '20, Zurwell-Whittaker Inc., Consulting Engineers, 605 Lincoln Rd.

Orlando — Frank E. Penn, '40, Vacuum Foods Corp., Plymouth.

St. Petersburg — William H. Mills, '34, P.O. Box 264.

Tampa — Franklin O. Adams, '07, 404 Franklin St.

GEORGIA

Atlanta — James F. Crist, '24, Vice President, The Southern Co., 1216-21 William Oliver Bldg.
William E. Huger, '22, Courts & Co., 11 Marietta St., P.O. Box 1295.

ILLINOIS

Chicago — Louis H. G. Bouscaren, '04, Stone and Webster Engineering Corp., 33 S. Clark St.
Edmund G. Farrand, '21, United Conveyor Corp., 1200 Old Colony Bldg., 37 W. Van Buren St.
Lauren B. Hitchcock, '20, Quaker Oats Co., Board of Trade Bldg.
Bruce T. Humphreville, '26, Johns-Manville Corp., Merchandise Mart, 222 N. Bank Drive.
P. F. Lavedan, '20, President, The Liquid Carbonic Corp.
Sherry O'Brien, '17, 1200 Lake Shore Dr.
Ralph Sargent, '18, Sargent & Lundy, 140 S. Dearborn St.
William Steinwedell, '25, Fansteel Metallurgical Corp., No. Chicago.
Edmund Q. Sylvester, '34, Griffin Wheel Co., 410 N. Michigan Ave.
Willard M. Woll, '26, Commonwealth Edison Co., 72 West Adams St.

Elgin — G. R. Stevens, '17, President, Elgin Mfg. Co.

Hinsdale — Bruce T. Humphreville, '26, 503 S. Grand St.

Rockford — Arthur B. Brand, '26, Cummings, Brand & McPherson, Advertising, 409 Gas-Electric Bldg.

Waukegan — Robert N. Nelson, '30, 2446 Iroquois Rd., Wilmette.

Winnetka — Louis H. G. Bouscaren, '04, 646 Prospect Ave.
William Steinwedell, '25, 693 Walden Rd.

INDIANA

Fort Wayne — Frederick P. Feustel, '33, Indiana & Michigan Electric Co., 2101 Spy Run Ave.

Indianapolis — T. G. Harvey, '28, 5685 No. Delaware St.
Lowell L. Holmes, '23, Management Research Associates, 635 N. Pennsylvania St.

Kokomo — F. S. Badger, '27, Vice-President and Technical Director, Haynes Stellite Co., Division Union Carbide & Carbon, So. Lindsey St.

IOWA

Des Moines — Harold C. Neumann, '17, Arthur H. Neumann & Bros., Inc., Hubbell Bldg.

Dubuque — Richard V. McKay, '06, Key City Gas Co., 669 Main St.

KANSAS

Wichita — Fred C. Koch, '22, Wood River Oil & Refining Co., Inc., 501 K. F. H. St.

KENTUCKY

Louisville — T. W. Rucker, III, '31, Vice President, General Plywood Corp.

LOUISIANA

New Orleans — Theo O. Hotard, '12, Commissioner of Public Property, City of New Orleans.

MAINE

Augusta — Willard B. Purinton, '22, Purinton Bros. Co., 333 Water St.

Bangor — Frank A. Knight, '38, Eastern Corp.

Portland — Stanley W. Hyde, '17, Principal, N. Yarmouth Academy, Yarmouth.

MARYLAND

Baltimore — J. Carl Fisher, '17, Consolidated Gas-Electric Light and Power Co., Lexington Bldg.
Melvin C. Rose, '21, 320 St. Paul Place.
George W. Spaulding, '21, 1605 Lexington Bldg,

MASSACHUSETTS

Springfield — Ralph E. Curtis, '15, Curtis Universal Joint Co., Inc., 4 Birnie Ave.

MICHIGAN

Detroit — Morgan Collins, '27, Divisional Controller, Lincoln-Mercury Division, 6200 W. Warren Ave.
Charles T. Ellis, '17, 1377 Harvard Rd., Grosse Pointe Park.
Allyne C. Litchfield, '17, U. S. Rubber Products, Inc., 6600 E. Jefferson Ave.
Adam K. Stricker, Jr., '29, General Motors Corp., General Motors Bldg., 3044 W. Grand Blvd.

Kalamazoo — W. A. Kirkpatrick, '32, Technical Director, Allied Paper Mills.

MINNESOTA

Minneapolis — Willis R. Salisbury, '12, The Salisbury Co., 104 2d Ave., S. E.

St. Paul — Winter Dean, '21, Nicols, Dean and Gregg, 177 W. Fifth St.

MISSISSIPPI

Jackson — Donald B. Gilman, '32, Mississippi Products, Inc.

MISSOURI

Kansas City — James C. Irwin, '18, U. S. Cold Storage Corp., 500 E. 3d St.
Wesley H. Loomis, III, '35, Loomis Advertising Co., 20 W. Ninth St. Bldg.

St. Louis — Delos G. Haynes, '09, 818 Olive St.
Otway W. Rash, '32, Lambert Pharmacal Co., 2117 Franklin Ave.
Wesley W. Wedemeyer, '30, Wedemeyer & Hecker, 111 N. 4th St.

MONTANA

Butte — Walter R. C. Russert, '18, Anaconda Copper Mining Co.

Great Falls — Earl S. Bardwell, '06, 2305 Third Ave., N.

NEBRASKA

Omaha — John M. Hanley, '30, Northern Natural Gas Co., Room 228, Aquila Court.

NEW HAMPSHIRE

Concord — Leigh S. Hall, '14, Hall Bros. Co., 31 S. Main St.

NEW JERSEY

Atlantic City — Harold I. Eaton, '09, Eastern Eng. Co., 4 N. North Carolina Ave.

Bloomfield — Carole A. Clarke, '21, 215 Linden Ave., Glen Ridge.

Camden — W. N. Currier, '31, 232 Elm Ave., Haddonfield.

Dover — Howard B. Allen, '18, N. J. Power and Light Co., 9 W. Blackwell St.

East Orange — George F. Des Marais, '20, 140 Glenwood Ave.

Elizabeth — Donald D. Way, '19, 226 Wychwood Rd., Westfield.

Englewood — Austin R. Caverly, '27, 246 McElroy Ave., Palisade.
Donald G. Fink, '33, 2 Knoll Rd., Tenafly.

Glen Ridge — Stewart C. Coey, '06, 39 Wildwood Ter.

Hackensack — Harold H. Brackett, '12, 515 Summit Ave., Oradell.

Irvington — William J. Grady, '22, 26 North Crescent, Maplewood.

Jersey City — Edwin S. Lockwood, '21, Public Service Electric and Gas Co., 325 Palisade Ave.

Kearny — Dr. Robert V. Townend, '14, 101 Seeley Ave., Arlington.

Manasquan — Munroe C. Hawes, '21, 111 Union Ave.

Maplewood — M. J. Blackwood, '30, 16 Kensington Ter.

Matawan — Channing P. Clapp, '23, 210 Main St.

Millburn — A. Raymond Brooks, '17, 15 Wayside, Short Hills.

Millville — Davis D. Lewis, '17, 825 Columbia Ave.

Montclair — Warren W. Walker, '29, 29 Laurel Place, Upper Montclair.

Morristown — Everett W. Vilett, '22, 91 Whitney Rd., Short Hills.

Newark — Henry C. Colson, Jr., '09, Carnrick Co., 20 Mt. Pleasant Ave.

Orange — Frank Maguire, '17, 201 Vose Ave., S. Orange.

Passaic — Frank L. Bradley, '20, Forstmann Woolen Co.

Paterson — Edmund J. Thimme, '23, Valley View Ter., Packanack Lake.

Plainfield — Geoffrey M. Rollason, '13, Aluminum Co. of America, Garwood.

Ridgewood — Sumner Hayward, '21, 224 Richards Rd.

Rutherford — Newton S. Foster, '28, 15 E. Pierrepont Ave.

Summit — Herman A. Affel, '14, 31 West End Ave.

Trenton — Thomas H. Gill, '22, 9 Stuart Ave., Hillwood Lakes.

Westfield — Lyman L. Tremaine, '23, 422 Baker Ave.

NEW YORK

Albany — John F. Longley, '33, Slingerlands
Burt R. Rickards, '99, 381 State St.

Binghamton — William W. McDowell, '30, International Business Machines Corp., Endicott.

Buffalo — Whitworth Ferguson, '22, Ferguson Electric Construction, Inc., 333 Ellicott St.

Hudson — R. A. Freeman, '26, The V & O Press Co., Division of Rockwell Mfg. Co.

Newburgh — Thomas C. Desmond, '09.

New York — William J. Barrett, '16, Metropolitan Life Ins. Co.
Charles G. Dandrow, '22, Johns-Manville Corp., 22 E. 40th St.
Charles P. Fiske, '14, General Motors Acceptance Corp., 1775 Broadway.

New York Continued

SAXTON W. FLETCHER, '18, President, J. O. Ross Eng. Corp., 350 Madison Ave.
ALFRED T. GLASSETT, '20, W. J. Barney Corp., 101 Park Ave.
G. PETER GRANT, '35, President, Grant Photo Products, Inc., 401 Broadway.
LAURENCE C. HART, '13, Johns-Manville Corp., 22 E. 40th St.
DONALD A. HENDERSON, '25, 20th Century-Fox Film Corp., 444 W. 56th St.
H. D. HUMPHREYS, '34, Seatrain Lines, Inc., 15 Broad St.
IRVING D. JAKOBSON, '21, Jakobson Shipyard, Inc., West End Ave., Oyster Bay, L.I.
WILLIAM H. LATHAM, '26, Director of Maintenance and Operation, Arsenal Building, 5th Ave. and 64th St.
GEORGE J. LENESS, '26, Merrill Lynch, Pierce, Fenner & Beane, 70 Pine St.
DUNCAN R. LINSLEY, '22, First Boston Corporation, 100 Broadway.
P. H. LITTLEFIELD, '24, Vice President, Canada Dry Ginger Ale, Inc., 100 E. 42d St.
JAMES A. LYLES, '27, Vice President, First Boston Corp., 100 Broadway.
WINFIELD I. MCNEILL, '17, Gen. Aniline and Film Corp., 230 Park Ave.
WILLIAM H. MUESER, '22, Moran, Proctor, Freeman and Mueser, 420 Lexington Ave.
DAVID A. WRIGHT, '38, Twenty Exchange Place.

