M.I.T. ANNUAL CATALOGUES AND BULLETINS
1938/39

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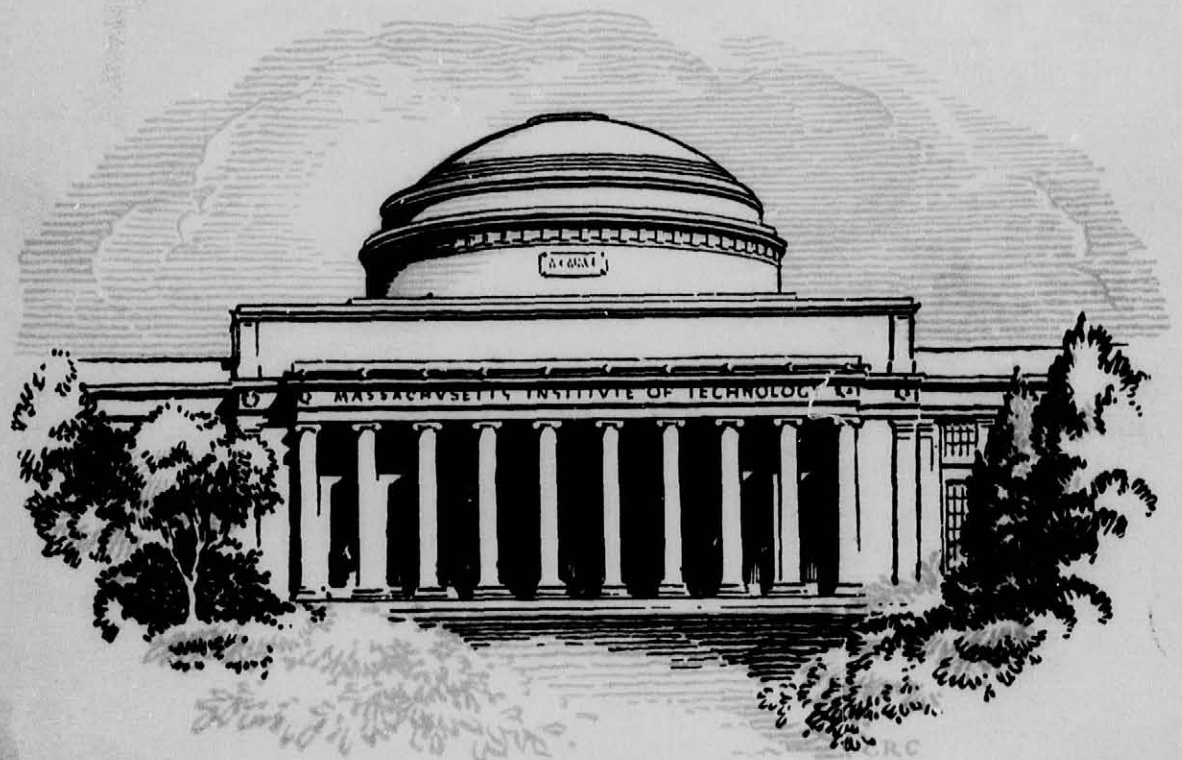
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

BULLETIN



VOLUME 73 NUMBER 4

CATALOGUE ISSUE, JUNE 1938

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

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY BULLETIN: CATALOGUE ISSUE

SCHOOL OF ARCHITECTURE

SCHOOL OF ENGINEERING

SCHOOL OF SCIENCE

GRADUATE SCHOOL

DIVISION OF HUMANITIES


MASSACHVSETTS INSTITVTE OF

MASSACHUSETTS INSTITUTE

of

TECHNOLOGY BULLETIN

Catalogue Issue 1938

VOLUME 73 NUMBER 4

A BULLETIN OF GENERAL INFORMATION ABOUT THE INSTITUTE, ITS GOVERNMENT, STAFF, REGULATIONS, REQUIREMENTS FOR ADMISSION, FACILITIES, AND COURSES OF INSTRUCTION, BOTH UNDERGRADUATE AND GRADUATE

PUBLISHED BY THE INSTITUTE · CAMBRIDGE

CALENDAR

FOR ACADEMIC YEAR 1938–1939

		1938
Entrance Examinations at Technology Begin		Sept. 14
Institute Year Begins		Sept. 26
Columbus Day (*Holiday*)		Oct. 12
Armistice Day (*Holiday*)		Nov. 11
Thanksgiving Day (*Holiday*)		Nov. 24
Christmas Vacation	Dec. 23 through	Jan. 2
		1939
Last Exercises, First Term		Jan. 21
Examination Period	Jan. 23 through	Feb. 4
Second Term Begins		Feb. 6
Washington's Birthday (*Holiday*)		Feb. 22
Spring Recess	Apr. 19 through	Apr. 22
Last Exercises, Second Term		May 24
Second Term Examinations Begin		May 25
Memorial Day (*Holiday*)		May 30
Commencement Day		June 6
Summer Session 1939 Begins		June 12

(*Except for a few subjects which begin on June 5*)

FOR ACADEMIC YEAR 1939–1940

		1939
Entrance Examinations at Technology Begin		Sept. 13
Institute Year Begins		Sept. 25
Columbus Day (*Holiday*)		Oct. 12
Armistice Day (*Holiday*)		Nov. 11
Thanksgiving Day (*Holiday*)		Nov. 30
Christmas Vacation	Dec. 22 through	Jan. 1
		1940
Last Exercises, First Term		Jan. 20
Examination Period	Jan. 23 through	Feb. 3
Second Term Begins		Feb. 5
Washington's Birthday (*Holiday*)		Feb. 22
Spring Recess	Apr. 17 through	Apr. 20
Last Exercises, Second Term		May 22
Second Term Examinations Begin		May 23
Memorial Day (*Holiday*)		May 30
Commencement Day		June 4
Summer Session 1940 Begins		June 10

(*Except for a few subjects which begin on June 3*)

In the adjacent column dates in boldface indicate holidays on which exercises of the Institute are omitted.

1938

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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 farsighted 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 vitality to the Institute throughout its history, and that have made it, not the local institution originally planned, but one of national and international influence.*

Motivated by the pioneering spirit of its founder the Institute proceeded rapidly to make many seminal contributions to education and industry. It pioneered in extending the laboratory method of instruction as an indispensable educational technique. It virtually created the modern profession of chemical engineering; its Courses in electrical and 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, and in collaboration with a sister institution it established the first systematic training in public health.

From the rented rooms in which it started with 15 students, the Institute has grown until today it has a student body of 2900, including 600 graduate students, a staff of over 500, a plant and endowment representing an investment of over $50,000,000, and a living alumni body of 32,000 in 82 countries. The original school of industrial science has grown into the four schools of today, the School of Science, the School of Engineering, the School of Architecture, and the Graduate School, which together offer over 900 subjects of instruction.

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 practising 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.

* At the present time all the states of the union as well as 37 foreign countries are represented in the student body.

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

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

IN recent years there has been a marked trend at the Institute toward greater flexibility in the curriculum, and more individual treatment of students. This results from a developing policy on the part of the Faculty of making it possible for each member of the student body to follow the line of his special interests, with ample opportunity to work closely with members of the Staff, but with no lessening of the emphasis which the Institute has long placed on the fundamental sciences as a basis for advanced science or engineering.

For many years M. I. T. has been notable for the large amount of study of the humanities which is included in its regular curricula. There has also been a wholesome regard for those extra-curricular activities which tend to broaden a man's outlook, and these have had the cordial support of Faculty and Administration.

The number of Courses and options has been increased, until there are over forty regular Courses of Study, arranged to meet the needs of students of diverse interests. Moreover, the authority to make substitutions, which resides in the department heads and the petitions committee, renders it possible to alter any one of these to suit special cases. In addition there is the possibility, in the Courses in General Engineering and General Science, of arranging special schedules for those who are pursuing unusual objectives.

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 increased opportunity to map out his own path with the aid and counsel of the Staff.

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[1] Address correspondence to Massachusetts Institute of Technology.

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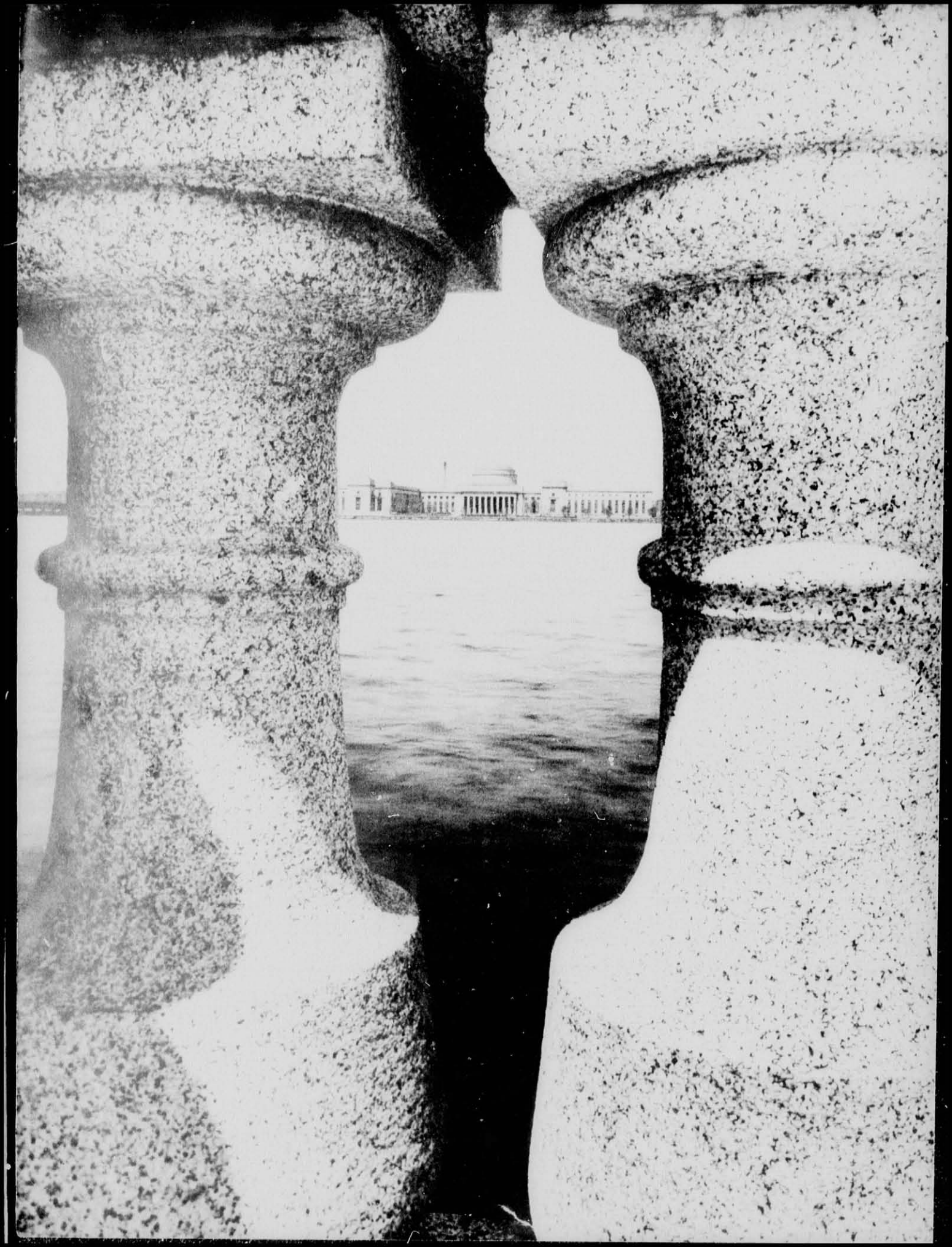

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DIRK JAN STRUIK, PH.D.
Associate Professor of Mathematics
RAYMOND DONALD DOUGLASS, PH.D.
Associate Professor of Mathematics
SAMUEL DEMITRY ZELDIN, PH.D.
Assistant Professor of Mathematics
PRESCOTT DURAND CROUT, PH.D
Assistant Professor of Mathematics
ROBERT HORTON CAMERON, PH.D.
Assistant Professor of Mathematics
WILLIAM TED MARTIN, PH.D.
Assistant Professor of Mathematics
GEORGE PROCTOR WADSWORTH, PH.D.
Assistant Professor of Mathematics

Instructors

WILLIAM CLARE TAYLOR, PH.D.
NORMAN LEVINSON, SC.D.
BREWSTER HUNTINGTON GERE, PH.D.
BROCKWAY MCMILLAN, S.B.
WILLIAM ROBERT HYDEMAN, M.A.
SAMUEL W. STEWART, B.A., M.S.

Assistants

ELLIOTT LYNDON BUELL, A.B.
FRANCIS BEGNAND HILDEBRAND, M.A.
CLAUDE ELLWOOD SHANNON, B.S.

MECHANICAL ENGINEERING

Professors

JEROME CLARKE HUNSAKER, SC.D.
Professor in Charge of the Department; in charge of the Course in Aeronautical Engineering
ALLYNE LITCHFIELD MERRILL, S.B.
Professor of Mechanism, Emeritus
CHARLES EDWARD FULLER, S.B.
Professor of Theoretical and Applied Mechanics; Dean of Army Students
CHARLES FRANCIS PARK, S.B.
Professor of Mechanism, Emeritus
GEORGE BARTHOLOMEW HAVEN, S.B.
Professor of Advanced Machine Design, Emeritus
JOSEPH CAINS RILEY, S.B.
Professor of Heat Engineering
CHARLES WILLIAM BERRY, S.B.
Professor of Heat Engineering
GEORGE WRIGHT SWETT, S.B.
Professor of Machine Design; Secretary of the Faculty
CHARLES FAYETTE TAYLOR, PH.B., M.E.
Professor of Automotive Engineering
GORDON BALL WILKES, S.B.
Professor of Heat Engineering
EARLE BUCKINGHAM
Professor of Mechanical Engineering
ALFRED VICTOR DE FOREST, S.B.
Professor of Mechanical Engineering
EDWARD ROBINSON SCHWARZ, S.B.
Professor of Textile Engineering
CARL RICHARD SODERBERG, S.B.
Professor of Applied Mechanics
THEODORE HOWARD TAFT, S.B.
Associate Professor of Heat Engineering

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BENJAMIN ERNEST SIBLEY, M.D.
Assistant to Medical Director
HARLAND FRANCIS LANCASTER, M.D.
Assistant to Medical Director
ROGER THOMAS DOYLE, M.D.
Assistant to Medical Director
JOHN WINSLOW CHAMBERLAIN, M.D.
Assistant to Medical Director
JOHN WEBSTER WILLIAMS, M.D.
Associate Professor of Public Health Laboratory Methods; Pathologist
HENRY PATRICK MCCARTHY
Director of Physical Training

Student Assistant

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Professor of Mathematics, Emeritus
FREDERICK HAROLD BAILEY, A.M.
Professor of Mathematics, Emeritus
FRANK LAUREN HITCHCOCK, PH.D.
Professor of Mathematics
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Professor of Mathematics
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Professor of Mathematics
NATHAN RICHARD GEORGE, A.M.
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PHILIP FRANKLIN, PH.D.
Professor of Mathematics
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Assistant Professor of Mathematics

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MORRIS COHEN, Sc.D.
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GEORGE PARSONS SWIFT, S.M.

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ALBERT RUDOLPH KAUFMANN, Sc.D.

Research Assistant

KARL LEROY FETTERS, B.S.

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Associate Professor of Military Science and Tactics; in charge of Engineer Unit; Executive Officer

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Associate Professor of Military Science and Tactics; in charge of Ordnance Unit

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Associate Professor of Military Science and Tactics; in charge of Coast Artillery Unit

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Associate Professor of Military Science and Tactics: in charge of Chemical Warfare Unit

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Associate Professor of Military Science and Tactics; in charge of Signal Corps Unit

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Associate Professor of Military Science and Tactics; with Coast Artillery Unit

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HAROLD FRANCIS MCDONNELL, LL.B. Staff Sergeant, D.E.M.L., Corps of Engineers

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HORACE THARP MANN, SC.D.
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Instructor

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ALBERT WILBUR SCHLECHTEN, B.S.

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Professor of German

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FRITZ GROB, S.J.D.

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Professor of Naval Architecture and Marine Engineering, Emeritus; Honorary Curator of the Nautical Museum

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Professor of Naval Design and Construction, Emeritus

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Professor of Naval Architecture

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

HENRY EASTIN ROSSELL, GRAD. U.S.N.A., S.M. Commander (C.C.) U.S.N. (Retired)
Professor of Naval Construction; in charge of course in Naval Construction (XIII-A)

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EVERS BURTNER, S.B.
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Lieutenant Commander (C.C.) U.S.N. *Naval Architecture*

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MILTON KARR, S.B.

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Professor of Physics and Electrochemistry; Dean of the Graduate School

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

PHILIP MCCORD MORSE, PH.D.
Associate Professor of Physics

BERTRAM EUGENE WARREN, SC.D.
Associate Professor of Physics

DONALD CHARLES STOCKBARGER, SC.D.
Associate Professor of Physics

HANS MUELLER, D.SC.
Associate Professor of Physics

JULIUS ADAMS STRATTON, SC.D.
Associate Professor of Physics

NATHANIEL HERMAN FRANK, SC.D.
Associate Professor of Physics

WAYNE BUCKLES NOTTINGHAM, PH.D.
Associate Professor of Physics

JOHN CARL GAUDE WULFF, D.SC.
Associate Professor of Physical Metallurgy

JOSEPH CANON BOYCE, PH.D.
Associate Professor of Physics

ROBLEY DUNGLISON EVANS, PH.D.
Associate Professor of Physics

FRANCIS WESTON SEARS, S.M.
Assistant Professor of Physics

WILLIAM PHELPS ALLIS, D.SC.
Assistant Professor of Physics

EDWARD STONESTREET LAMAR, PH.D.
Assistant Professor of Physics

WALTER EDWARD ALBERTSON, PH.D.
Assistant Professor of Physics

CHESTER MURRAY VAN ATTA, PH.D.
Assistant Professor of Physics

LESTER CLARE VAN ATTA, PH.D.
Assistant Professor of Physics

GEORGE GRAHAM HARVEY, PH.D.
Assistant Professor of Physics

Instructors

WILLIS MACNAIR RAYTON, PH.D.
ARTHUR FRANCIS TURNER, PH.D.
ALBERT GORDON HILL, PH.D.
C. HAWLEY CARTWRIGHT, PH.D.
JOHN HENRY BUCK, M.S.

Research Associates

CARYL PARKER HASKINS, PH.D.
ROY MAXFIELD WHELDEN, PH.D.
ARTHUR ROBERTS, PH.D.

Research Assistants

ROBERT LEE ALDER, S.B.
JONATHAN BISCOE, S.M.
CHARLES EDWARD BUCHWALD, M.S.
CLARK GOODMAN, B.S.
DOYLE LANGDON NORTHRUP, S.M.

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RICHARD LELAND BROWN, M.A.
SANBORN CONNER BROWN, A.M.
JOE STEARNS CLARK, S.B.
ALBERT MCCAVOUR CLOGSTON, S.B.
JOHN HARRISON DANIEL, M.S.
JAMES ROBERT DOWNING, B.A.
SEIBERT QUIMBY DUNTLEY, M.S.
DEMETRIUS GEORGE JELATIS, S.B.
JULIUS PAUL MOLNAR, A.B.
NORMAN HALLAM MOORE, A.B.
JOSEPH ROSS PERKINS, JR., B.S., E.E.
ALEXANDER ANSELMUS PETRAUSKAS, M.S.
CHARLES SYDNEY SMITH, JR., B.S.
EDWARD HOWARD SMITH, M.A.
GERALD LEON TAWNEY, B.S.

Assistant

JAMES WOODRUFF FARMER, B.E.E.

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General Study subjects are given by members of the staffs of various Departments and by the following:

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Samuel Chamberlain — *Lecturer in Expressions of Graphic Art*
Theodor Carl Muller, S.B., — *Lecturer in Design in Manufactured Products*

Chairman of the Committee on the Technology Museum
Arthur Chase Watson, A.B.

Director of the Dard Hunter Paper Museum
Dard Hunter

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Professor of Industrial Physics; Director

Robert Collins Eddy, Grad. U.S.M.A.
Associate Professor. On special assignment

Nathaniel McLean Sage — *Placement Officer*

Research Associates
William Ellwood Yelland, Ph.D.
Herbert Henry Uhlig, Ph.D.

Research Assistant
Victor George Mooradian, Sc.D.

SECTION OF DRAWING

Professors

John Thomas Rule, S.B.
Associate Professor of Drawing and Descriptive Geometry; in charge of the section

Stephen Alec Breed, S.B.
Associate Professor of Drawing and Descriptive Geometry, Emeritus

Ervin Kenison, S.B.
Associate Professor of Drawing and Descriptive Geometry, Emeritus

Earl Francis Watts, S.B.
Assistant Professor of Drawing and Descriptive Geometry

Arthur Lindsay Goodrich, S.B.
Associate Professor of Drawing and Descriptive Geometry

Charles Hill Roe Mabie
Assistant Professor of Drawing and Descriptive Geometry

Instructors

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Bertha Preston Trull, A.B.
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Marguerite Chamberlain, A.B., B.S.

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Alfred Korach, M.D.
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Clarence Albert Johnson, M.Sc.
Royal Society of Canada Fellow
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Arthur D. Little Post-Doctorate Fellow
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Ralph Flint Phillips, A.B., M.Sc.
Arthur D. Little Fellow
Walter Hugo Stockmayer, S.B.
Polymerization Process Corporation Fellow
Wilbur Joseph Wald, B.S., *Cellulose Fellow*

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National Research Fellow
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R. E. Freeman
C. E. Fuller
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J. L. Reid
T. K. Sherwood
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R. S. Williams

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J. B. Babcock	1940
A. L. Townsend	1940
J. C. Boyce	1941
J. T. Norton	1941
R. H. Robnett	1942

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C. L. Svenson	1941
D. C. Stockbarger	1942

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G. B. Wilkes	1941

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T. S. Gray	1941
W. C. Voss	1941
A. R. Davis	1942
J. T. Rule	1942
F. L. Foster	1943
H. E. Rossell	1943

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Secretary*	
Dean of Students*	
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E. E. Bugbee	1940
B. E. Proctor	1941
E. L. Gamble	1942

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Dean of Students*	
Registrar*	
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W. J. Mead	1939
W. R. Maclaurin	1940
R. S. Woodbury	1940
J. W. Horton	1941
S. G. Simpson	1941

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Librarian (*Secretary*)*	
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P. Roberts	1939
J. M. Lessells	1940
M. W. Jennison	1941
L. B. Slichter	1941

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G. P. Wadsworth

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B. A. Thresher
W. H. McAdams
C. E. Tucker
F. G. Keyes

INSTRUCTION OF SUPERIOR STUDENTS

C. E. Fuller (*Chairman*)
H. H. W. Keith
E. B. Millard
R. E. Freeman
R. H. Frazier

TECHNOLOGY MUSEUM

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

GRADUATION EXERCISES AND SENIOR WEEK

R. G. Hudson (*Chairman*)
H. M. Goodwin
R. S. Williams
J. W. M. Bunker
R. C. Eddy
J. C. MacKinnon
H. S. Ford

STUDENT-FACULTY

S. C. Prescott (*Chairman*)
C. E. Fuller
W. M. Fife
K. D. Fernstrom
J. A. Stratton
R. D. Douglass

SUMMER SESSION

R. D. Douglass (*Chairman*)
E. R. Gilliland
A. F. Holmes
J. W. Horton
J. C. MacKinnon
B. E. Warren

PATENT POLICY

V. Bush (*Chairman*)
A. C. Hardy
C. L. Norton
F. G. Keyes
E. L. Bowles

DORMITORY BOARD

L. F. Hamilton (*Chairman*)
H. E. Lobdell
D. L. Rhind
A. A. Ashdown
W. C. Wood

LOAN BOARD

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

UNDERGRADUATE BUDGET BOARD

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

P. S. Lincoln

Above and below and on the following page are views of the Technology buildings and of Boston across the Charles River Basin. On the Basin row Technology crews and here, too, students sail Technology's fleet of 36 dinghies

P. A. Cole

A. R. Anderson

F. S. Lincoln

themselves to the work of the school between the hours of 9 A.M. and 5 P.M. There are no exercises on Saturday after 1 P.M. Students who withdraw during the term should give advance notification to the Dean of Students and the Registrar.

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

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

Conditions received at the end of the first term must be made up during the second term on Saturday afternoons beginning in March; those received at the end of the second term must be made up the following September. A student not taking an examination at the time stated forfeits the right to this examination.

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

Examinations for Advanced Standing. Registered undergraduate students of all classes, with a cumulative rating of 3.50 and above, may take examinations for advanced standing, in subjects for which they have never been registered, during the condition examination periods in September and March. Notice of intention must be filed with the Registrar on the usual petition blanks, and must be submitted at least two weeks before the scheduled examination period.

The privilege of an examination in a subject which involves laboratory instruction, or drawing, must be approved by the Faculty member in charge of the subject.

Health of Students. The Department of Hygiene is organized to protect and improve the health of students. A clinic is held by a doctor every day 8.30–10; 10.30–1.30; and 3.30–5 (except Saturday), for the care of the sick. Students in the first year are required to take physical exercise, and have the option of taking routine gymnastic work in the gymnasium or substituting one of the competitive sports. Gymnastic facilities are available for all students.

The Homberg Memorial Infirmary cares for seventeen ward and private room patients and is fully equipped. A moderate charge *per diem* is made to students who use a bed in the wards with an increased fee for use of a private room. Extra charges are made only for special medical or surgical services, or for special nursing, medicines or supplies.

Every male undergraduate student is required to report to the Medical Director for a complete physical examination during the first term of each academic year, and every male graduate student is required to report for such examination during his first term of residence as a graduate student at the Institute.

Conduct. It is assumed that students come to the Institute for a serious purpose, and that they will cheerfully conform to such regulations as may be, from time to time, made by the Faculty or Administration. In case of injury to any building, or to furniture, apparatus, or other property of the Institute, the damage will be charged to the student or students known to be immediately concerned; but if the persons who cause the damage are unknown, the cost of repairing the same may be assessed equally upon all the students of the school.

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

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

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

Advisers. The Dean of Students is the general consulting officer for all students, and coöperates with the President in matters of discipline and general student relations. On request to his office, advisers from the Instructing Staff will be assigned to new students. It is not intended that the advisers shall become, in any sense, guardians of the students assigned to them; nor does the Faculty by this action assume any responsibility for the conduct of students outside the halls of the Institute.

Each student is assigned to a Registration Officer who is a member of the Faculty having responsibility for, and control of, his academic program. The Assistant Dean of Students serves as Registration Officer for all first-year students, except those in the School of Architecture.

FEES, DEPOSITS, PAYMENTS, EXPENSES

Tuition Fees. For all students pursuing regular courses, undergraduate or graduate, the tuition fee of $600 per year, must be paid *in advance* as follows: $300 before the opening of each academic term, the date and hour to be specified in the Registration Instructions issued prior to the opening of the particular term. Special students pay, in general, the full fee; but when a few subjects only are pursued, application for reduction may be made to the Bursar.

For convenience, the tuition fees for students taking coöperative work in II-A or VI-A after the second year is $200 for the summer term and $200 for each of the two regular academic terms. If not registered or attending in the summer term, the regular tuition fee of $300 per academic term is required.

Sons of regular Army, Navy and Marine Corps Officers who are admitted to the Institute as undergraduate students will pay one-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. Holders of these awards, if recommended by the Committee, may continue at the half tuition rate during their second and succeeding undergraduate years.

For fees and deposits required for the professional summer schools see page 39.

Members of the teaching staff on full-time appointment, pursuing programs leading to the Master's or Doctor's degree, and taking more than one subject or engaged on research or thesis, pay $100 for each term for which they are registered as proceeding toward the degree. If taking but a single subject, the fee shall be at the staff rate of $6.00 per "unit." Those on half-time appointment pay $150 for each term for which they are registered as proceeding toward the degrees. The above fees admit members of the Staff working for the Master's or Doctor's degree to all subjects, both undergraduate and graduate, which are approved by their respective Departmental Committees, and to thesis work.

The only fee charged for carrying on research or thesis during the Summer Session is a registration fee of $5.

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

Entrance Examination Fee. The charge for entrance examinations is $10, except that when a candidate takes only one examination the fee is $5. A candidate will be required to pay the fee for each period in which he takes examinations. Fees should be paid in advance of the first examination.