Poughkeepsie — GEORGE T. WELCH, '21, Comptroller and Asst. Treasurer, Vassar College.

Rochester — DWIGHT VANDEVATE, '22, Gleason Works, 1000 University Ave.

Rome — RICHARD A. WILKINS, '18, Revere Copper and Brass Co.

Schenectady — CHARLES J. KOCH, '23, 1185 Ardsley Rd.
RALPH C. ROBINSON, '01, 1138 Oxford Pl.

Syracuse — FREDERICK W. BARKER, '12, Syracuse Savings Bank, 102 N. Salina St.
EDWIN A. GRUPPE, '22, Central N. Y. Power Corp., 300 Erie Blvd. W.

NORTH CAROLINA

Charlotte — BEAUMERT H. WHITTON, '33, Southeastern Constr. Co., 301 W. Second St.

OHIO

Akron — PARRY KELLER, '15, Goodyear Tire and Rubber Co.

Cincinnati — JOHN D. COCHRANE, JR., '23, Formica Insulation Co., 4620 Spring Grove Ave.
GEORGE F. SCHATZ, '30, Harold N. Hermann & Associates, Enquirer Bldg.
ROBERT B. SCHILDKNECHT, '30, Architect, 31 East Fourth St.

Cleveland — HOWARD P. FERGUSON, '27, Standard Oil Co., 1765 Midland Bldg.
WILLIAM C. SESSIONS, '26, Bosworth & Sessions, 1337 Guardian Bldg.
HENRY G. STEINBRENNER, '27, Kinsman Transit Co., 706 Rockefeller Bldg.
G. RICHARD YOUNG, '37, Weatherhead Co., 300 E. 131st St.

Columbus — CLARENCE E. RICHARDS, '18, American Education Press, Inc., 400 South Front St.

Dayton — MICHAEL J. GIBBONS, '06, 116 Thruston Blvd.
W. G. PAYNE, '28, Payne & Co., 841 East Monument Ave.

Fostoria — ZAY B. CURTIS, JR., '35, Asst. Plant Mgr., Fostoria Pressed Steel Corp.

Toledo — HERBERT A. BARNBY, '23, Owens-Illinois Glass Co.

Youngstown — JAMES L. WICK, JR., '06, Falcon Bronze Co., 218 S. Phelps St.

OKLAHOMA

Oklahoma City — CHARLES B. STUART, '34, The Fidelity Nat'l Bank, P.O. Box 1218.

Tulsa — WILLIAM J. SHERRY, '21, 804 Kennedy Bldg.

OREGON

Portland — ERNEST B. MACNAUGHTON, '02, First National Bank, P. O. Box 3457.
A. GLENN STANTON, '21, 208 S.W. Stark St., 500 Concord Bldg.

PENNSYLVANIA

Bethlehem — CHARLES H. HERTY, JR., '21, Bethlehem Steel Co.

Erie — RICHARD P. PRICE, '25, Vice President, Hammermill Paper Co.

Harrisburg — PERCY E. TILLSON, '06, Bell Telephone Co. of Pa., 210 Pine St.

Lancaster — CHARLES K. MILLER, '23, Armstrong Cork Co.

Palmerton — EDMUND J. FLYNN, '19, 1033 Fourth St.

Philadelphia — PHILIP M. ALDEN, '22, Philadelphia Electric Co., 1000 Chestnut St.
HENRY W. JONES, '26, Atlantic Refining Co., 260 S. Broad St.
GEORGE T. LOGAN, '29, Philadelphia Electric Co., 1000 Chestnut St.
CHARLES W. STOSE, '22, Atlantic Refining Co., 3144 Passyunk Ave.
ROBERT E. WORDEN, '36, Worden & Risberg, Fidelity-Philadelphia Trust Bldg., 123 So. Broad St.

Pittsburgh — CHARLES M. BOARDMAN, '25, Duquesne Light Co., 435 Sixth Ave.
T. W. BOSSERT, '29, 801 Gulf Bldg., Aluminum Co. of America.

Prospectville — H. W. ANDERSON, '15, Winding Brook.

Reading — ALLYN TAYLOR, '06, Consumers Gas Co., 441 Penn St.

Scranton — WILLIAM L. DENNEN, '17, 805 Ash St., Lansdowne Park, Clarks Summit.
ADRIAN ROSS, '35, 934 Richmont St.

SOUTH CAROLINA

Charleston — C. G. DAVIES, '27, Coney-Davies Lumber Co., P.O. Box 901.

TENNESSEE

Chattanooga — RICHARD S. BICKNELL, '10, 1516 Sunset Rd.

Kingsport — T. M. TAYLOR, '22, 1508 Fairidge Drive.

Knoxville — VAN COURT M. HARE, '23, T.V.A., 605 Union Bldg.

Memphis — CLAUDE M. MCCORD, JR., '42, Separator Manufacturing Co., P.O. Box 4652, North Station.

Monteagle — HARRY WEBB, '09, Monteagle S.S. Assembly.

Nashville — JAMES M. WHITE, '28, Proprietor, White Trunk & Bag Co., 609 Church St.

TEXAS

Austin — RALPH C. GOETH, '14, Tips Engine Works.

Dallas — FRANK F. BELL, '10, Uvalde Constr. Co., Hiline Dr. & Industrial Blvd., P.O.Box 3027.
D. H. CLEWELL, '33, Asst. Director, Magnolia Petroleum Co., P.O. Box 900.
JONATHAN A. NOYES, '12, c/o Joy Mfg. Co., 6540 Hines Blvd.

El Paso — CHARLES I. AUER, '01, 902 Park Rd.

Fort Worth — COUNT B. CAPPS, '20, W. B. Fishburn Cleaners, Inc., 1212 Main St.
SIMON W. FREESE, '21, Freese & Nichols, 407–410 Danciger Bldg.

Houston — T. H. JENKINS, '32, Stanolind Oil & Gas Co., 712 Main St., P.O. Box 3092.
RICHARD T. LYONS, '17, Vice President, Tide Water Associated Oil Co., P. O. Box 1404.
DUKE SELIG, '33, 228 West Cowan St.

San Antonio — TERRELL BARTLETT, '06, The Terrell Bartlett Engineers, 2700 Transit Tower.
J. FRED BUENZ, '26, Architect, Majestic Bldg.
E. BARTLESS COCKE, '23, 3501 Broadway.

UTAH

Salt Lake City — GEORGE M. GADSBY, '09, Utah Power and Light Co., Kearns Bldg.

VERMONT

Montpelier — R. G. HOLT, '33, National Life Ins. Co.

Proctor — REDFIELD PROCTOR, '02.

St. Albans — H. E. RAYMOND, '31, Fonda Container Co., Inc.

Springfield — D. K. PARKER, '32, 17 Clement Rd.

VIRGINIA

Lynchburg — EDWARD R. HARRIS, '25, Mead Board Sales, Inc.

Norfolk — CHARLES W. JOHNSTON, '05, 214 Broad St., Portsmouth.

Richmond — DONALD N. FRAZIER, '11, American Mutual Liability Ins. Co., 1226 Mutual Bldg., 909 E. Main St.

WASHINGTON

Olympia — HOLLAND H. HOUSTON, '24, Route 1, Box 326.

Seattle — JAMES W. BARTON, '39, Boeing Airplane Co.
H. W. McCURDY, '22, Puget Sound Bridge and Dredging Co., 2929 16th Ave., S.W.
E. W. RUDOW, '21, Scientific Supplies Co., 122 Jackson St.
J. A. SAMUELSON, '40, General Construction Co., 3840 Iowa Ave.

Spokane — EDWARD E. SCOFIELD, '19, c/o Lee F. Austin Co., P. O. Box 1213.

WEST VIRGINIA

Charleston — R. V. WALLIN, '32, Carbide & Carbon Chemical Corp., Engineering & Construction Dept., Division CC, P.O. Box 24, So. Charleston.

WISCONSIN

Milwaukee — FRANK E. BRIBER, Jr., '43, 8103 West Blue Mound Rd.
PHILIP N. CRISTAL, '17, Northwestern Mutual Life Ins. Co., 720 E. Wisconsin Ave.
DAVID G. SMITH, '31, Safway Steel Products, Inc., West State St. at 63rd.

U. S. TERRITORIES AND DEPENDENCIES

CANAL ZONE:

Balboa Heights. C. W. Chase, '34, Box 77.

HAWAII:

Honolulu. Harry P. Field, '21, The Hawaiian Electric Company, Ltd.

PUERTO RICO

Hato Rey. Luis R. Gonzalez, '12, Ochoa Fertilizer Corp., Apartado 117.

FOREIGN COUNTRIES

ARGENTINA:

Buenos Aires. Prof. Jose Carlos Bertino, '23, Florida 801.

AUSTRALIA:

Melbourne. Lionel H. Lemaire, '13, "Thendara," Taggerty, Victoria.

BELGIUM:

Brussels. Dr. Charles L. Manneback, '21, 27 Rue de la Tourelle.

BRAZIL:

Rio de Janeiro. Alexandre H. Leal, '35, Cia Carris, Luz e Forca Avenida Marechal Floriano 168.

CANADA:

Montreal, Que. H. S. Chandler, '08, Canadian Industries, Ltd., Box 10.
Jean M. Raymond, '34, President, Raymond Hardware Ltd., 658 Craig West.

St. John, N. B. H. Usher Miller, '09, P. O. Box 796.