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

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

Deposits to Cover Chemical Supplies, Military Uniforms, etc. All first-year students will be required to make a deposit of $25, from which 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 chemicals and laboratory supplies will be charged.

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

If the total of chemicals and supplies exceeds the amount of this deposit, an additional amount sufficient to cover this excess must be paid. Unused balance of deposits *will be returned at the end of the year upon application*, or held for credit the following year.

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

Graduate and Undergraduate Dues. From the tuition fee of each student registered, the Institute will appropriate the sum of $3.50 per term ($7 per year) to be devoted to the promotion of student life with special reference to the physical and social welfare of the students. No part will be spent for any class function, athletic event or social entertainment that is not open without charge to every qualified member of the student body in good standing.

These dues will be expended under the general direction of the Institute Committee subject to the approval of an Advisory Committee appointed by the Corporation.

Subject to modification, dues will be apportioned as follows:

Institute Committee	$0.50
Class Dues	.44
Athletics	5.80
Reserve and Contingent Fund	.26

In addition to the amount made available through these dues, the Institute yearly appropriates from its operating budget about $60,000 to cover athletic coaching salaries and the maintenance and operation of Walker Memorial, Tech Field, the Boat House and Sailing Pavilion, and the launches.

Payments. *No bills are sent.* All payments should be made to D. L. Rhind, Bursar, Massachu-

setts Institute of Technology, Cambridge, Mass. *Students are advised to make their payments by mail.*

Estimated Expenses. For the school year 1938–1939, a period of 38 weeks, an estimate of expenses exclusive of personal expenditures such as transportation, clothing, recreation, etc., is given below:

FOR A PERIOD OF 38 WEEKS

Tuition	$600
Board	300
Room	205
Books and materials	70
	$1,175

To assist students to secure employment, either during the school year or the summer, the Student Employment Bureau is maintained by the Technology Christian Association. Application may be made at this office by students desiring to help themselves in meeting their expenses. Prospective students should, however, realize that the demands of the Institute curriculum are such as to make it impracticable to devote a large amount of time to outside employment during the school year. Students from foreign lands, in particular, should clearly understand that the opportunities to secure remunerative employment for them are seriously restricted by their unfamiliarity with the English language and American business customs.

LOANS, SCHOLARSHIPS, FELLOWSHIPS, AND PRIZES

See Appendix A for Complete Details

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

The extent of these resources is indicated by the facts that, since its establishment in 1930, over 1,750 men have borrowed more than $1,150,000 from the Technology Loan Fund; that, during 1938–39, $102,800 and $115,000 will be available for undergraduate and graduate scholarship aid respectively.

For regulations and full information on Student Aid of all types consult Appendix A ("Student Aid") of this Catalogue.

PLACEMENT

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

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

EDUCATIONAL BUILDINGS

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

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

Laboratories. Another marked characteristic of the Institute from the material point of view is found in its numerous large and well-equipped laboratories. Notable among these are the George Eastman Research Laboratories of Physics and Chemistry, the Spectroscopy Laboratory, the Guggenheim Aeronautical Laboratory, and the Laboratories of Steam and Compressed Air, Refrigeration, Testing Materials, Hydraulics, Gas Engines, Mining, Metallurgy, Chemical Engineering, Physical Chemistry, Applied Physics, Electrical Engineering, Biology, 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 well-organized branches, containing all together approximately 335,000 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 1,400 periodicals, not counting transactions and other annuals.

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, public health, and mechanical and electrical engineering. Especially notable is the Vail Collection in electrical engineering, described at length on page 101. Cultural subjects, such as history, biography, travel, literature, are not neglected.

The Central Library is open on week days during term time from 8.45 A.M. to 9 P.M., except on Saturdays when it is closed at four o'clock. During the summer it will be open from 8.45 to 4 P.M. and possibly during evening hours. Individual reference service, bibliographical aid, and assistance in the use of the card catalogue are given at the two reference desks in the Central Library and in the larger branch libraries. Seniors, graduate students and others engaged on theses or other research are granted admission to the stacks.

Books and periodicals which the Institute Library does not own can often be obtained from other libraries, on interlibrary loan, or, in lieu of the actual book, it is generally possible to obtain photostats or film reproductions. A certificate, obtainable at the main circulation desk, enables students to obtain borrowing privileges at the Boston Public Library.

The following branch libraries, located near the departments which they serve, supplement the work of the Central Library: Aeronautics, Architecture, Dewey (civil and mechanical engineering, naval architecture, 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, mining, metallurgy and ceramics), and Walker Memorial, the last-mentioned being a "browsing library" for recreational reading. The material in all these libraries is listed in the Central Library catalogue, and telephone interconnection affords a well-integrated service.

Summer Camps. Two admirably located and amply equipped engineering camps are maintained, one by the Department of Mining Engineering, the other by the Department of Civil and Sanitary Engineering. During the summer sessions at these camps, students get field practice under competent instructors and, incidentally, obtain the healthful experience of approximately two months of outdoor life.

The former is in the magnetic iron ore field near Dover, N. J., about an hour's distance from New York City on the Delaware, Lackawanna and Western Railroad; the latter on the shore of Gardner's Lake about eight miles from East Machias, Maine.

Camp Technology, the summer school of Civil Engineering, comprises about 850 acres of rolling terrain, some of which is wooded, in a region well adapted for carrying out exercises in plane and geodetic surveying as well as opportunities for hydrographic field work and the study of limnology.

Bemis Hall, the headquarters of Camp Technology, has a sightly location on a high bluff overlooking Gardner's Lake, and, in a direct line, is less than three miles from tidewater. In Bemis Hall and other buildings connected with it by covered passages are lounging and dining facilities, lecture, recitation and drafting rooms, office accommodations for the Staff, a store and post office.

Sleeping quarters for students are provided in eight wooden barracks facing the lake; and for the Staff in a clubhouse known as Eaton Hall. Other structures include a geodetic observatory, a seismograph house, a limnological laboratory, extra space for drafting or classroom usage, and an infirmary which serves as an emergency hospital. A physician is in constant attendance throughout the period of instruction.

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.

STUDENT HOUSING

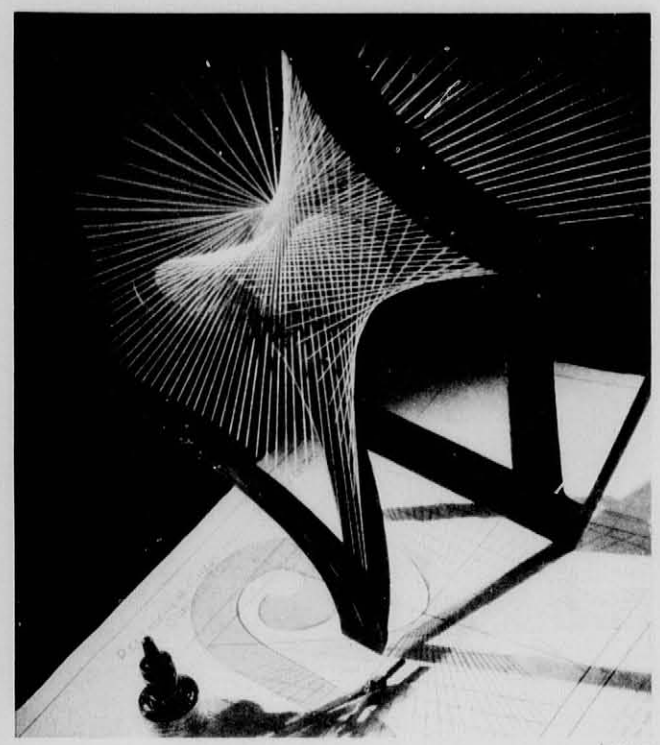
Complete information on the Student Houses, both Graduate and Undergraduate, including floor plans, and details regarding application, allotment of rooms, equipment, rentals, payments, occupancy, government and so forth, is presented in Appendix B (Student Housing) of this Bulletin. Reprints will be supplied on request. For further information regarding the Undergraduate Houses, address D. L. Rhind, Bursar. Inquiries and applications for the Graduate House should be addressed to Professor A. A. Ashdown, House Master.

RECREATIONAL FACILITIES

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

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

Adjacent to this building and the dormitories are

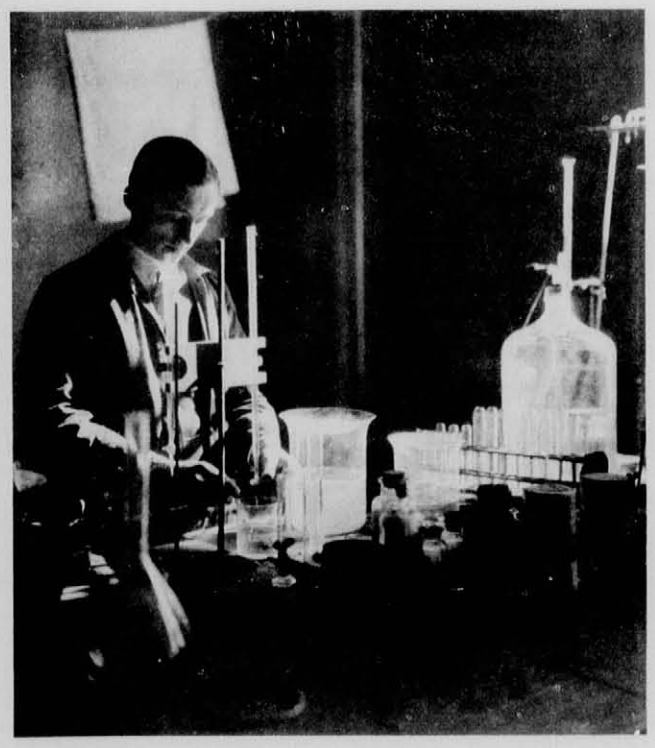


Mathematics

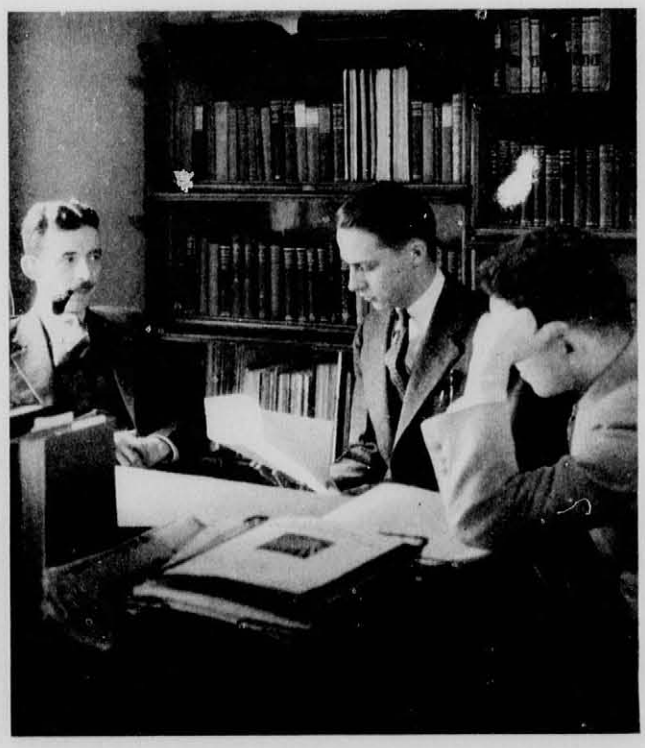
Physics

FUNDAMENTALS

WHEN the freshman begins his work, he finds that the subjects of study consist mainly of such fundamentals as physics, chemistry, mathematics, and English. It is not until the third year that students in different Courses find their paths diverging, but even as they then begin to major in selected fields they find a continued emphasis on fundamental science and design.