Toronto, Ont. Hal L. Bemis, '35, Campbell Soup Co., Ltd., Third and Birmingham Sts., New Toronto.
M. C. Coutts, '39, Sangamo Co., Ltd., Leaside.

Winnipeg, Man. Richard C. Huggard, '30, Huggard & Moncrieff, Ltd., 1421 Whyte Ave.

CENTRAL AMERICA:

San Salvador. Ernesto de Sola, '33.

CHINA:

Shanghai — Paul S. Hopkins, '10, President, Shanghai Power Company, 181 Nanking Road.

COLOMBIA:

Bogota. John O. Bower, '22, Apartado Aereo 3622.

CUBA:

Havana. Antonio H. Rodriguez, '21, Calle 19 No. 506, Vedado (Tel. F-8892); Office, Concordia No. 61, Havana (Tel. M-9521).

ENGLAND:

London. David A. Shepard, '26, 36 Queen Anne's Gate, Westminster, London S.W. 1.

FRANCE:

Paris. F. E. Walch, '26, Dewalco, 14 Avenue Hoche.

INDIA:

Calcutta. C. L. Bond, '20, Manager, Standard-Vacuum Oil Co., 6 Church Lane.

New Delhi. W. F. Rivers, '26, Standard-Vacuum Oil Co., P.O. Box 255, Queensway.

ITALY:

Milano. Herman F. Krantz, '28, Stigler-Otis S.p.A. Via Copernico, 34.

MEXICO:

Mexico City. George D. Camp, '16, Apartado 1005, Ejido 7, Office 602.
Clarence M. Cornish, '24, Underwood Mexicana S. A., Artes 20.
Thomas M. Nevin, '24, Manuel Ma., Contreras 58.

Monterrey. E. Garza-Sada, '14, Cerveceria Cuauhtemoc S. A., Apdo. Postal No. 755, Monterrey, N. L.
Ramon F. Munoz, '09, Munoz y Martinez, Apdo. Postal No. 347, Monterrey, N. L.

NORWAY:

Oslo. Harold R. Bjerke, '23, Osterhausgaten 18.

SOUTH AFRICA:

Johannesburg. Glenn L. Bateman, '25, Box 1671.

SWITZERLAND:

Zurich. Werner Schoop, '22, Managing Director, Flexflam A. G. Talacker, 40.

VENEZUELA:

Caracas. Robert R. Ellis, Jr., '26, Vice President, Frederick Snare Corp., Apartado 1647.

APPENDIX C

STUDENT HOUSING

(*All rental rates and information apply to the school year* 1949-50.)

FOR MARRIED STUDENTS

"WESTGATE" and "Westgate West" are housing developments on the campus, in which occupancy will, for the present, be confined to honorably discharged married veterans of World War II who are actually in residence at the Institute.

Application for Westgate and Westgate West should be filed at the Office of the Dean of Students for consideration by a committee of faculty members charged with the allotment of available homes.

Married students who are not eligible for assignment to Westgate or Westgate West should call in person at the Office of the Technology Christian Association, Basement of Walker Memorial. This office maintains a list of rooms and other accommodations, furnished or unfurnished, for students and staff who require assistance in finding living quarters off campus.

The Technology Christian Association cannot contract for housing, but merely refers applicants to possible landlords. All contracts are made by the applicant and the lessor. Men with children are especially urged to postpone bringing their families to Cambridge or Boston until they have definitely arranged for suitable accommodations, and to make their arrangements well in advance of the opening of the academic year.

"WESTGATE" AND "WESTGATE WEST" THE TECHNOLOGY HOUSING DEVELOPMENTS

WESTGATE. The Institute has constructed 100 small homes on Institute land in Cambridge. This residential project, known as Westgate, which was erected because of an acute housing shortage in the Greater Boston area, includes 50 houses containing one bedroom and 50 houses containing two bedrooms. The houses, arranged in single and twin units, are similar to small apartments with the privacy of a house and with the additional advantage that each house has its own plot of land. The smaller houses consist of a bedroom, combination living room and dining room with a kitchen unit closed off by doors, bath, and ample closet space. The larger type house has in addition a second bedroom and a separate kitchen. These houses, which are unfurnished except for stove, refrigerator, and kitchen cabinet, have thermostatically-controlled gas heaters and hot water units.

Leases for Westgate will be drawn on the monthly rental basis of $51 and $63 for the one-bedroom and two-bedroom houses, respectively, including all utilities except telephone and gas. The cost of gas for cooking, heating, and hot water is not included in the monthly rental figures given above, and is estimated to be approximately $12 a month over the calendar year.

WESTGATE WEST. Adjoining Westgate is Westgate West, the Government-constructed housing project of 170 apartments, each consisting of two bedrooms, living room, kitchen, bath, and storage space. Most of these apartments are partially furnished (maximum: four single beds, two bureaus, two mirrors, six chairs, and one table) and all are supplied with an ice box, a gas stove, and thermostatically-controlled gas heater and hot water unit.

For Westgate West the leases will be drawn on the monthly rental basis of $33 to $39.50, prorated according to the amount of Government furniture in the apartment, and will include all utilities except telephone and gas. The cost of ice and gas for cooking, heating, and hot water, not included in the monthly rental figure given above, is estimated to be approximately $15 per month over the calendar year. An additional charge of $1 per month for electricity will be made in the event the tenant installs his own refrigerator.

Parking space is adequate, and off-highway safe play space is provided for children.

WOMEN'S DORMITORY

The Women's Dormitory, located at 120 Bay State Road, Boston, accommodates 17 students. It is an attractively furnished house, presided over by a House Mother, where girls may enjoy a home-like atmosphere. It is a fifteen to twenty minute walk to M. I. T. Breakfast and dinner are served to all residents from September 15 to June 15. During the Summer Session residents are allowed kitchen privileges. Application blanks as well as further information may be obtained from the Office of the Dean of Students.

THE GRADUATE HOUSE

THE Graduate House, having a maximum capacity of 455 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 group. The graduate students originally occupied the oldest of the dormitories known as the Faculty Group, now an undergraduate housing unit. The House was established in 1933 in the belief that "those contacts which aid in developing qualities of leadership and cooperation 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. An attractive lounge is located at the left of a short flight of stairs leading from the lobby. The Crafts Living Room and Library, named for James M. Crafts, President of the Institute at the turn of the century, are at the end of the west corridor leading towards the Charles River. The Macomber Room also opens from this same corridor. It is used chiefly in connection with the Fabyan Dining Room. The Campus Room, serving luncheons and dinners, and the Buttery, designed for the Buttery Hour, and containing a soda bar, are 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 the nineteenth, 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 football, in basket ball, in bowling, and in soft ball. 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.

EQUIPMENT

Each resident is provided with a bed, an innerspring mattress, blankets, towels, bed linen, a pillow, desk, side chair, easy-chair, bookcase, wastebasket, and ash tray. All rooms are furnished with rugs and window draperies, and are on the interconnecting house telephone system. Most of the double and triple suites are provided with tables. The rooms are thus fully equipped for immediate occupancy, and it is requested that additions by students be only upon agreement with the manager of the Graduate House.

Service

In addition to the use of the space and the equipment, the rental covers the service of porters who take care of the cleaning and make up the beds with clean linen once each week. Also included are heat, light, electric bulbs, continuous hot and cold water, soap, and the laundering of towels and all bed linen. The house service is directly in charge of the manager.

Applications for Rooms

Applications for the Graduate House should be made to Mr. Henry K. Dow, Manager of the Graduate House, 305 Memorial Drive, Cambridge 39, Massachusetts.

Each student must file an application card, and if applying for double or triple suites, he may indicate on the application suggestions of possible roommates. Lacking any suggestions, he will be provided an opportunity for meeting prospective roommates.

An application fee of $5 is required. This amount is credited toward room rent. It will be returned if no room is assigned.

Allotment of Rooms

The assignment of rooms by the Director of Housing will be in order of application, but the Director reserves the right to reject any applicant for sufficient reason. Priority in the assignment of rooms is granted to Graduate Students already living in the House whose applications are filed on or before the date posted on the bulletin board. Notices of assignments will be forwarded to these applicants as soon as possible, and acceptances must be returned to the manager as requested, otherwise, the rooms may be reassigned.

Occupancy

The reservation and the $5 application fee entitle the applicant to occupy a room in the Graduate House from the Wednesday preceding the date established for the opening of the term to 4 p.m. on Registration Day. The applicant must, however, appear in person on Registration Day at the Graduate House and extend the reservation by payment of the balance of the rent for the term, which entitles him to occupancy until the Tuesday following the last day of the scheduled examination period for that term; *otherwise the reservation is automatically cancelled and the room made available to another applicant. Reservations may, however, be cancelled up to the Wednesday preceding Registration Day upon written notice to the Manager, and the application fee of $5 refunded in full.* The rental due on Registration Day should not be sent in advance nor included with other payments which are made directly to the Bursar. Graduate students, who, by virtue of their staff appointment, are required to be in residence one week before the opening of any term, will, upon written request to the Manager, be given every consideration in the assignment of accommodations.

Rentals, Payments, and Refunds

The rental of single rooms and suites varies according to space, exposure, and lavatory installation. These prices are clearly indicated on the floor plans.

Payments for each term will be due regularly without notice before the beginning of each term and not later than 4 p.m. on Registration Day. *No bills will be sent.*

The Director of Housing extends the following privileges, subject to change without notice, in the cancellation of applications.

Applications may be cancelled without charge before the Wednesday prior to Registration Day upon written notice to the Manager. No refund will be allowed after 4 p.m. on Registration Day. The $5 fee does not automatically apply to a reservation for the following terms.

Students who desire to move from the Graduate House after Registration Day and who do not contemplate leaving the Institute will be refunded a proportionate part of their payments, based on a weekly rate, less $10, on condition that another student can be secured immediately to take over the remaining portion of the rental.

Rentals are automatically cancelled upon transfer to a cooperative course and a proportionate refund is allowed. The student is not allowed, however, to sublet or transfer his room, or his share in a room, without the consent of the Director of Housing.

Further Information

Keys. Key cards for individual room keys and post office box keys may be obtained at the Graduate House Office. A deposit of $1 for the two is required, but this is refunded upon surrender of the keys.

The Graduate House Office is located in the lobby of the House. A clerk is in attendance from 8 a.m. to 12 p.m. All necessary information may be obtained there. A night porter and a watchman are on duty from midnight until eight o'clock in the morning. The office of the Manager of the Graduate House is at the head of a short flight of stairs leading from the lobby.

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.

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 the leading magazines.

Mail and Express. Packages and mail for students living in the Graduate House should be addressed as follows: *The Graduate House, Massachusetts Institute of Technology, Cambridge 39, Massachusetts.* Individual post office lock boxes are provided and are located in the lobby. Express and freight are handled through the office. Trunks and boxes to be sent out should be packed and labeled and left in the basement near the elevator. The Graduate House shipping clerk will see that they are called for by the appropriate shipping agency and forwarded at cost.

Telephone Service. Persons calling the Graduate House from outside should ring KIrkland 7-2680. Through a system of intramural telephone service the Office is easily enabled to call any occupant between the hours of 8 a.m. and midnight. Telephone pay stations for out-going calls are located on the first floor at the foot of the central staircases.

Laundry and Valet Service. The Graduate House Office operates a laundry and valet agency, and residents are enabled to secure such service through the Office at reasonable prices.

Storage. Space is available in the basement for trunks and baggage at the owner's risk. The Institute assumes no liability, and articles must be removed when occupancy is terminated. No boxes or trunks will be permitted in the rooms.

Automobile Regulations and Parking. Residents of the Graduate House and all other dormitories should consult the Massachusetts Registry of Motor Vehicles regarding the operation and insurance of out-of-state motor vehicles.

Outdoor parking of properly registered automobiles is permitted on the Graduate House parking lot at the risk of the owner.

Dining Service. On the first floor of the west wing of the Graduate House there are three attractive dining rooms. The Main Dining Room has a capacity of 180, and the West Dining Room, capacity 89, adjoins the Main Dining Room. Here breakfast, luncheon, and dinner are served cafeteria style. The Fabyan Room, capacity 14, is used for small private luncheons and dinners. The Campus Room, by means of a folding partition, can be divided into two Dining Rooms: one is used for table service at luncheon and dinner; the other is available to groups up to 100 for luncheon and dinner. The entire Campus Room can be made available to groups up to 225. Arrangements for private functions should be made with the Manager of the Graduate House.

All foods are prepared in well coordinated, modern kitchens and bake shops located in the building.

No board by the day or week is furnished and no resident of the House is required to use the dining service. Because of the attractiveness of the rooms, their convenient location, and the high quality of the food provided, the patronage is excellent.

The Director of Housing to whom reference has been made, is charged with the responsibility for the general regulations, sanitation, service, maintenance of buildings and allotment of rooms.

For further information address Mr. Henry K. Dow, Manager of the Graduate House, Massachusetts Institute of Technology, Cambridge 39, Massachusetts.

UNDERGRADUATE HOUSES

Effective September 13, 1949 (Subject to change)

The permanent houses of the undergraduate dormitories and other temporary campus buildings which have been remodelled to provide inexpensive living accommodations for three hundred fifty additional students are available for occupancy. The following information is effective as of September 13, 1949, and subject to change.

The permanent student housing facilities provided at the Massachusetts Institute of Technology have been carefully planned and organized to afford an economical, comfortable place in which to live, an environment conducive to study and an opportunity to participate in those social and extra-curricular activities which properly supplement scholastic work.

Additional accommodations, designed for temporary emergency housing, have many desirable features such as adequate heating, lighting, toilet facilities, single beds, mattresses, individual study desks, lockers, and so forth, but are of the "barracks" type in both sleeping and studying accommodations. These accommodations have been in use since September 1946 and are considered to be very satisfactory by the majority of the residents.

Government

The undergraduate houses and the emergency housing unit are administered as a part of the general plan of student self-government at the Massachusetts Institute of Technology, with the cooperation of an Advisory Committee, appointed by the President. The student dormitory committee organizes and supervises all activities, athletic and social, and cooperates with all recognized undergraduate activities at the Institute.

The success of student self-government depends upon the willingness of every resident to cooperate 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 dormitories will therefore be denied to those who do not accept this responsibility.

The New Dormitory

This new undergraduate house, located on the river front at 362 Memorial Drive, Cambridge, west of Massachusetts Avenue, will be completed and available for occupancy for the opening of the Fall Term 1949. The New Dormitory has its own dining facilities. Residents of this Hall are required to pay, in advance, with the term rental, $170 for fifteen meals each week, seventeen weeks of each academic term. Three meals a day are served, Monday through Friday each week, except during the stated vacation periods. No meals are served on Saturdays and Sundays but the other dining facilities on campus are available to this group on a cash basis.

The Faculty Group

Ware, Atkinson, Runkle, Holman, Nichols, and Crafts

These six Houses, located on Memorial Drive, east of Walker Memorial and near the President's House, have been completely reconditioned. Accommodations are available for two hundred and twenty-seven registered male students.

Most of the first floor rooms in all the halls except Crafts and Ware are designed for single occupancy. On the upper floors most of the quarters are suites, comprised of a living room, a dressing room, and a sleeping room arranged for two students. Because of the demand for additional accommodations a few of the larger suites have been re-equipped to accommodate three men. There are differences in location, exposure, size of rooms, and so forth, in the Houses, but the facilities, equipment and service are standard throughout the dormitory system.

The Alumni Group

Munroe, Hayden, Wood, Goodale, Bemis, Walcott

These six halls are situated on the main campus near Walker Memorial. They have accommodations for four hundred and eighty-three men. Most of the rooms are designed for single occupancy — some inter-connecting — with a limited number of double and triple suites. Due to the housing shortage, many of the interconnecting rooms have been equipped as a combination suite, a study and bedroom accommodating three men. There are lavatory installations in all these rooms, supplemented by adequate toilets and showers on each floor of every hall.

Equipment and Service

(Permanent Undergraduate Houses Only)

All the rooms in the permanent dormitory units at the Massachusetts Institute of Technology are *fully equipped for occupancy*, and additions by students are not permitted. All single rooms are equipped with a special bed or couch, all hair innerspring mattress, pillow, blankets, chiffonier or wardrobe, desk and chair, study chair, bookcase, waste basket, light bulbs, extra electrical outlets, and interconnecting telephone. Double and triple suites are furnished in a manner similar to the single rooms, but in addition some have study tables. Bed linen and towels are furnished and replaced regularly by porters who make up the beds once each week and clean the rooms each day except week-ends and holidays.

In addition to space, the rental includes heat, light, continuous hot and cold water, intercommunicating telephone service, porter service, soap, towel and linen supply and laundry service for bed linen and towels. The dormitory buildings are of first-class construction and are fireproof. Steam heat is available throughout the year, day and night. The house service is directly in charge of the Manager and is maintained by experienced porters. A representative of the Institute is on the premises day and night.

The above applies to permanent buildings only. (See special paragraph "Barracks Housing" below.)

Rental and Occupancy

The rental for accommodations in the permanent undergraduate houses of the Faculty and Alumni Groups is either $120 or $155 each person each academic term. Payments for each term will be due regularly without notice. *No bills will be sent.*

The period of occupancy for any academic term is from the Wednesday preceding Registration Day (Monday) through the Tuesday following the last day of the scheduled examination period. (See official M. I. T. calendar.)

All accommodations, regardless of location, in the New Dormitory are at the rate of $180 each occupant, each academic term.

All accommodations in Ware, Atkinson, Runkle, Holman, Nichols and Crafts are at the rate of $155 each occupant each academic term, except the following which are $120 each occupant each academic term.

3-Man Suites

Atkinson	203	205	Runkle	203-04-06		Holman	203	204
	303	305		303-04-06			303	304
	403	405		403-04-06			403	404
			Nichols	203	204			
				303	304			
				403	404			

Single Rooms

Atkinson	204A	204B	Runkle	206A	601
	304A	304B		306A	602
	404A	404B		406A	603
				501	604
				502	604A
				505	605
					605A

All accommodations in Munroe, Hayden, Wood, Goodale, Bemis, Walcott are at the rate of $155 each occupant each academic term, except the following, which are $120 each occupant each academic term.

GOODALE — 3-MAN SUITES

108–09	111–12	113–14	101–02	103–04	106–07
208–09	211–12	213–14	201–02	203–04	206–07
308–09	311–12	313–14	301–02	303–04	306–07
408–09	411–12	413–14	401–02	403–04	406–07
508–09	511–12	513–14	501–02	503–04	506–07

WALCOTT — 3-MAN SUITES

101–02	104–05			110–11	113–14
201–02	204–05	206–07	208–09	210–11	213–14
301–02	304–05	306–07	308–09	310–11	313–14
401–02	404–05	406–07	408–09	410–11	413–14
501–02	504–05	506–07	508–09	510–11	513–14

BEMIS — DOUBLE ROOMS

112	212	312	412	512

APPLICATIONS AND RESERVATIONS

Applications for rooms must be accompanied by a deposit of $5, check made payable to D. L. Rhind, Bursar, forwarded to Mr. Granville Sheldon, Manager of the Undergraduate Dormitories, Massachusetts Institute of Technology, 3 Ames Street, Cambridge 39, Massachusetts.

ASSIGNMENT OF ROOMS
(Residents only)

Priority in the assignment of rooms, except those especially reserved for entering first-year students, is granted to students in residence. Application forms for the next regular term will be distributed to residents about thirty days prior to the end of a term and must be returned to the Manager of the Dormitories accompanied by a reservation fee of $5, check payable to D. L. Rhind, Bursar. Assignments will be made to these applicants immediately and a definite reservation made. The Director of Housing reserves the right to reject any application for sufficient reason.