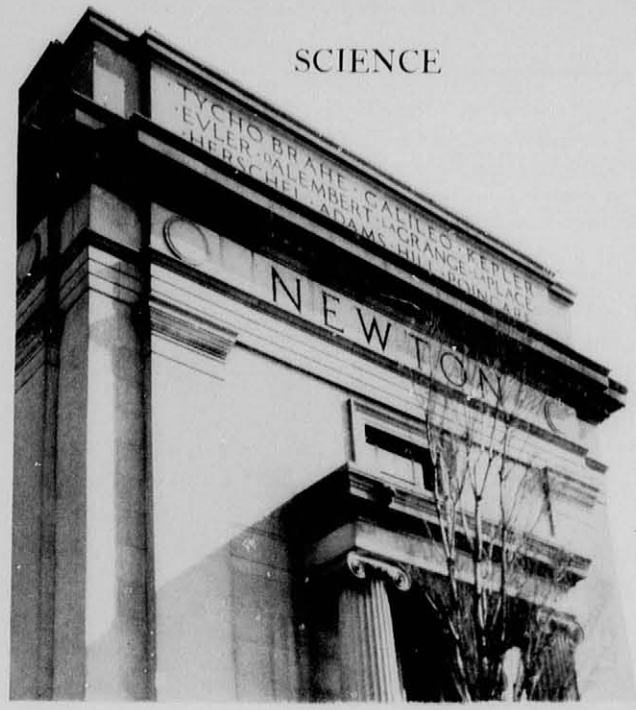


Chemistry

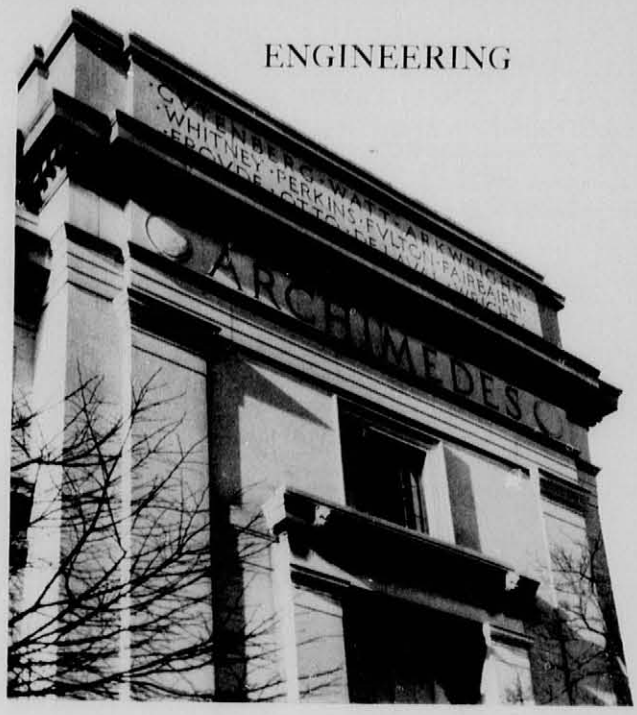


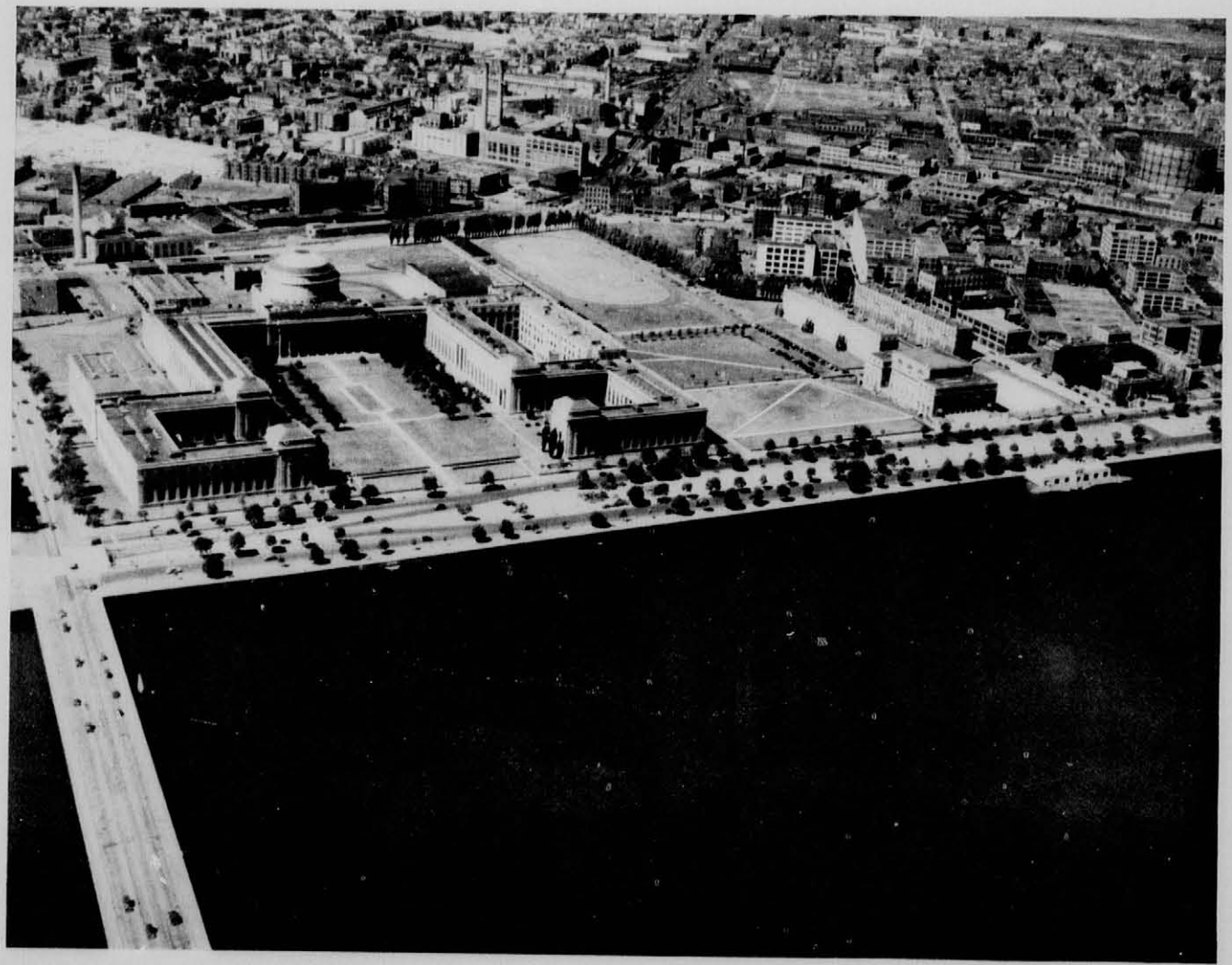
The Humanities

SCIENCE

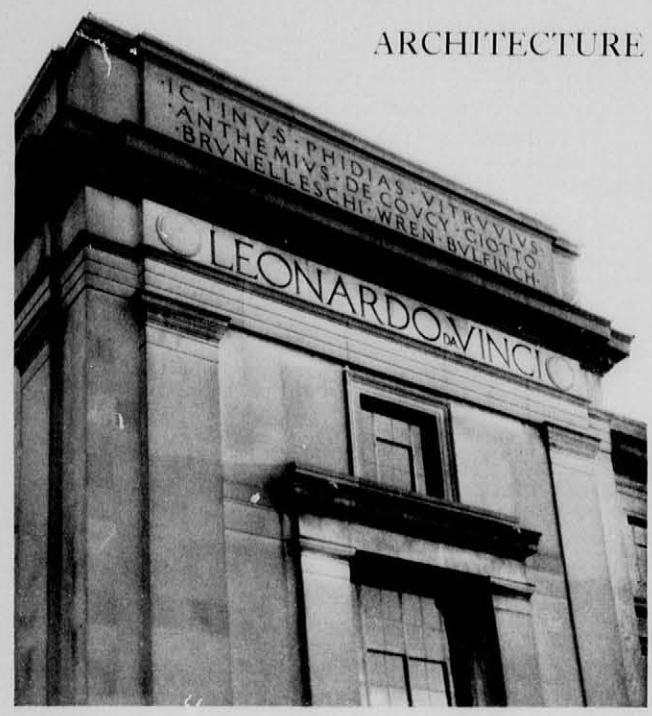


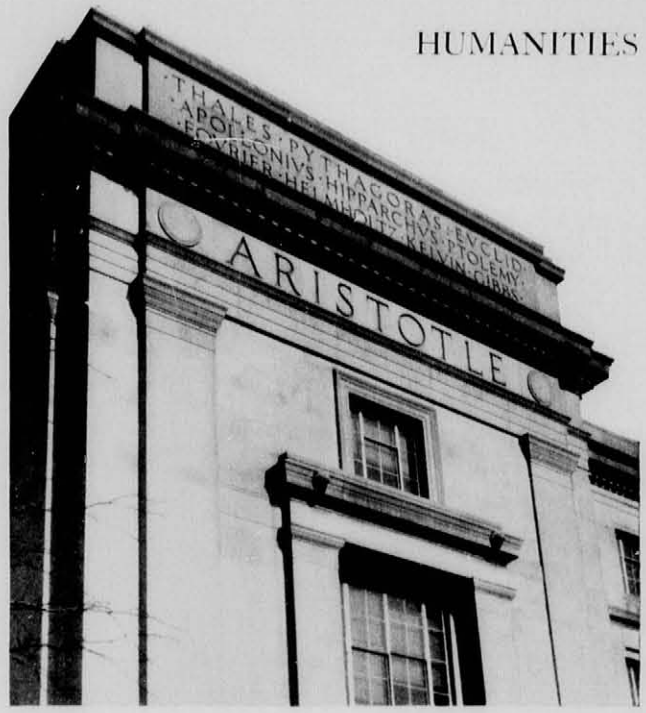
ENGINEERING





Fairchild





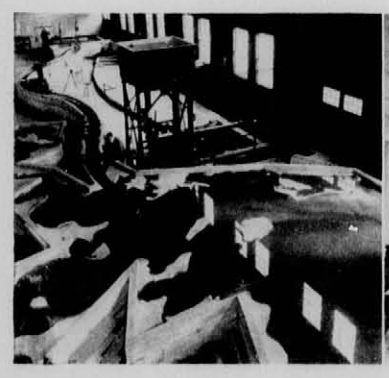
SCOPE—UNITY—COÖRDINATION

THE characteristic spirit of M. I. T. finds its material embodiment in the great group of educational buildings. Here the many departments of study and instruction are brought together under a single roof. Corresponding to this structural unity is vital unity of coöperation in work and teaching.

Never, as here at Technology, have the problems of research and of technical proficiency been dealt with as coöperative projects, to be studied and solved coöperatively. This spirit, distinctive of the methods of study and instruction at the Institute, is in perfect agreement with that ancient yet most modern of philosophic generalizations according to which the entire field of scientific knowledge is seen as fundamentally one. Valuable, too, is the close contact that this unity of plant and work permits between undergraduate and graduate students and between both these groups and the staff.

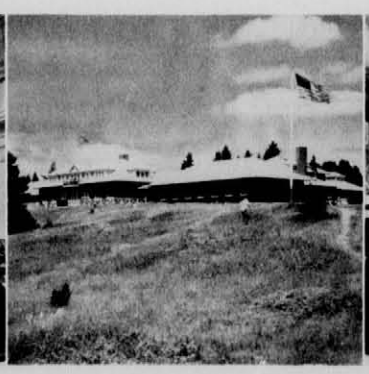
Within this unity there also exists a diversity that gives the student great flexibility in selecting a course of study best suited to his abilities and wishes. This adaptability arises out of the provision by the Institute of over forty programs of study, and from the division of the Institute into the following groups: the Graduate School, the School of Architecture, the School of Science, the School of Engineering, the Division of Humanities, and of Industrial Coöperation.

In the Schools of Architecture, Engineering, and Science are grouped those departments of study which lead to degrees and which embody the primary educational objectives of the Institute. In the Division of Humanities are grouped the studies which are provided in order that students may supplement the cultural values inherent in their scientific and engineering studies with the discipline of the humanities. The Graduate School coördinates the work leading to advanced degrees in all the departments. In the Division of Industrial Coöperation are centered the organized activities devoted wholly or in part to the assistance of industry.



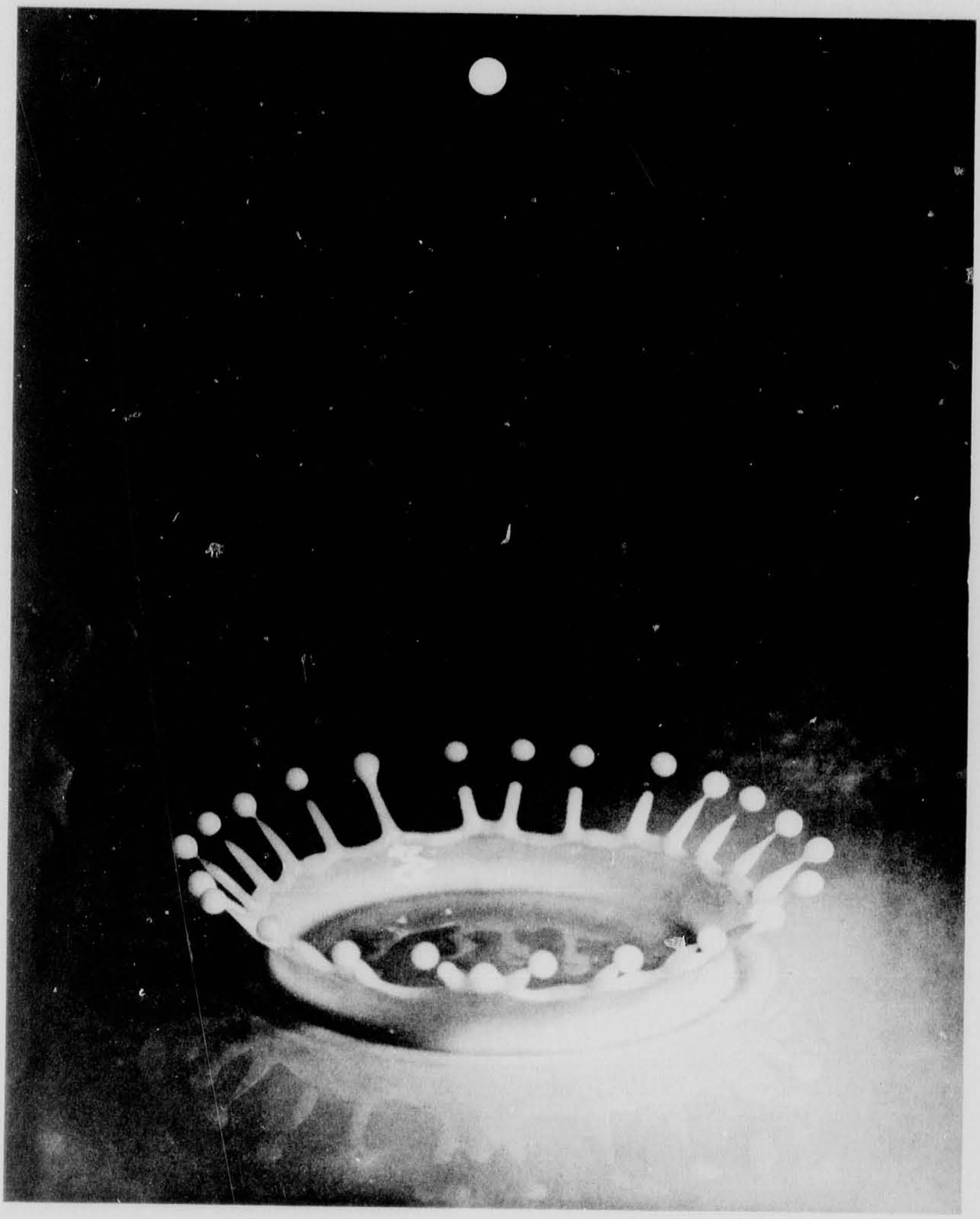
Laboratories

Libraries



Engineering Camps

Museums



Superhigh-speed photograph of falling drop of milk taken in the Institute's laboratories

SCIENCE

. . . it is valued for its practical advantages, it is valued because it gratifies disinterested curiosity, and it is valued because it provides the contemplative imagination with objects of great æsthetic charm. J. W. N. Sullivan

tennis courts, a football field, a quarter-mile cinder track with a 220-yard straightaway, and accommodations for the field events. To care for the needs of the track men during the winter an outdoor board track is provided.

The Barbour Field House, opened in September, 1934, has, in addition to modern shower and locker facilities, special rooms for visiting teams. Connected with the Field House there is another gymnasium with a regulation basketball court, a movable boxing ring, wrestling mats and indoor jumping pits, and a Squash Building with eight courts. On the land west of Massachusetts Avenue are fields for soccer, lacrosse and baseball, as well as additional tennis courts.

A boathouse on the Charles River supplied with indoor rowing machines has also a number of singles and wherries available for students, in addition to the opportunities offered to all undergraduates to learn how to row in an eight-oared shell under competent coaching. The Sailing Pavilion, located on the Charles River in front of Walker Memorial, is the headquarters of the Nautical Association's fleet of thirty-six dinghies.