ASSIGNMENT OF ROOMS
(New Students)

The number of rooms reserved for first-year students in the permanent undergraduate houses varies from term to term depending upon circumstances. Applications will be accepted only from those who have been notified of their admission by the Admissions Office. Application forms for dormitory accommodations are mailed with the admission notice. Order of preference in the assignment of rooms will be by date of application as received. Notification of an assignment to either the permanent undergraduate houses, or to the temporary emergency housing Building 22 as requested on the application, will be forwarded to successful applicants and a definite reservation made about thirty days prior to the opening of a term.

OCCUPANCY

The reservation and the $5 application fee entitle the applicant to occupy a room in the dormitories from the Wednesday preceding the date established for the opening of the term to 4 p.m. on Registration Day. The applicant must, however, appear in person on Registration Day at the Dormitory Office of the unit to which he is assigned and extend the reservation by payment of the balance of the rent for the term, which entitles him to occupancy until the Tuesday following the last day of the scheduled examination period for that term; *otherwise the reservation is automatically cancelled and the room made available to another applicant. Reservations may, however, be cancelled up to the Wednesday preceding Registration Day upon written notice to the Manager of the Dormitories, and the application fee of $5 refunded in full.* The Dormitory rental due on Registration Day should not be sent in advance nor included with other payments which are made directly to the Bursar.

WAITING LIST

The names of unsuccessful applicants remain on the waiting list, and assignments are made as rooms become available. Due to the privilege in the cancellation of Dormitory reservations extended to those who affiliate with recognized fraternities, a number of rooms become available for occupancy at the beginning of the term. Applicants on the waiting list should, therefore, report in person to the office of the Manager, Building 22 (rear of the main building), on arrival, for immediate assignment to rooms released by cancellation, to be assigned to temporary quarters in Building 22 pending the release of accommodations on Registration Day or thereafter, or to withdraw their names from the waiting list if accommodations have been secured elsewhere. *Applicants who withdraw their names from the waiting list by 4 p.m. on Registration Day will be refunded the application fee of $5. The refund of $5 will be made directly to the applicant regardless of the source of the application fee. No refunds will be made after 4 p.m. on Registration Day. The fee does not automatically apply to the following term.*

The original priority list established, as applications are received, is automatically discontinued at 4 p.m. on Registration Day, and those who have temporary accommodations who wish to be considered for vacancies as they occur in Building 22 (see below) should list their names with the Manager and provide information as to temporary address, and so forth. Vacancies in the permanent undergraduate houses are filled from those in residence in the temporary housing unit, Building 22.

FRATERNITY AFFILIATION

The "recognized list" of fraternities at the Massachusetts Institute of Technology includes twenty or more chapters whose houses are situated on private property in Cambridge, Boston, and Brookline. Residence in the dormitories or fraternities offers advantages over local apartment and rooming houses in that the former provide a more intimate contact with Technology life and activities. Approximately ninety per cent of the new fraternity men are pledged prior to the end of the first week of the academic year, and in order that they may assume residence at the fraternity house of their choice immediately and thereby release accommodations to those on the waiting list who prefer residence in the dormitories, privileges in the cancellation of dormitory reservations are extended to those who make a decision on or before Registration Day. Parents who anticipate fraternity affiliation for their sons should, if possible, grant them permission to act on their own initiative. The satisfactory housing of a large group of entering students under present conditions can be accomplished only through the cooperation of parents, students, and fraternity and dormitory representatives in making early and prompt decisions so that temporary housing is reduced to a minimum. Students are therefore requested to withdraw applications for dormitory residence promptly if they are certain that such accommodations will not be required.

REFUNDS

Reservations are automatically cancelled upon withdrawal of a student from the Institute or transfer to a cooperative course, and a proportionate refund allowed.

Residents of the dormitories who desire to move to recognized fraternity houses after Registration Day and prior to the following Monday, and whose transfer is requested by authorized representatives of the fraternity, will be refunded the rental fee less a charge for occupancy at the weekly rate, less $10. If, however, another student is available on the waiting list to assume occupancy immediately, the charge of $10 will not be made.

Students, except transfers to fraternities, who desire to move from the dormitories prior to the Monday following Registration Day and who do not contemplate leaving the Institute, will be refunded the rental fee less a charge for occupancy at the weekly rate, less $10.

Students who desire to move from the dormitories after the Monday following Registration Day, and who do not contemplate leaving the Institute will be refunded the rental fee less a charge for occupancy at the weekly rate, less $25.

The student is not allowed, under any circumstances, to sublet or transfer his room or his share in a room, without the consent of the Director of Housing.

REGULATIONS AND GENERAL INFORMATION

KEY DEPOSITS AND REFUND. A deposit of $1 is required for a room key, subject to refund in full when returned.

MAIL SERVICE. Each single room, double or triple suite has a separate combination lock mail box, located in the dormitory office.

LAUNDRY AND VALET SERVICE. Laundry service is on a cash basis. Laundry bags, slips and tags are available at the office desk. Notification of return of laundry will be through the mail boxes. Laundry service takes one week; valet service, four days. Prices are reasonable.

TELEPHONE AND WESTERN UNION SERVICE. Long-distance and local calls received through the dormitory switchboard will be relayed through telephones located on each floor. Intercommunicating and Institute service is available through the room telephones. Western Union messages may be sent from the office. *Telephone number for the Faculty and Alumni Group is KIrkland 7-5300; for the New Dormitory, UNiversity 4-2111.*

PORTER SERVICE. This service is available Monday through Saturday only. Sunday and holiday porter service is limited under present conditions to cases of emergency only.

VISITORS. The dormitories are for men only, and persons of the opposite sex are not permitted in the rooms or buildings, except the dormitory offices, and the Lounge Rooms except on special occasions as recommended by the Dormitory Committee and approved by the Director of Housing. The preparation of meals or cooking of any kind on the premises are prohibited. Violations of these regulations will result in the cancellation of room assignments.

DINING SERVICE. Dining facilities for residents of the Faculty and Alumni Groups and for the Barracks unit on a cafeteria basis are in the Walker Memorial, headquarters of student activities, adjacent to the dormitories. No board by the day or week is furnished. Most of the students use these facilities. Because of the low cost and the excellent quality and variety of the food, about 5,000 meals a day are served. The dining service operates seven days a week. There are other suitable dining facilities in the vicinity. A new modern social room and soda bar, where light refreshments are served, has been installed in Pritchett Hall, second floor of Walker Memorial. This room is open to residents of the dormitories and their guests during the evening hours and is equipped with a dance floor and other facilities for entertainment. A hostess is on duty in this room at all times.

STORAGE. Space is available in the basement for trunks and baggage at the owner's risk. The Institute assumes no liability, and articles must be removed when occupancy is terminated. No boxes or trunks will be permitted in the rooms.

MAIL AND EXPRESS. Packages and mail for residents of the Faculty and Alumni Groups should be addressed to Massachusetts Institute of Technology Dormitories, 3 Ames Street, Cambridge 39, Massachusetts. Packages and mail for residents of the New Dormitory should be addressed to 362 Memorial Drive, Cambridge 39, Massachusetts.

INQUIRIES

Faculty and Alumni Houses

Address correspondence to Mr. Granville Sheldon, Manager, Massachusetts Institute of Technology Dormitories, 3 Ames Street, Cambridge 39, Massachusetts. Telephone: KIrkland 7-5300, or KIrkland 7-6900 Extension 437.

The New Dormitory

Address correspondence to Mr. Gordon Watson, Manager, The New Dormitory, Massachusetts Institute of Technology, Cambridge 39, Massachusetts. Telephone: UNiversity 4-2111, or KIrkland 7-6900 Extension 585.

BARRACKS HOUSING

Building 22

The Massachusetts Institute of Technology has remodelled and equipped a large, three-story war laboratory building directly in the rear of the main educational group as a temporary inexpensive housing unit, designed to accommodate 350 registered male students. The building is well heated and lighted, and has an excellent sprinkler system and several completely enclosed fire exits. The use of this building as a temporary housing unit has been approved by the proper authorities.

Accommodations are of necessity of the "barracks" type in both sleeping and study. The study rooms are, however, partitioned in sections to accommodate two students, and individual desks and desk chairs are provided. The sleeping areas vary in size and accommodate from 5 to 7 men, and are equipped with single beds, mattresses, lockers, and chairs. There is a large shower room on the first floor and adequate toilet facilities throughout the building. There is adequate ventilation.

This temporary barracks unit is in charge of a manager who is assisted by experienced porters who clean the rooms. Facilities for the handling of mail, laundry, and cleaning are available.

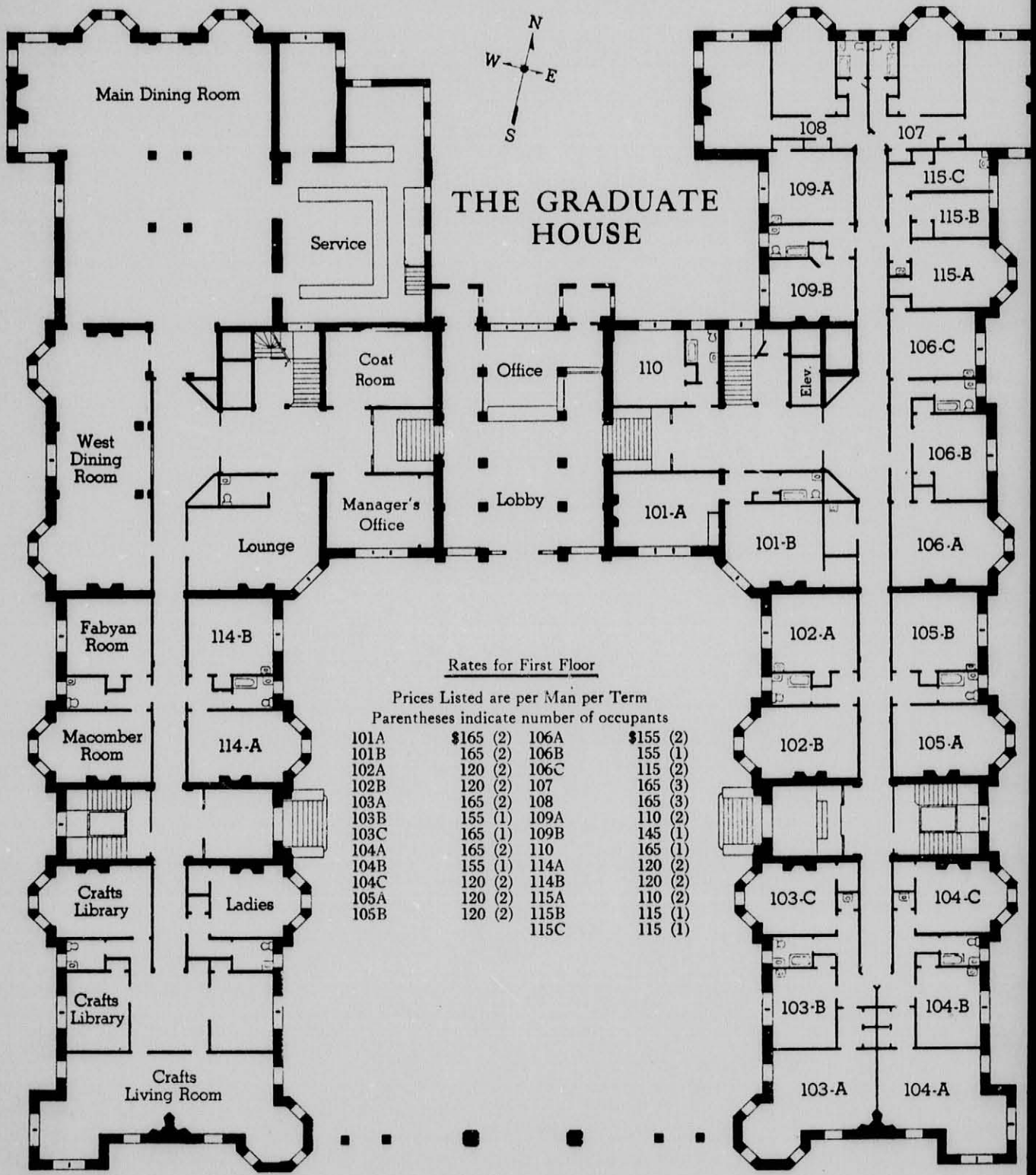
Sheets, blankets, pillow, pillow-cases, and soap are provided but the resident is required to make up his bed. The bed linen, however, is changed regularly by experienced porters. Each student should provide two padlocks for the clothes lockers, and an adequate supply of towels. Laundry service for bed linen is included in the rental but towels are considered to be the personal property of the resident.

The rental for these accommodations has been established at $90 each occupant, each academic term, $5 of which should accompany the application. The balance of $85 is payable in advance on Registration Day. That portion of the section on student housing (Undergraduate Houses) dealing with government, application and reservation, assignment of rooms, occupancy, waiting list, fraternity affiliation, and regulations is applicable to this housing unit, except that residents may transfer to fraternities, other M. I. T. housing units, or other available outside accommodations without penalty, at any time with a proportionate refund. Since Building 22 was established for emergency housing only the Director of Housing reserves the right to discontinue its use as a dormitory at any time. The unit, however, will be in operation until February 1950, which is the end of the first term of the academic year 1949-50, and may be continued beyond that date.

In the establishment of this housing unit it has been the aim of the Director of Housing to provide adequate temporary housing, with such essential conveniences as are necessary, at a rental which is consistent with the allowances under the G. I. Bill of Rights.

Students assigned to this unit are advised to ship personal effects, and so forth, in a trunk or locked box which may be used for storage for belongings and are encouraged to provide such banners and other decorative material as will lend a more collegiate atmosphere to a barracks dormitory. This unit is operated under a system of student government and the cooperation of all residents in recognizing the rights and privileges of others is required.

Correspondence and express should be addressed to Mr. Joseph De Costa, Manager, Building 22, Massachusetts Institute of Technology, Cambridge 39, Massachusetts. Telephone: ELiot 4-3341, or KIrkland 7-6900 Extension 433.