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 a year ago, with space and equipment provided by the Institute, it has been, in response to the student interest, doubled in size. All the machines and other tools needed for woodworking, metalworking, and the like, are installed, and equipment for new groups interested in radio, photography, electroplating, and telescope-making, is now being assembled.

Alumni of the Institute are now raising funds to enlarge the recreational facilities, particularly those for athletics. A new athletic field and a swimming pool are included in the plans.

UNDERGRADUATE ACTIVITIES

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

Athletics. The purpose of athletics at the Institute is not to develop highly trained athletes, but rather to encourage all students to participate in some form of physical recreation. Control is vested in the M. I. T. Athletic Association, an undergraduate organization composed of all captains and managers of varsity teams as working members, and assistant managers and officials of class teams as associate members. Funds are secured by undergraduate dues, appropriated by the Institute authorities, but disbursed by the Undergraduate Association. An Advisory Council of Alumni works with the students and exercises the functions which its name implies.

No attempt is made to concentrate on coaching the few men composing a single varsity team, but instruction is given to all men reporting for a sport. As a corollary to this, the success of a given athletic activity is gauged by the number of men it attracts. Among the activities are: track and field sports, cross country running, rowing, basketball, boxing, fencing, golf, gymnastics, hockey, lacrosse, rifle shooting, soccer, swimming, tennis, squash racquets, wrestling. Class teams are organized informally in football and baseball.

Nautical Association. The Nautical Association offers every student an opportunity to learn sailing. A fleet of thirty-six dinghies, constituting a special Technology class designed by Technology men, is 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.

Sailing activities of the Nautical Association are under the advisory direction of a sailing master who is an experienced yachtsman. 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 excellent opportunities to broaden contacts and to receive practical experience in the field of journalism—experience that in after years frequently proves to be of material value. All work incident to the editing and financing of the publications is carried on by the students, with an Alumni Advisory Council available for consultation.

There are four self-supporting undergraduate publications: *The Tech*, a bi-weekly newspaper; *The Tech Engineering News*, a monthly technical journal; *Technique*, the year book; and *Voo Doo*, a comic magazine. The staffs are chosen as a result of open competition. *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 year book, which is issued as a large volume, containing pictures and records of seniors and graduate students and, in addition, accounts of all regular undergraduate activities and outstanding social functions of the year.

Music, Drama, and Public Speaking. The Combined Musical Clubs, consisting of the Glee, Instrumental and Banjo clubs, provide opportunities for training and expression in instrumental and vocal music. The Dramashop produces plays. Members of the Debating Society participate in inter-collegiate debates and exhibition contests. The Technology Union holds public meetings for debating and discussing current problems.

Student Professional Societies. The Professional Societies, of which there are twelve, hold meetings for the presentation of scientific papers by students, culminating in the presentation of the Stratton Prizes at Commencement. The Combined Professional Societies also manage Open House, which brings more than 20,000 visitors to the Institute.

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

Technology Christian Association. This student activity aims to be of practical service to every student and to foster among members of the Institute community the ideals of Christian living and active Christian service. It organizes students for social service and religious activity in Metropolitan Boston, maintains a theater ticket service and book exchange, operates the Student Employment Bureau, the Tech Cabin and Freshman Camp, and publishes the Freshman *Handbook*.

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

REQUIREMENTS FOR ADMISSION

ADMISSION FROM SECONDARY SCHOOLS

Selection of Applicants. Under the plan for stabilization of the Institute enrollment the size of the First Year class admitted in 1938 and 1939 may not exceed six hundred. Since it is expected that the number of applicants will be more than six hundred, the Faculty Committee on Admissions will exercise discretionary powers of selection.

Preference will be accorded applicants whose evidence of academic fitness and of professional promise indicates that they are particularly qualified to pursue Institute Courses with success. It is the desire of the Faculty to admit only those candidates who possess qualities, both of character and intellect, which indicate their adaptability to an academic environment, and which show promise of their development into useful and forceful citizens. All applicants for admission to the First Year class will be expected to arrange for an interview with the Director of Admissions or (for applicants outside New England) with an alumnus designated by the Director of Admissions. It is recommended that this be done before March 1 of the year in which the applicant desires to enter.

The candidate is requested to indicate his tentative choice of Professional Course at the time of filing his application. After admission, he may reconsider his choice, and he has the option of changing at any time during his 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. It is presupposed that a candidate's training in English has been such that he can properly express his ideas. Unless he has completed preparation in three units of English, he must otherwise demonstrate to the satisfaction of the Committee on Admissions that he has this ability. The candidate should bear in mind that the broader his intellectual training and the more extensive his general attainments, the greater will be the advantages he may expect to gain. The training given in the better high and preparatory schools will, in general, afford suitable preparation.

Attention is called particularly to the necessity of thorough preparation in Mathematics, not merely as to the extent and amount of work done, but as to its quality. Candidates should be thoroughly grounded in fundamental principles, operations and definitions.

The following subjects are specifically required of each applicant (the figure in parentheses after each subject indicates the usual unit rating. In general a unit represents a full year's study in a secondary school subject taken four or five times a week):

Algebra (2)	Trigonometry (½)
Plane Geometry (1)	Physics (1)
Solid Geometry (½)	English (3)

Further evidence of adequate preparation, amounting to seven units of elective subjects is required and may be offered from the following groups:

Foreign Language	Mathematics
Social Science	Mechanic Arts
(History, Civics, etc.)	Mechanical Drawing
Biological Science	Commercial Studies
(Biology, Zoology, etc.)	Fine Arts, Drama, and
Physical Science	Music
(Chemistry, General Science, etc.)	

In the choice of electives, the following limitations are imposed:

1. Not less than two units of any language will be accepted. The following languages may be offered: French, German, Spanish, Italian, Latin, and Greek.
2. A total of not more than two units will be accepted from the following groups: Mechanic Arts, Mechanical Drawing, Commercial Studies, Fine Arts, Drama, and Music.

In order that an applicant may arrange his program of study to provide the most suitable preparation, the following electives, though not required, are recommended:

Chemistry (1). A preparatory course in Chemistry is highly desirable to provide a background for the first year required work at the Institute.

History (1). The study of history is advisable in order that a student may have a better understanding of contemporary civilization.

French (3) or *German* (3). If it is impracticable to present three units of French or three units of German, it is recommended that two units of each be offered. Since preparation in these languages is necessary in certain Courses, an applicant who does not offer them may be required after admission to study one or both before becoming eligible for the Bachelor's degree. When planning his entrance program, a student who intends to pursue graduate work should consider that one (or sometimes both) of these languages will be required.

Application Procedure. A Preliminary Application form may be obtained from the office of the Director of Admissions. Final Application forms and Personal Endorsement forms will be mailed about January 15 to applicants who expect to enter the following September and for whom there is a Preliminary Application on file.

The following must be received by the Institute by March 1 for all final applicants:

1. Final Application.
2. Endorsements from two persons, not relatives or teachers of the applicant, of recognized standing in their community.
3. School Record obtained by the Institute directly from the principal or headmaster.

Methods of Admission.

I. *Admission without Examinations*

1. The applicant must have been graduated from a secondary school accredited by the Institute and have ranked in the highest fifth of his class during the two years immediately preceding his graduation. This plan of admission will not apply if the graduating class has less than ten students. The accrediting of a school depends on the accomplishments of its graduates at the Institute. An applicant ineligible for consideration under this plan will be so notified at the time of filing his preliminary application.
2. The applicant must have completed preparation in the subjects specifically required for admission and in seven units of electives chosen from the list given above.

II. *Admission by Examinations*

1. The applicant must pass examinations in Algebra, Plane Geometry, Solid Geometry, and Trigonometry. A satisfactory grade in Mathematics Gamma, given by the College Entrance Examination Board, will be accepted in place of examinations in the single mathematical subjects. Records in Mathematics Alpha and Beta will not be accepted.
2. He must present satisfactory school records, or pass examinations in English, Physics and seven units of electives chosen from the list of electives under "Subjects Required for Admission". Preference will be given to applicants who present school records of certificate grade in these subjects.

Examinations may be extended over a period of not more than three years and may be any (or a combination) of the following:

a. College Entrance Examination Board examinations.

These are held in June in the principal cities of the United States and in Canada, London, Paris, Geneva and other foreign centers. A list of places and dates of the examinations is published by the Board each year about March 1. Application for examination must be made on a form to be obtained from the Secretary of the College Entrance Examination Board, 431 West 117th Street, New York City. If the application is received sufficiently early, the examination fee will be $10.

TABLE OF EQUIVALENTS:

M. I. T. Subjects	*C.E.E.B. Subjects*
Algebra	Mathematics, A, or A1 and A2
Geometry, Plane	Mathematics C
Geometry, Solid	Mathematics D
Plane Trigonometry	Mathematics E
Physics	Physics
English	English
Chemistry	Chemistry
History	History A, B, C, or D
French (Elementary)	French 2
French (Intermediate)	French 3
German (Elementary)	German 2
German (Intermediate)	German 3

b. New York State Regents examinations.

Only grades of 80 per cent, or better, will be accepted in the specifically required examination subjects. The official report of these examinations will be secured by the Institute from the State Board of Regents at Albany.

c. Institute entrance examinations, given in September in Cambridge only.

Application in advance for admission to the examinations is not necessary. Candidates will register during the examination period.

The charge for entrance examinations held at the Institute is $10, except that when a candidate takes only one examination the fee is $5. A candidate will be required to pay the fee for each year in which he takes examinations. Fees should be paid in the examination room before taking the first examination.

d. Summer courses given at the Institute in entrance subjects.

A satisfactory grade in any of these subjects excuses the student from the corresponding entrance examination and is accepted as completing the entrance requirement in that subject.

ADMISSION WITH ADVANCED STANDING

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

Students who plan to attend another college with the intention of later applying for admission to the Institute should note the Coöperative Plan in effect between the Institute and certain colleges (p. 28).

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 record appears not to warrant advanced credit in a subject may be permitted to demonstrate by passing an examination that they are entitled to such credit.

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

Application Procedure. A student who seeks admission after completing only one year in college should defer submitting his credentials until his record for the entire academic year is available, but should make application as promptly as possible thereafter. He should submit in addition to the credentials listed below, an official record of his secondary school studies. Other applicants should submit their credentials as soon as possible after April 1 of the year in which they desire to enter, and forward in June a certified record of subjects completed at that time.

All applicants should submit, enclosed in one envelope, the following:

1. Application for Admission with Advanced Standing, filled out to show advanced credits expected.
2. Course Schedule, with subjects underlined in which advance credit is expected.
3. Certified transcript of college record, including statement of honorable dismissal or its equivalent.
4. Pages taken from college catalogue with subjects which the applicant has completed indicated. Name of applicant should be written at the top of each page.

As soon as the applicant's status is determined he will be informed whether he is admitted and how much advance credit he will be granted.

Questions about credits in professional subjects of the third and fourth years will, in general, await adjustment in personal interview. In such cases the student is expected to consult the department concerned during the week immediately preceding the opening of the academic year.

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 considerably above the usual age, and wishing to carry on a special program of study with a clearly defined objective, may be admitted as Special Students, 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 pre-requisite to those in which they wish to register.

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

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

UNDERGRADUATE COURSES OF STUDY

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

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

School of Architecture

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

School of Engineering

AERONAUTICAL ENGINEERING, Course XVI.

BUILDING ENGINEERING AND CONSTRUCTION, Course XVII.

BUSINESS AND ENGINEERING ADMINISTRATION, Course XV, with options in Engineering based on Physical Sciences and on Chemical Sciences.

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

CIVIL ENGINEERING, Course I.

ELECTRICAL ENGINEERING, Course VI. Also options in Illuminating Engineering, VI-B, and in Communications Engineering, VI-C, and Coöperative Course in Electrical Engineering, VI-A.

ELECTROCHEMICAL ENGINEERING, Course XIV.

GENERAL ENGINEERING, Course IX-B.

MARINE TRANSPORTATION, Course XIII-C.

MECHANICAL ENGINEERING, Course II, with options. General (1), Automotive (2), Refrigeration and Air Conditioning (3), Materials and Design (4), Textile (5). Also Coöperative Course in Mechanical Engineering, II-A.

METALLURGY. Course XIX.

MINING ENGINEERING, Course III, with options. Mining Engineering (1), Petroleum Production (2).

NAVAL ARCHITECTURE and MARINE ENGINEERING, Course XIII.

SANITARY ENGINEERING, Course XI.

School of Science

BIOLOGY AND PUBLIC HEALTH, Course VII, with options. Biology and Public Health (1a), Biology (1b), Industrial Biology (2), Public Health Engineering (3). Also Biophysics and Biological Engineering, Course VII-A.

CHEMISTRY, Course V.

GENERAL SCIENCE, Course IX-A.

GEOLOGY, Course XII, with options. Geology (1), Mineral Resources (2).

MATHEMATICS, Course XVIII.

PHYSICS, Course VIII, with options. General Physics (1), and Applied Physics (2).

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

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

An important part of all of the professional Courses consists of general cultural subjects given by the Division of Humanities, including English and history, economics and sociology, languages and the General Studies. The latter are required in the last three years and the student is encouraged to elect them in some one of the following four fields of interest:

HISTORY OF SCIENCE AND THOUGHT
HISTORY OF CIVILIZATION
LITERATURE AND THE FINE ARTS
SOCIAL SCIENCE

The required work in English and history in the first two years relates to and leads into these fields of interest in the humanities.

All of the Courses offered, except Architecture and City Planning, are identical in the first year. This first year is devoted to such fundamental subjects as physics, chemistry, mathematics, and English. The student, therefore, may change his course of study at any time before the beginning of the second year.

In the second year, Courses (except Architecture and City Planning) are divided into two general groups, Engineering and Chemistry. In each group

certain basic subjects are common to all Courses. In individual Courses the remaining time is given to introductory professional subjects.

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

Course IV-C is of six years' duration, includes three periods of outside office practice, and leads to the degrees of Bachelor of Architecture in City Planning, and Master in City Planning.

PROFESSIONAL SUMMER SCHOOLS

To bring the students into closer relations with the practical side of their work, professional summer schools are held in the Departments of Civil Engineering, Mining Engineering, and Metallurgy. The students, accompanied by instructors, give their time to fieldwork, or visit and report on mines or industrial establishments.