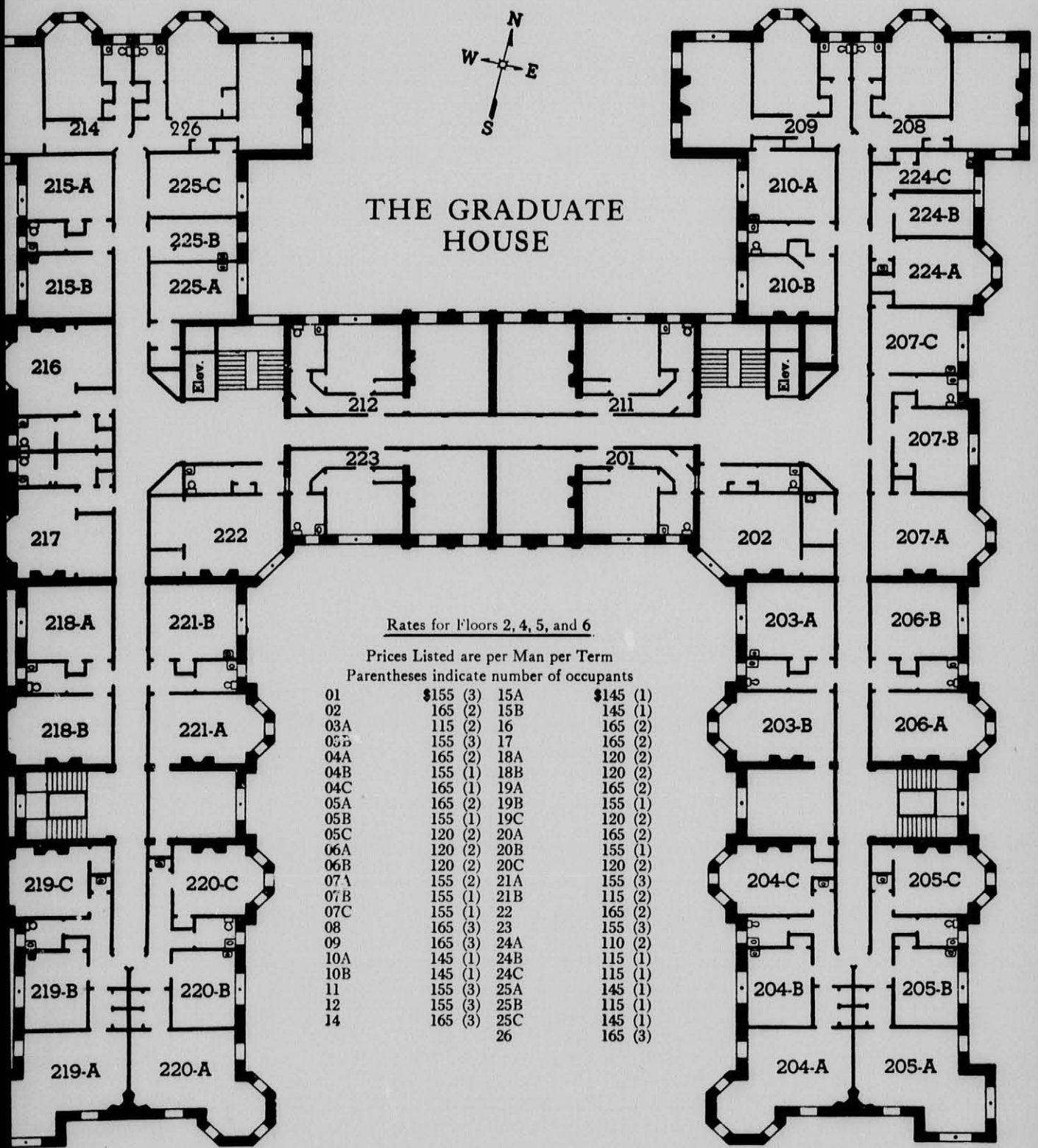


Rates for First Floor

Prices Listed are per Man per Term

Parentheses indicate number of occupants

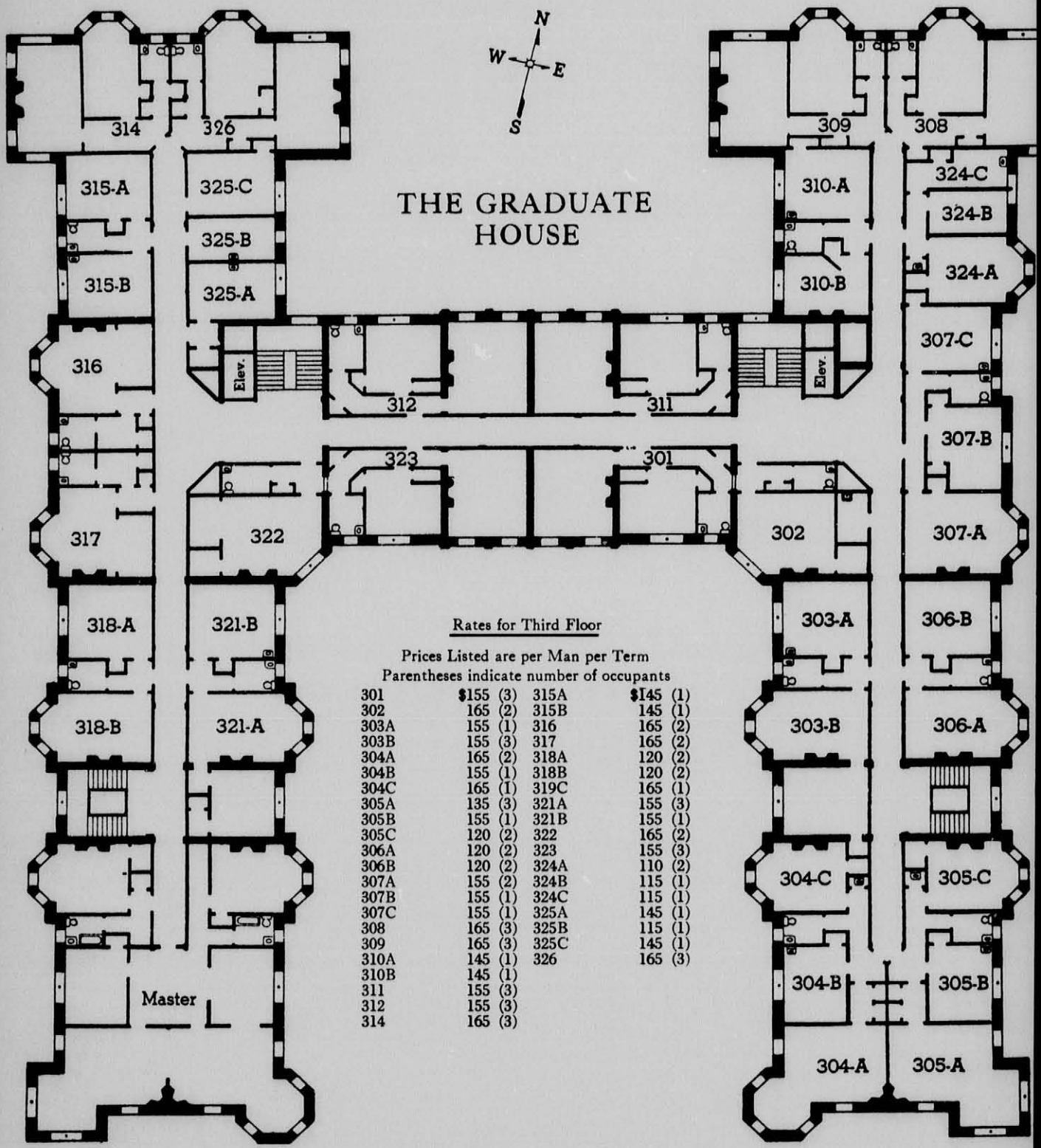
101A	$165 (2)	106A	$155 (2)
101B	165 (2)	106B	155 (1)
102A	120 (2)	106C	115 (2)
102B	120 (2)	107	165 (3)
103A	165 (2)	108	165 (3)
103B	155 (1)	109A	110 (2)
103C	165 (1)	109B	145 (1)
104A	165 (2)	110	165 (1)
104B	155 (1)	114A	120 (2)
104C	120 (2)	114B	120 (2)
105A	120 (2)	115A	110 (2)
105B	120 (2)	115B	115 (1)
		115C	115 (1)



Rates for Floors 2, 4, 5, and 6

Prices Listed are per Man per Term
Parentheses indicate number of occupants

01	$155 (3)	15A	$145 (1)
02	165 (2)	15B	145 (1)
03A	115 (2)	16	165 (2)
03B	155 (3)	17	165 (2)
04A	165 (2)	18A	120 (2)
04B	155 (1)	18B	120 (2)
04C	165 (1)	19A	165 (2)
05A	165 (2)	19B	155 (1)
05B	155 (1)	19C	120 (2)
05C	120 (2)	20A	165 (2)
06A	120 (2)	20B	155 (1)
06B	120 (2)	20C	120 (2)
07A	155 (2)	21A	155 (3)
07B	155 (1)	21B	115 (2)
07C	155 (1)	22	165 (2)
08	165 (3)	23	155 (3)
09	165 (3)	24A	110 (2)
10A	145 (1)	24B	115 (1)
10B	145 (1)	24C	115 (1)
11	155 (3)	25A	145 (1)
12	155 (3)	25B	115 (1)
14	165 (3)	25C	145 (1)
		26	165 (3)



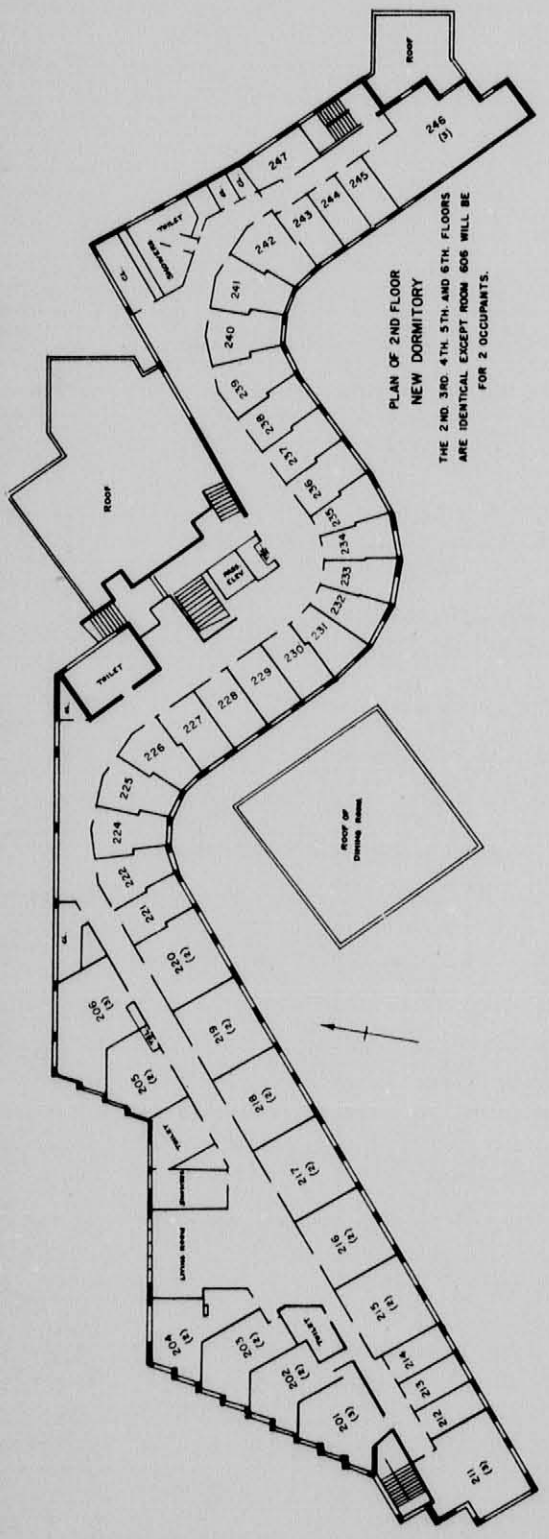
Rates for Third Floor

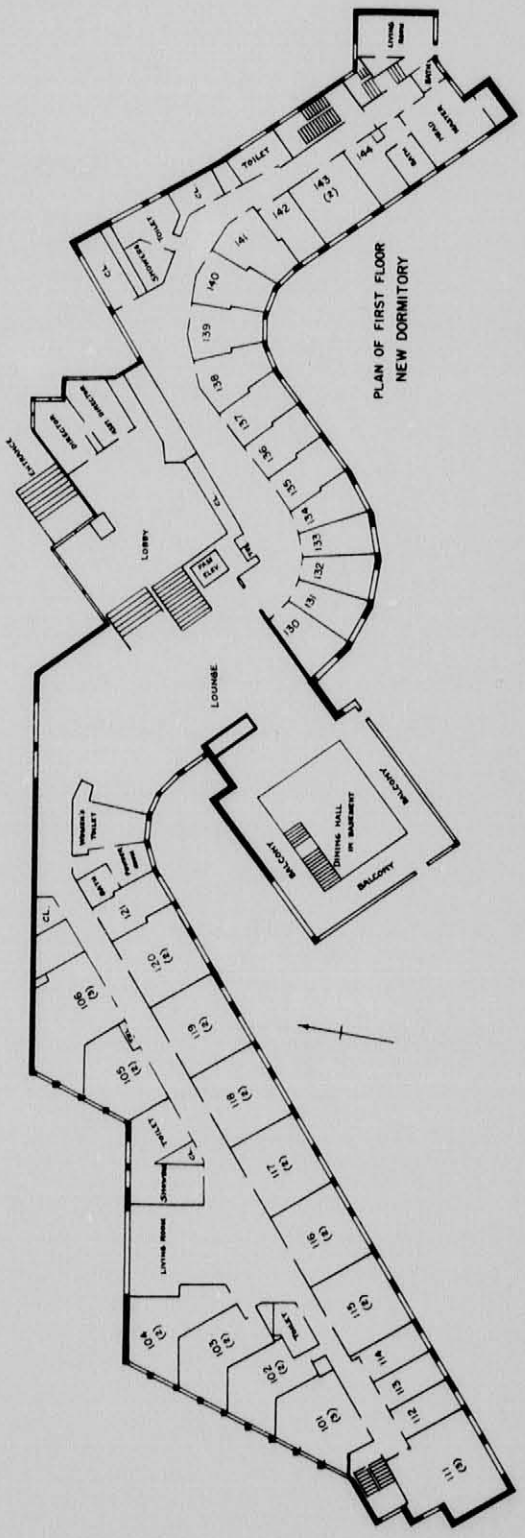
Prices Listed are per Man per Term
Parentheses indicate number of occupants

301	$155 (3)	315A	$145 (1)
302	165 (2)	315B	145 (1)
303A	155 (1)	316	165 (2)
303B	155 (3)	317	165 (2)
304A	165 (2)	318A	120 (2)
304B	155 (1)	318B	120 (2)
304C	165 (1)	319C	165 (1)
305A	135 (3)	321A	155 (3)
305B	155 (1)	321B	155 (1)
305C	120 (2)	322	165 (2)
306A	120 (2)	323	155 (3)
306B	120 (2)	324A	110 (2)
307A	155 (2)	324B	115 (1)
307B	155 (1)	324C	115 (1)
307C	155 (1)	325A	145 (1)
308	165 (3)	325B	115 (1)
309	165 (3)	325C	145 (1)
310A	145 (1)	326	165 (3)
310B	145 (1)		
311	155 (3)		
312	155 (3)		
314	165 (3)		