Summer School of Civil Engineering. With the exception of brief courses in the manipulation and use of the tape, transit and level, the fieldwork in surveying required of students in Courses mentioned below is given at Camp Technology on the shore of Gardner's Lake near the town of East Machias, Maine.

The subjects given at the camp are required for students of Courses I, VII Option 3, XI, and XVII, but students from other Courses will be admitted. Properly qualified students from other colleges will also be admitted. The session is for seven weeks.

The fee, including room and board, is $100.

Summer School of Surveying for Mining Engineers. Surveying, 1.10, which is given at the Summer Mining Camp at the Scrub Oak Mine near Dover, N. J., includes topographic surveying, leveling and mine surveying. It is required for students in Course III, between their second and third year; and it is open to students in other departments desiring to elect it after their second year. The camp is about one hour's distance from New York City, on the Lackawanna Line. The tuition fee is $100. Deposit for board and incidental expenses is $80. The session is for seven weeks.

Summer School in Mining Practice. Mining Practice, 3.08, required of all students in Course III, between their second and third year, is given at the Summer Mining Camp. The tuition fee is $15; deposit for board and incidental expenses, $20.

Summer School in Petroleum Production. Oil Field Visits 3.89, required of all students in Course III Option 2, either between the second and third or between the third and fourth years, is given in the oil fields of western Pennsylvania. The tuition fee is $15 and each student will pay his own expenses estimated at $30.

Summer School of Metallurgy. Plant Visits 19.22, required of all students in Course XIX, and any others planning to register for Metallurgy 19.07, 19.071, 19.19 or 19.21. A number of metallurgical plants in eastern Pennsylvania and New Jersey are visited. The fee is $15 and each student will pay his own expenses estimated at $75 round trip from Boston.

RESERVE OFFICERS' TRAINING CORPS

In coöperation with the War Department of the Federal Government, the Institute maintains the following units in the R. O. T. C.: Coast Artillery, Engineer, Signal, Ordnance and Chemical Warfare.

REQUIREMENTS FOR THE BACHELOR'S DEGREE

To receive the Degree of Bachelor of Science (S.B.), Bachelor in Architecture (B.Arch.) or Bachelor of Architecture in City Planning (B.Arch. in 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 satisfactorily completed the prescribed subjects of his professional Course or equivalent work.

The student must, moreover, prepare a thesis on some subject included in his course of study; or an account of some research made by him; or an original report upon some machine, work of engineering, industrial works, mine, or mineral survey, or an original design accompanied by an explanatory memoir.

All theses and records of work done in preparation of theses are the permanent property of the Institute, and must not be published, either wholly or in part, except by authorization of the heads of the respective departments. No degree will be conferred until all dues to the Institute are paid.

SUBJECT NUMBERING SYSTEM

Subjects are grouped and numbered according to the Department under which the instruction is given. A course is a program of study made up of subjects selected from the several Departments, and leads to a degree in a given field of science or engineering.

For description of subjects see pages 117–178.

Department	Subject Numbers
Civil and Sanitary Engineering	1·00 to 1·99
Mechanical Engineering	2·00 to 2·99
Mining Engineering	3·00 to 3·99
Architecture	4·00 to 4·99
Chemistry	5·00 to 5·99
Electrical Engineering	6·00 to 6·99
Biology and Public Health	7·00 to 7·99
Physics	8·00 to 8·99
Chemical Engineering	10·00 to 10·99
Geology	12·00 to 12·99
Naval Architecture and Marine Engineering	13·00 to 13·99
Business and Engineering Administration	15·00 to 15·99
Aeronautical Engineering	16·00 to 16·99
Building Engineering and Construction	17·00 to 17·99
Metallurgy	19·00 to 19·99
Drawing	D1 to D99
Economics and Social Science	Ec1 to Ec99
English and History	E1 to E99
General Studies	G1 to G99
Languages	L1 to L99
Mathematics	M1 to M99
Military Science and Tactics	MS1 to MS99
Hygiene	PT1 to PT2

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

One unit of Recitation or Lecture credit is equivalent to one semester hour. Two units of Drawing or Laboratory credit are equivalent to one semester hour.

FIRST YEAR SCHEDULES

As explained on page 38 the programs of study are identical in the first year for all Professional Courses with the exceptions of Architecture (IV), City Planning (IV-B), and City Planning Practice (IV-C). Below are the first year schedules for these two groups. Schedules for the other years for the several professional courses are given on the following pages.

FIRST YEAR

	ALL COURSES (Except IV, IV-B and IV-C)			COURSES IV, IV-B and IV-C		
First Term	5·01	Chemistry, General	7–4	4·06	Graphics	6–0
	8·01	Physics	6–5	4·11	Shades and Shadows	2–2
	D11	Engineering Draw. & Desc. Geom.	6–0	4·12	Perspective	4–3
	E11	English Composition	3–5	4·711	Architectural Practice	10–0
	M11	Calculus	3–6	E11	English Composition	3–5
	MS11	Military Science	3–0	M111	Calculus	3–6
	PT1	Physical Training	1–0	MS11	Military Science	3–0
			29–20	PT1	Physical Training	1–0
						32–16
Second Term	5·02	Chemistry, General	7–4			
	8·02	Physics	6–5	2·031	Structural Mechanics, Elem.	3–6
	D12	Engineering Draw. & Desc. Geom.	6–0	4·312	Abstract Design	10–5
	E12	English Composition	3–5	4·712	Architectural Practice	12–0
	M12	Calculus	3–6	E12	English Composition	3–5
	MS12	Military Science	3–0	MS12	Military Science	3–0
	PT2	Physical Training	1–0	PT2	Physical Training	1–0
			29–20			32–16

UNDERGRADUATE COURSE SCHEDULES FOR 1938–1939

I. CIVIL ENGINEERING

THE Course in Civil Engineering provides a training in the fundamental subjects of science and engineering with particular application to the broad field of design, construction, operation, and maintenance of structures and works necessary for modern industry and civilization. These include bridges, buildings, dams, and other fixed structures; hydraulic and sanitary works for water supply and sewerage, water power, river and harbor improvement; and facilities for transportation by railway, highway, water and air. Although the breadth of Civil Engineering opens up wide fields of service to the members of the profession, its various branches rest upon a relatively compact body of principles.

During the first three years, the Course includes the basic subjects of mathematics and science, and surveying, together with other introductory work in the field of civil engineering. In the fourth year, considerable time is devoted to structural theory and design, foundation problems, and construction methods, subjects which are essential in all branches of the Civil Engineering profession. In addition, the student has a choice of elective subjects which provide an opportunity for specialization in a particular field.

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

First Year. See page 40

Second Year

First Term	1·00	Surveying	2–2
	1·39	Graphic Statics	3–1
	2·00	Applied Mechanics	3–5
	8·03	Physics	5–5
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
		General Study	2–2
			24–26
Second Term	1·01	Surveying and Top. Draw.	4–0
	1·12	Astronomy and Spher. Trig.	3–4
	2·01	Applied Mechanics	3–5
	8·04	Physics	6–4
	E22	Literature and History	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
			25–24

REQUIRED DURING SUMMER. AT CAMP TECHNOLOGY

1·05	Surveying	12–1
1·20	Rail. and High. Fieldwork	5–0
1·60	Hydrographic Surveying	5–0

Third Year

First Term	1·21	Rail. and High. Curves	2–2
	1·35	Roads and Pavements	2–1
	2·04	Applied Mechanics	3–5
	6·40	Electrical Eng., Elem.	4–6
	6·89	Electrical Eng. Lab.	2–2
	12·321	App. Engineering Geology	5–2
	Ec11	Economic Principles	3–3
		General Study	3–3
			24–24
Second Term	1·13	Geodesy	2–4
	1·22	Quantity Surveying	2–2
	1·40	Structures	7–4
	1·62	Hydraulics	4–6
	2·371	Testing Materials Lab.	2–1
	15·52	Accounting	4–2
	Ec12	Economic Principles	3–3
			24–22

Fourth Year

First Term	1·25	Engineering Construction	4–1
	1·41	Structures	3–6
	1·48	Foundations	3–4
	1·501	Bridge Design	8–0
	2·411	Heat Engineering	2–4
		Professional Electives & Thesis*	14
			49
Second Term	1·42	Structures	2–4
	1·502	Structural Design	6–0
	1·58	Des. Reinf. Concrete Structures	6–0
	2·421	Heat Engineering	2–4
	2·687	Hydraulic Laboratory	2–2
		General Study	3–3
		Professional Electives & Thesis*	15
			49

Professional Electives

Water Works and Sewerage

First Term	1·75	Hydraulic & Sanitary Engineering	4–6
	1·801	Hydraulic & Sanitary Design	3–0
Second Term	1·76	Sanitary Engineering	2–3
	1·79	Sanitary Design	2–0

Transportation

First Term	1·271	Transportation Engineering	6–5
Second Term	1·272	Transportation Engineering	5–4

Water Power and Flood Control

First Term	1·70	Water Power Engineering	7–4
Second Term	1·71	Water Power Engineering	6–3
		or	
	1·72	Flood Control	6–3

*Total Thesis 9 units.

II. MECHANICAL ENGINEERING

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

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

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

In general, instruction by lectures is paralleled by laboratory work in which the student is given opportunity, not only to familiarize himself with materials, engines and machinery, but also to develop his ability to apply theory to the analysis of their characteristics. In the fourth year the student may choose a field of concentration by the election of one of the options listed.

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

Effective for the class of 1940 and thereafter this department will not admit to the work of the Senior year, or recommend for a degree, a student who has not acquired a reading knowledge of German or French. This requirement may be fulfilled by one of the following:

(1) Three years of a secondary school language (German or French).
(2) Two years of secondary school German and two years of secondary school French.
(3) Two years of German or two years of French taken at the Institute.
(4) Demonstrating a reading knowledge of technical German or French.

One year of language, taken at the Institute, may be used in anticipation of eight units of General Study required in the Senior year.

First Year. See page 40

Second Year

First Term	2·00	Applied Mechanics	3–5
	2·70	Machine Drawing	4–0
	2·851	Machine Tool Lab.	4–0
	5·683	Phys. Chemistry, Elem.	2–2
	8·03	Physics	5–5
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
			27–23
Second Term	2·01	Applied Mechanics	3–5
	2·30	Engineering Metals	3–1
	2·852	Machine Tool Practice	4–0
	8·04	Physics	6–4
	10·16	Applied Chemistry	2–2
	E22	Literature and History	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
			27–23

REQUIRED DURING SUMMER

2·02	Applied Mechanics	8–0

Third Year

First Term	2·04	Applied Mechanics	3–5
	2·251	Fluid Mechanics	6–2
	2·31	Engineering Metals	6–3
	2·40	Heat Engineering	4–5
	6·40	Electrical Eng., Elem.	4–6
	Ec11	Economic Principles	3–3
			26–24
Second Term	2·06	Applied Mechanics	3–5
	2·252	Fluid Mechanics	6–2
	2·37	Testing Materials Lab.	4–2
	2·42	Heat Engineering	4–5
	2·680	Engineering Laboratory	4–4
	2·731	Machine Design	4–1
	Ec12	Economic Principles	3–3
			28–22

Fourth Year. OPTION 1. GENERAL

First Term	2·081	Applied Mechanics	3–5
	2·37	Testing Materials Lab.	4–2
	2·43	Heat Engineering	3–5
	2·681	Engineering Laboratory	3–3
	2·682	Engineering Laboratory	3–3
	2·732	Machine Design	5–3
	6·47	App. of Elec. in Industry	4–4
			25–25
Second Term	2·082	Applied Mechanics	3–5
	2·56T	Power Plant Eng.	5–7
		General Study	8
		Elective and Thesis*	22
			50

SUGGESTED ELECTIVES

2·11	Industrial Plant Eng.	3–3
2·82	Diesel Engine Design	6–0
2·83	Steam Turbine Eng.	4–2
2·871	Manufacturing Eng.	2–4
2·872	Prep. for Manufacturing	2–4

*Thesis not less than 10 units.

II. Mechanical Engineering Continued

Fourth Year. OPTION 2. AUTOMOTIVE

First	2·081	Applied Mechanics	3–5
Term	2·37	Testing Materials Lab.	4–2
	2·791	Automotive Engines	4–4
	2·793	Automotive Engine Des.	4–0
	2·795	Automotive Vehicles	3–3
	2·797	Automotive Vehicle Des.	4–0
	6·47	App. of Elec. in Industry	4–4
		General Study	2–2
			28–20
Second	2·082	Applied Mechanics	3–5
Term	2·681	Engineering Laboratory	3–3
	2·792	Automotive Engines	4–4
	2·794	Automotive Engine Des.	4–0
	2·796	Automotive Vehicles	3–3
	2·798	Automotive Vehicle Des.	4–0
		General Study	2–2
		Thesis	10
			50

Fourth Year. OPTION 3. REFRIGERATION AND AIR CONDITIONING

First	2·43	Heat Engineering	3–5
Term	2·51	Heat Measurements	3–3
	2·621	Refrigeration Eng.	3–3
	2·66	Heat, Vent. & Air Cond.	3–5
	2·681	Engineering Laboratory	3–3
	6·47	App. of Elec. in Industry	4–4
		General Study	8
			50
Second	2·56T	Power Plant Eng.	5–7
Term	2·622	Refrigeration Eng.	3–5
	2·69	Refrig. & Air Cond. Lab.	6–6
		Elective and Thesis*	16
			48

Fourth Year. OPTION 4. MATERIALS AND DESIGN

First	2·081	Applied Mechanics	3–5
Term	2·35	Engineering Materials	3–3
	2·372	Testing Materials Lab.	4–4
	2·681	Engineering Laboratory	3–3
	2·732	Machine Design	5–3
	6·47	App. of Elec. in Industry	4–4
	19·50	Metallography	4–1
			26–23
Second	2·082	Applied Mechanics	3–5
Term	2·33T	Engineering Metals	4–2
	2·77	Design of Prod. Mach.	4–2
	19·54T	App. of Metallography	3–2
	19·70	X-Ray Metallography	3–3
		General Study	8
		Thesis	10
			49

* Thesis not less than 10 units.