UNDERGRADUATE HOUSES

The New Dormitory

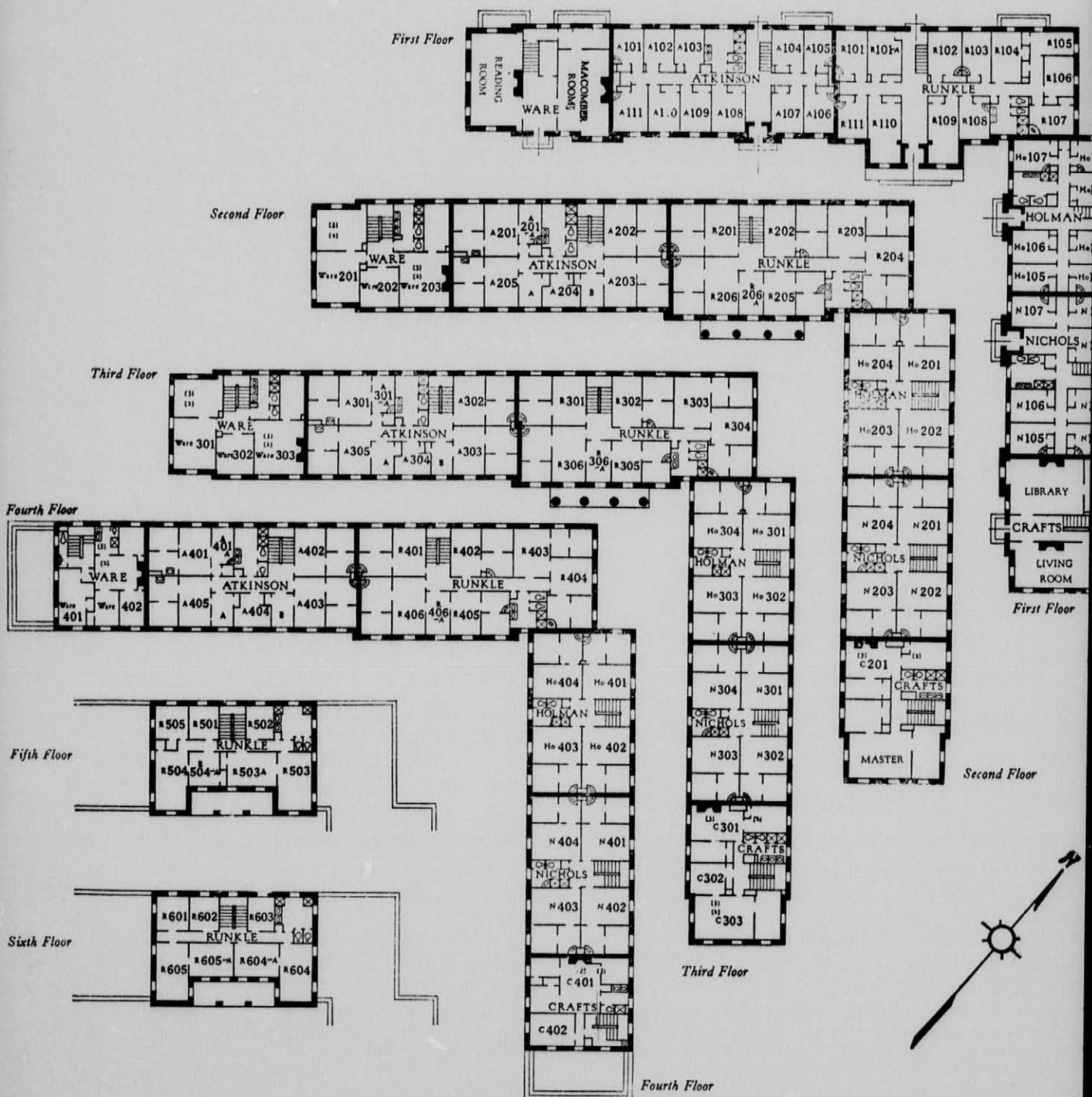




UNDERGRADUATE HOUSES

The Faculty Group

WARE ATKINSON RUNKLE
HOLMAN NICHOLS CRAFTS



UNDERGRADUATE HOUSES

MUNROE HAYDEN WOOD GOODALE BEMIS WALCOTT

THE PLANS OF THE THIRD FOURTH AND FIFTH FLOORS OF ALL THESE HOUSING UNITS ARE OMITTED, BUT ARE SIMILAR IN EVERY RESPECT TO THE CORRESPONDING PLAN OF THE SECOND FLOOR

REFER TO MAP IN FRONT OF CATALOGUE FOR LOCATION

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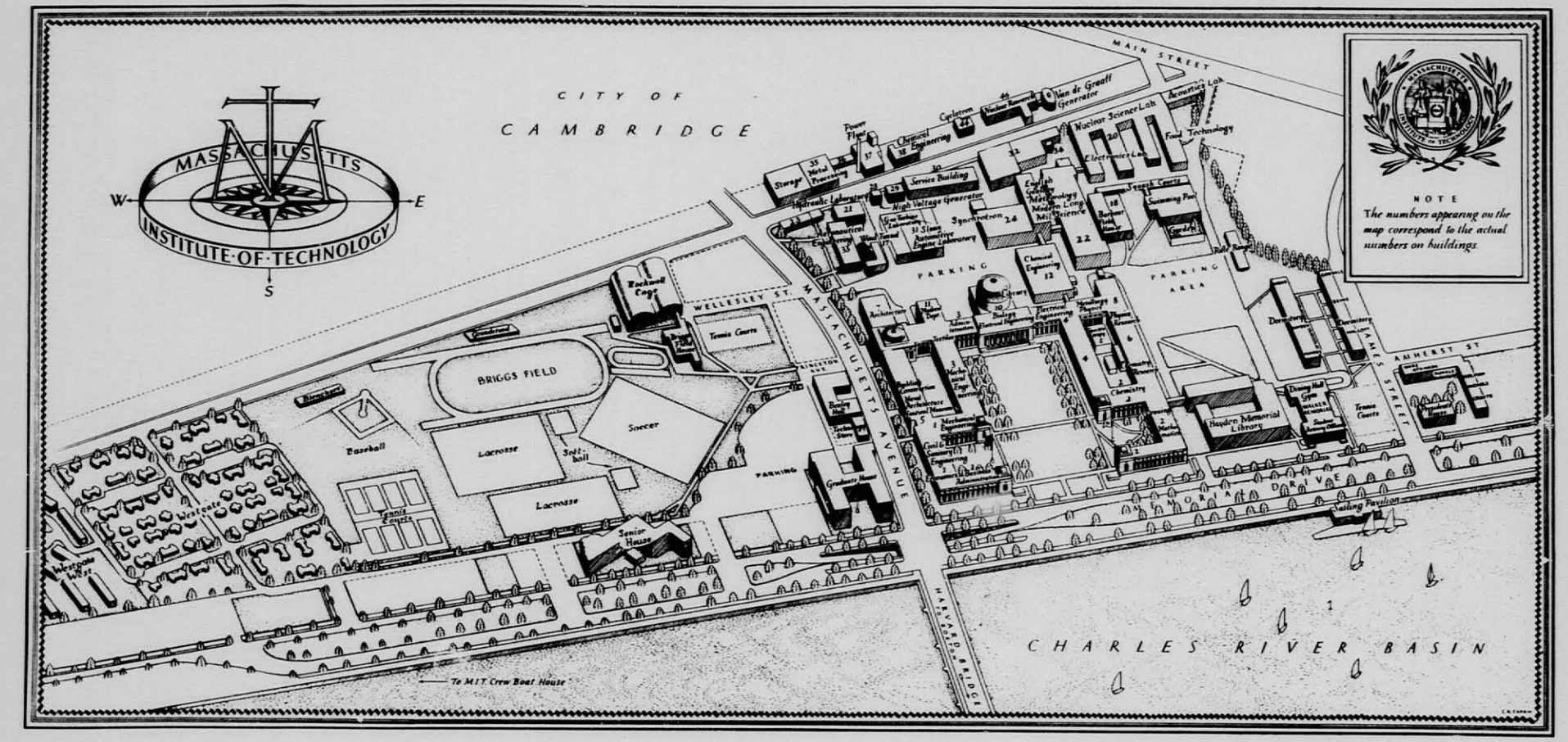
MASSACHUSETTS
INSTITUTE·OF·TECHNOLOGY
W
E
S
CITY OF
CAMBRIDGE
MAIN STREET
WELLESLEY ST.
MASSACHUSETTS AVENUE
AMHERST ST.
JAMES STREET
MEMORIAL DRIVE
CHARLES RIVER BASIN
BRIGGS FIELD
Baseball
Lacrosse
Soccer
Lacrosse
Soft Ball
Tennis Courts
Rockwell Cage
Practice Field
Track
Walcott
Walcott House
Tennis Courts
Senior House
Graduate House
PARKING
PARKING AREA
Hayden Memorial Library
Sailing Pavilion
Dormitory
Dormitory
Dormitory
Dormitory
Swimming Pool
Rifle Range
Chemistry
Chemical Engineering
Electrical Engineering
Architecture
Biology
Nuclear Science Lab
Food Technology
Acoustics Lab
Van de Graaff Generator
Cyclotron
Chemical Engineering
Power Plant
Metal Processing
Storage
Service Building
High Voltage Generator
Synchrotron
Hydraulics Laboratory
Sloan Automotive Engineering Laboratory
Wind Tunnel
Electronics Lab
Geology
Meteorology
Modern Languages
Physics
Building Practice
Tennis Courts
Graduate Dormitory
Graduate Dormitory
Graduate Dormitory
Graduate Dormitory
To M.I.T. Crew Boat House
HARVARD BRIDGE
NOTE
The numbers appearing on the map correspond to the actual numbers on buildings.