Fourth Year. OPTION 5. TEXTILE

First	2·081	Applied Mechanics	3–5
Term	2·66	Heat, Vent. & Air Cond.	3–5
	2·681	Engineering Laboratory	3–3
	2·732	Machine Design	5–3
	2·901	Prin. Fabric Structure	3–6
	2·903	Elem. Textile Manuf.	3–6
			20–28
Second	2·082	Applied Mechanics	3–5
Term	2·902	Prin. Fabric Structure	3–6
	2·904	Prin. Textile Manuf.	3–6
	8·173	Color Measurements	3–2
		General Study	8
		Thesis	10
			49

II-A. MECHANICAL ENGINEERING

IN COÖPERATION WITH THE GENERAL ELECTRIC COMPANY

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

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

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

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

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

It is assumed that students who are admitted to the course with the approval of the Institute and of

II-A. Mechanical Engineering Continued

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

The Course leads to the degree of Master of Science in Mechanical Engineering, together with the degree of Bachelor of Science as of the preceding year.

II-A. Mechanical Engineering

Same as regular Course II to the beginning of the third year.

Third Year

At Works

Summer	2·041	Applied Mechanics	4–8
Term	2·951	Manufacturing Practice (General Electric Co.)	40 h.p.w.

At M. I. T.

First	2·06	Applied Mechanics	3–5
Term	2·253	Fluid Mechanics	7–5
	2·351	Materials of Eng.	2–2
	2·40	Heat Engineering	4–5
	2·731	Machine Design	4–1
	Ec11	Economic Principles	3–3
		General Study	3–3
			26–24

At Works

Second	2·42	Heat Engineering	4–5
Term	2·952	Manufacturing Practice (General Electric Co.)	40 h.p.w.

Fourth Year

At M. I. T.

Summer	2·37	Testing Materials Lab.	4–2
Term	2·43	Heat Engineering	3–5
	6·40	Electrical Eng., Elem.	4–6
	6·89	Electrical Eng. Lab.	2–2
	Ec12	Economic Principles	3–3
			16–18

At Works

First	2·08	Applied Mechanics	4–8
Term	2·953	Manufacturing Practice (General Electric Co.)	40 h.p.w.

At M. I. T.

Second	2·082	Applied Mechanics	3–5
Term	2·51	Heat Measurements	3–3
	2·551	Power Plant Eng.	3–5
	2·680	Engineering Laboratory	4–4
	2·733T	Machine Design	5–3
	2·82	(a) Diesel Engine Design	6–0
	2·83	(b) Steam Turbine Eng.	4–2
		General Study	3–3
		(a)	27–23
		(b)	25–25

Graduate Year

At Works

Summer	2·96	Study and Research	6
Term	2·954	Manufacturing Practice (General Electric Co.)	40 h.p.w.

At M. I. T.

First Term		Graduate Study & Research	48

At M. I. T.

Second Term		Graduate Study & Research	48

Effective for the class of 1940 and thereafter this department will not admit to the work of the Senior year, or recommend for a degree, a student who has not acquired a reading knowledge of German or French. This requirement may be fulfilled by one of the following:

(1) Three years of a secondary school language (German or French).
(2) Two years of secondary school German and two years of secondary school French.
(3) Two years of German or two years of French taken at the Institute.
(4) Demonstrating a reading knowledge of technical German or French.

III. MINING ENGINEERING

THE demands made upon engineers in mining engineering and petroleum engineering call for training in a variety of lines. The Courses are designed to give the student sound training in the sciences, upon which professional practice is based. The application of these sciences is enforced through instruction in mining engineering, and petroleum engineering, as well as in related branches of engineering and economics and business administration. Thus equipped, the student can take up specialized work after graduation with the expectation of carrying it on successfully, while the broad foundation laid in scientific and engineering subjects affords the general training needed in case he desires to engage in technical enterprises other than mining or petroleum engineering.

Valuable opportunities are offered for observation and field work in the laboratories of the Institute, in the Summer Mining Camp at Dover, N. J., and the summer visits to oil fields. Two optional courses are open to students in mining engineering and petroleum engineering.

Option 1. Mining Engineering. The field of mining engineering includes study in geology, mining methods and economics and principles of mining, together with instruction in metallurgical subjects adequate to equip the graduate to engage in the practice of the branches of metallurgy which so often make an important part of mining operations.

Option 2. Petroleum Production. Emphasizes prospecting, development, production, trans-

V. CHEMISTRY

THE main objective of the Course in Chemistry is to provide a general and fundamental education based on science. Its secondary objectives are to train men (1) who seek only the Bachelor's degree and a career in some field in which a sound knowledge of chemistry is important, (2) 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, physical, and industrial chemistry, supplemented by instruction in mathematics and physics and in the humanities, including English, history, German, French, and other nonprofessional subjects.

In the third and fourth years, electives are available enabling students to extend their knowledge in fields of special interest to them. Students intending to take graduate work, for example, may elect a series of subjects tending to enhance their ability to utilize the opportunities in graduate study. Students intending to enter industry may take subjects giving them a command of the fundamentals in a selected field of science or engineering. Elective time is also available for additional subjects in the humanities.

In all students, the Course aims to stimulate and develop the research attitude. The thesis coming in the fourth year provides an opportunity for the student to demonstrate his aptitude for creative effort. Throughout the Course, the student has the benefit of counsel by experienced instructors who assist him in selecting electives and aid him in acquiring the education and training necessary for well-balanced and intelligent living.

Elective series are available in inorganic, organic, and physical chemistry, ceramics, textiles, economics, metallography, mineralogy and geology, biology and biochemistry, industrial chemistry, food and water chemistry, and metallurgy.

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

NOTE ON SECOND-YEAR LANGUAGE

Students credited with Elementary and Intermediate French will take Elementary German. Students credited with Elementary and Intermediate German will take Elementary French. Students credited with Elementary French and Elementary German will take Intermediate German. Students who present neither French nor German on entrance will take Elementary German, and may be required to take Elementary French as an elective in the third year, particularly if they expect to be candidates for an advanced degree.

V. CHEMISTRY

First Year. See page 40

REQUIRED DURING SUMMER

	5·10	Qualitative Analysis	14–4

Second Year

First	5·12	Quantitative Analysis	7–2
Term	8·03	Physics	5–5
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
		Language	3–5
			24–23
Second	5·13	Quantitative Analysis	7–2
Term	5·142	Analytical Chemistry	2–1
	8·04	Physics	6–4
	E22	Literature and History	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
		Language	3–5
			27–23

Third Year

First	*5·141	Analytical Chemistry	4–1
Term	5·41	Organic Chemistry I	4–3
	5·414	Organic Chemistry Lab.	9–0
	5·61	Physical Chemistry I	4–4
	5·611	Physical Chem. Lab. I	4–0
	5·81	Chemical Literature I	2–3
	Ec11	Economic Principles	3–3
		Elective	5
			49
Second	5·42	Organic Chemistry I	4–2
Term	5·424	Organic Chemistry Lab.	9–0
	5·62	Physical Chemistry II	4–4
	5·621	Physical Chem. Lab. II	4–0
	5·82	Chemical Literature II	1–1
	Ec12	Economic Principles	3–3
		General Study	2–2
		Elective	10
			49

* Analytical Chemistry (5·141) may be taken in the second term of the third year by interchanging electives, 5 units. Registration in either term is limited by equipment.

Fourth Year

First	5·061	Inorganic Chemistry	2–3
Term	5·417	Quant. Organic Anal.	4–0
	5·63	Int. to Thermodynamics	3–5
	10·203	Industrial Chemistry	3–4
		Thesis	16
		Elective	9
			49
Second	5·062	Inorganic Chemistry	2–3
Term	5·64	Int. to Radiation Chem.	2–3
	5·66	Surface & Colloid Chem.	2–3
	5·83	History of Chemistry	2–2
	10·21	Industrial Chemistry	2–2
		General Study	2–2
		Thesis	16
		Elective	6
			49

Fourth year students may register for the Research Conferences in inorganic, organic, or physical chemistry, 5·941, 5·942, 5·943, 5·944, as a part of thesis, subject to the approval of the Registration Officer.

VI. ELECTRICAL ENGINEERING

GREAT importance is attached in Electrical Engineering to the study of mathematics, chemistry, physics and applied mechanics in the earlier years, and of the theory of electricity and magnetism beginning in the second year and continuing throughout the remainder of the course. The work in Principles of Electrical Engineering is conducted by means of recitations and supervised problem work. Along with these are associated the essential principles of heat engineering, hydraulic power engineering, and economics. The electrical engineering instruction of the third and fourth years takes on a distinctly scientific character besides offering a variety of alternative subjects involving the applications of electricity to the various problems in railroad work, power-station design, electric machine design, industrial applications of electric power, illumination, communications, electric insulation, etc.

The theoretical work runs parallel with an extended course in the laboratories, which begins with the work in chemistry and physics and extends through all of the scientific branches studied. The electrical measurements laboratories and the laboratories devoted to electrical machinery are component parts of the equipment. These laboratories are extensively provided with apparatus adapted to the needs of undergraduate and advanced study. The purpose of the laboratory work is not only to bring to the student's consideration methods and tests of fundamental importance in the art, but to aid him in the formation of habits of accurate observation and reflection, in the development of initiative, and in the cultivation of judgment in questions of balance between economy of time and precision of results. The work culminates in a thesis requiring originality and the application of acquired technique.

Competent students who desire for adequate reasons to make substitutions in the curriculum may be permitted to do so with the approval of the Head of the Department.

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

Effective for the class of 1940 and thereafter this department will not admit to the work of the Senior year or recommend for a degree a student who has not acquired a reading knowledge of German or French. This requirement may be fulfilled by one of the following:

(1) Three years of a secondary school language (French or German).
(2) Two years of secondary school German and two years of secondary school French.
(3) Two years of German or two years of French taken at the Institute, of which one term may be used as a General Study.
(4) Demonstrating a reading knowledge of technical German or French.

VI. Electrical Engineering

First Year. See page 40

Second Year

First Term	2·00	Applied Mechanics	3–5
	2·853	Machine Tool Laboratory	4–0
	6·09	Int. to Electrical Eng.	2–0
	8·03	Physics	5–5
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
		General Study	3–3
			26–24
Second Term	2·01	Applied Mechanics	3–5
	6·00T	Electrical Eng. Prin.	4–6
	8·04	Physics	6–4
	E22	Literature and History	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
			22–26

Required during Summer

	1·02	Surveying	3–1

Third Year

First Term	2·04	Applied Mechanics	3–5
	2·40	Heat Engineering	4–5
	6·01	Electrical Eng., Prin.	4–6
	6·75T	Electrical Eng. Lab.	3–4
	Ec12	Economic Principles	3–3
	M31	Differential Equations	2–4
		General Study	2–2
			21–29
Second Term	2·07	Applied Mechanics	3–5
	2·42	Heat Engineering	4–5
	6·02	Electrical Eng., Prin.	4–6
	6·76	Electrical Eng. Lab.	4–5
	6·77	Electrical Eng. Lab.	4–4
		General Study	3–3
			22–28

Fourth Year

First Term	1·64	Hydraulics	3–6
	2·686	Engineering Laboratory	3–3
	6·03	Electrical Eng., Prin.	6–8
	6·78	Electrical Eng. Lab.	4–5
		Thesis	2
		Professional Elective	3–6
			49
Second Term	6·04	Electrical Eng., Prin.	6–9
	6·79	Electrical Eng. Lab.	3–4
	G12	Biography in Science	3–3
		Thesis	11
		Professional Elective	3–6
			48

VI. Electrical Engineering Continued

ELECTIVES

First Term	6·211	App. of Elec. in Industry	3–6
	6·221	Electric Power Generation	3–6
	6·241	Electric Railways	3–6
	6·251	Electric Machine Des.	3–6
	6·26	Elec. Insulation	3–6
	6·281	Prin. Wire Com.	3–6
	6·29	Storage Batteries	1–2
	6·80	Electrical Eng. Lab.	Time arr.
	M77	Vector Analysis	3–6

ELECTIVES

Second Term	6·212	App. of Elec. in Industry	3–6
	6·222	Electric Power Generation	3–6
	6·242	Electric Railways	3–6
	6·252	Electric Machine Des.	3–6
	6·27	Illuminating Eng., Prin.	5–4
	6·282	Prin. Radio Com.	3–6
	6·48	Electric Equip. Bldgs.	1–2
	6·80	Electrical Eng. Lab.	Time arr.
	8·54	Electromagnetic Theory	3–6

ELECTRICAL ENGINEERING

OPTION VI-B. ILLUMINATING ENGINEERING

RECENT advances in the lighting art—the development of new gaseous-conduction lamps for highways and for interiors, the use of built-in architectural lighting, and the growing consciousness of the necessity of careful planning of lighting to insure good vision and prevent impairment of eyesight—make the field of illuminating engineering increasingly attractive and important.

Illuminating engineering is fundamentally different from all other branches of engineering because the psychophysiological aspects of vision must always be considered and because esthetics are also of importance. Course VI-B is especially designed to meet these requirements. The fundamental subjects, physics, mathematics, and principles of electrical engineering, are essentially as in Course VI, but considerable time is also devoted to a study of optics, vision, color, architecture, the calculation of illumination, and the design of lighting systems of all kinds. Competent students wishing to make substitutions to fit themselves particularly for special phases of illuminating engineering may do so with the approval of the Head of the Department. A reading knowledge of German or French is required for a degree, as stated in detail on page 50.

The student will select subjects marked (a) or (b) depending upon whether his inclinations are primarily scientific or artistic. A mixture of electives in the two groups is generally inadvisable.

The Option leads to the degree of Bachelor of Science in Electrical Engineering.

Option VI-B. ILLUMINATING ENGINEERING

First Year. See page 40

Second Year

First Term	2·00	Applied Mechanics	3–5
	4·021	(b) Freehand Drawing	4–0
	6·09	Int. to Electrical Eng.	2–0
	8·03	Physics	5–5
	D21	(b) Perspective	2–2
	E21	Literature and History	3–5
	M21	Calculus	3–6
	M23	(a) Algebra and Geometry	3–6
	MS21	Military Science	3–0
			(a) 22–27
			(b) 25–23
Second Term	4·022	(b) Freehand Drawing	4–0
	6·00T	Electrical Eng. Prin.	4–6
	8·04	Physics	6–4
	E22	Literature and History	3–5
	Ec11	(b) Economic Principles	3–3
	M22	Differential Equations	3–3
	M24	(a) Algebra and Geometry	3–6
	MS22	Military Science	3–0
			(a) 22–24
			(b) 26–21

Third Year

First Term	4·031	(b) Freehand Drawing	4–0
	4·071	(b) Modeling	3–0
	4·421	(b) Architectural History	4–5
	6·01	Electrical Eng. Prin.	4–6
	6·75T	Electrical Eng. Lab.	3–4
	8·161	Optics	3–6
	8·162	Optical Measurements	3–2
	8·50	(a) Heat and Thermodynamics	3–4
	M441	(a) Projective Geometry	3–6
			(a) 19–28
			(b) 24–23
Second Term	6·02	Electrical Eng. Prin.	4–6
	6·27	Illuminating Eng. Prin.	5–4
	6·76	Electrical Eng. Lab.	4–5
	8·15	(a) Photography	2–1
	Ec11	(a) Economic Principles	3–3
	M77	(a) Vector Analysis	3–6
		(b) Electives	18
		General Study	2–2
			(a) 23–27
			(b) 50

ELECTIVES

4·312	Abstract Design	10–5
4·422	Architectural History	4–5
6·77	Electrical Eng. Lab.	4–4
8·15	Photography	2–1
8·201	Electronics	3–5

Fourth Year

First Term	2·01	(b) Applied Mechanics	3–5
	4·081	(b) Color, Comp. Th. & App.	1–3
	6·03	(a) Electrical Eng. Prin.	6–8
	6·271	Illuminating Eng. Prin.	5–4
	8·461	(a) Int. Theoret. Physics	4–8
	8·50	(b) Heat and Thermodynamics	3–4
		(a) Thesis* and Electives	9
		(b) Thesis* and Electives	16
		General Study	3–3
			50

*Total for thesis at least 10 units.

VI-B. Electrical Engineering, Fourth Year, Continued

Second Term	2·04	(b) Applied Mechanics	3–5
	4·082	(b) Color, Comp. Th. & App.	1–3
	6·272	Illuminating Eng. Prin.	5–4
	8·462	(a) Int. Theoret. Physics	4–8
	Ec12	Economic Principles	3–3
	G12	Biography in Science	3–3
		Thesis* and Electives	17
			50

ELECTIVES

First Term	4·081	Color, Comp. Th. & App.	1–3
	4·11	Shades and Shadows	2–2
	4·641	Hist. & Prin. City Planning	2–2
	4·721	Architectural Design II	13–1
	8·171	Advanced Optics	2–3
	D21	Perspective	2–2
Second Term	4·032	Freehand Drawing	4–0
	4·072	Modeling	3–0
	4·082	Color, Comp. Th. & App.	1–3
	8·15	Photography	2–1
	8·173	Color Measurements	3–2
	8·311	Atomic Structure	3–5

ELECTRICAL ENGINEERING

OPTION VI-C. ELECTRICAL COMMUNICATIONS

STUDENTS who wish to follow particularly the theory and practice underlying Electrical Communications may register for the Electrical Communications Option at the beginning of the junior year. For admission to this option a student must have completed the first two years of the undergraduate Course VI at the Institute or their equivalent.

The option embraces the scientific work underlying telegraphy and telephony by wire and radio. Electromagnetic wave theory, the properties and engineering applications of electron tubes and acoustics are included as a natural part of the work in this field. A reading knowledge of German or French is required for a degree, as stated in detail on page 50.

The Option leads to the degree of Bachelor of Science in Electrical Engineering.

OPTION VI-C. ELECTRICAL COMMUNICATIONS

SAME AS REGULAR COURSE VI TO THE BEGINNING OF THIRD YEAR

Third Year

First Term	2·04	Applied Mechanics	3–5
	6·01	Electrical Eng., Prin.	4–6
	6·75T	Electrical Eng. Lab.	3–4
	8·50	Heat & Thermodynamics	3–4
	Ec12	Economic Principles	3–3
	M31	Differential Equations	2–4
		General Study	2–2
			20–28

Total for thesis at least 10 units.

Second Term	6·02	Electrical Eng., Prin.	4–6
	6·30	Electrical Com., Prin.	3–6
	6·76	Electrical Eng. Lab.	4–5
	6·77	Electrical Eng. Lab.	4–4
	8·201	Electronics	3–5
		General Study	3–3
			21–29

Fourth Year

First Term	6·031	Electrical Eng., Prin.	4–6
	6·31	Electrical Com., Prin.	3–5
	6·331	Electrical Com. Lab.	3–4
	6·781	Electrical Eng. Lab.	3–4
	8·05	Vibrations and Sound	3–6
		Elective	3–6
			19–31
Second Term	6·32T	Electrical Com., Prin.	4–8
	6·332	Electrical Com. Lab.	4–4
	G12	Biography in Science	3–3
		Thesis	13
		Elective	3–6
			48

ELECTIVES

First Term	6·211	Appl. of Elec. in Industry	3–6
	6·221	Electric Power Generation	3–6
	6·241	Electric Railways	3–6
	6·251	Electric Machine Design	3–6
	6·26	Electric Insulation	3–6
	6·281	Prin. Wire Com.	3–6
	6·29	Storage Batteries	1–2
	6·80	Electrical Eng. Lab.	Time arr.
	M77	Vector Analysis	3–6

ELECTIVES

Second Term	6·212	Appl. of Elec. in Industry	3–6
	6·222	Electric Power Generation	3–6
	6·242	Electric Railways	3–6
	6·252	Electric Machine Design	3–6
	6·27	Illuminating Eng., Prin.	5–4
	6·282	Prin. Radio Com.	3–6
	6·48	Electric Equip. Bldgs.	1–2
	6·80	Electrical Eng. Lab.	Time arr.
	8·54	Electromagnetic Theory	3–6

VI-A. ELECTRICAL ENGINEERING

OPTION 1—MANUFACTURING. In coöperation with the General Electric Company.

OPTION 2—PUBLIC UTILITIES.

(a) Light and Power. In coöperation with the Boston Edison Company.

(b) Transportation. In coöperation with the Boston Elevated Railway.

OPTION 3—COMMUNICATIONS. In coöperation with the Bell Telephone System in New York City.

The Institute offers three distinct coöperative Courses in Electrical Engineering. Option 1 affords training for the technical and executive responsibilities of electrical manufacturing industries. The manufacturing practice is taken at the plants of the General Electric Company in Lynn, Schenectady,

VI-A. Electrical Engineering Continued

Pittsfield and Erie. Options 2 and 3 offer a training of like nature for the technical and executive responsibilities in the operation of public utilities and communications systems.

The plan includes practical experience with the Boston Edison Company for those who wish to go into the distribution of light and power, and experience with the Boston Elevated Railway for those who are interested in Electric railway work.

For communications work, the coöperation is with the shops of the Western Electric Company, Inc., the plants of the New York Telephone Company and the laboratories of the Bell Telephone Laboratories, Inc., coördinated through the American Telephone and Telegraph Company.

Each Course covers a period of five years, the first two (except for Group B, Option 1) being identical with Course VI, and the last three being divided between instruction at the Institute and practical training in the shops of the General Electric Company, or in the plants of the Boston Edison Company, the Boston Elevated Railway, or the Bell Telephone System.

The instruction of the first four years is similar in method and content to Course VI with minor omissions. The work of the final or fifth year is definitely of a graduate nature. For Option 1 the emphasis during this year is on problems of manufacturing enterprises, the design and development of engineering projects and creative research. For Option 2 the emphasis during the fifth year is on problems of public utilities together with research on technical, scientific and administrative matters incident to the conduct of affairs of such enterprises. In Option 3 the emphasis during the fifth year is on corresponding problems of electrical communications.

The training at the plants is laid out and conducted with a view to educational value and is intimately correlated with the professional instruction at the Institute. In the final year considerable latitude may be exercised in the assignment of men to posts in the engineering and research bureaus of the respective companies in order to utilize and develop individual aptitudes.

The number of men who may be admitted to the coöperative training each year is at present limited to forty-six. Candidates for admission are subject to the approval of both the Institute and the coöperating companies. 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. Well qualified students who have completed at other institutions the substantial equivalent of the work of the first two years of Course VI may be admitted to advanced standing at the beginning of the coöperative training. Students in training at the plants are subject to the usual regulations of the company. They receive regular compensation for their work, the total of which approximates the tuition charges for the three years of coöperation. The work in the shops, testing departments and engineering divisions is supplemented by conferences with department heads in which technical and administrative problems arising in the work are discussed. While at the shops, students also devote a maximum of six hours a week to classroom work in electrical engineering or other professional studies, for which ten hours of preparation a week is expected. At the conclusion of the Course, graduates are free to accept employment wherever offered.

Under present regulations no students will be admitted to Course VI-A in the second year with incomplete records in any entrance subject or an incomplete record in any first-year subject. On account of the number of applications it is probable that no admissions to the third year will be made without clear records in both first and second-year subjects and entrance requirements.

Each class is divided into two groups (A and B) which alternate after the second year, one group working at the plant of a coöperating company while the other is at the Institute in Cambridge.

Whenever there is not available practice of the proper kind, or of sufficiently long duration to justify placing students at the plants of the coöperating companies, works assignments may be omitted. All coöperating companies however make their selections from the students of the second-year class and from students who transfer from other institutions, and who have completed the equivalent of the first two years. These selections are made with the understanding that assignments to the works will be made if and when the level of industrial activity has risen sufficiently to permit practice assignments of appropriate character. Extra classroom and laboratory work is substituted for the industrial practice when it is not available.

A reading knowledge of German or French is required for a degree, as stated in detail on page 50.

The Course leads to the degree of Master of Science in Electrical Engineering, together with the degree of Bachelor of Science in Electrical Engineering as of the preceding year.

VI-A. Electrical Engineering

First Year. See page 40

Required during Summer

1·02	Surveying	3–1

Second Year. Same as Course VI

(Except Group B, Option 1)

VI-A. Electrical Engineering Continued

Group A—Option 1. Manufacturing

Third Year

At M. I. T.

Summer	2·04	Applied Mechanics	3–5
Term	6·01	Electrical Eng., Prin.	4–6
	6·75T	Electrical Eng. Lab.	3–4
	M31	Differential Equations	2–4
			12–19

At Works

First	6·02	Electrical Eng., Prin.	4–6
Term	6·901	Manufacturing Practice (General Electric Co.)	40 h.p.w.

At M. I. T.

Second	2·07	Applied Mechanics	3–5
Term	2·371	Testing Materials Lab.	2–1
	6·03	Electrical Eng., Prin.	6–8
	6·76	Electrical Eng. Lab.	4–5
	6·77	Electrical Eng. Lab.	4–4
	G12	Biography in Science	3–3
			22–26

Fourth Year

At Works

Summer	2·40	Heat Engineering	4–5
Term	6·902	Manufacturing Practice (General Electric Co.)	40 h.p.w.

At M. I. T.

First	2·42	Heat Engineering	4–5
Term	6·04	Electrical Eng., Prin.	6–9
	6·78	Electrical Eng. Lab.	4–5
	Ec12	Economic Principles	3–3
		General Study	3–3
			20–25

At Works

Second	1·64	Hydraulics	3–6
Term	6·903	Manufacturing Practice (General Electric Co.)	40 h.p.w.
		Graduate Study	8

Graduate Year

At M. I. T.

Summer	6·501	Seminar	2–10
Term		Graduate Study & Thesis	22
			34

At Works

First	6·904	Manufacturing Practice (General Electric Co.)	40 h.p.w.
Term		Thesis	14

At M. I. T.

Second	6·502	Seminar	2–2
Term	15·64	Law of Business Organization	3–6
		General Study	3–3
		Graduate Study & Thesis	30
			49

Group A—Option 2. Public Utilities

Third Year

At M. I. T.

Summer	2·04	Applied Mechanics	3–5
Term	6·01	Electrical Eng., Prin.	4–6
	6·75T	Electrical Eng. Lab.	3–4
	M31	Differential Equations	2–4
			12–19

At Works

First	6·02	Electrical Eng., Prin.	4–6
Term	6·911	Public Utility Practice (Boston Edison Company)	40 h.p.w.
	6·921	Public Utility Practice (Boston Elevated Ry.)	40 h.p.w.

At M. I. T.

Second	2·07	Applied Mechanics	3–5
Term	2·371	Testing Materials Lab.	2–1
	6·03	Electrical Eng., Prin.	6–8
	6·76	Electrical Eng. Lab.	4–5
	6·77	Electrical Eng. Lab.	4–4
	G12	Biography in Science	3–3
			22–26

Fourth Year

At Works

Summer	2·40	Heat Engineering	4–5
Term	6·912	Public Utility Practice (Boston Edison Company)	40 h.p.w.
	6·922	Public Utility Practice (Boston Elevated Ry.)	40 h.p.w.

At M. I. T.

First	2·42	Heat Engineering	4–5
Term	6·04	Electrical Eng., Prin.	6–9
	6·78	Electrical Eng. Lab.	4–5
	Ec12	Economic Principles	3–3
		General Study	3–3
			20–25

At Works

Second	1·64	Hydraulics	3–6
Term	6·913	Public Utility Practice (Boston Edison Company)	40 h.p.w.
	6·923	Public Utility Practice (Boston Elevated Ry.)	40 h.p.w.
		Graduate Study	8

Graduate Year

At M. I. T.

Summer	6·501	Seminar	2–10
Term		Graduate Study & Thesis	22
			34

At Works

First	6·914	Public Utility Practice (Boston Edison Company)	40 h.p.w.
Term	6·924	Public Utility Practice (Boston Elevated Ry.)	40 h.p.w.
		Thesis	14

VI-A. Electrical Engineering, Group A—Option 2, Continued

AT M. I. T.

Second Term	6·502	Seminar	2–2
	15·64	Law of Business Organization	3–6
		General Study	3–3
		Graduate Study & Thesis	30
			49

GROUP A—OPTION 3. COMMUNICATIONS

Third Year

AT M. I. T.

Summer	2·04	Applied Mechanics	3–5
Term	6·01	Electrical Eng., Prin.	4–6
	6·75T	Electrical Eng. Lab.	3–4
	M31	Differential Equations	2–4
			12–19

AT WORKS

First Term	6·02	Electrical Eng., Prin.	4–6
	6·941	Communications Practice (Western Electric Co.)	40 h.p.w.

AT M. I. T.

Second Term	2·371	Testing Materials Lab.	2–1
	6·03	Electrical Eng., Prin.	6–8
	6·76	Electrical Eng. Lab.	4–5
	6·77	Electrical Eng. Lab.	4–4
	8·201	Electronics	3–5
	G12	Biography in Science	3–3
			22–26

Fourth Year

AT WORKS

Summ.	6·31	Electrical Com. Prin.	3–5
Term	6·942	Communications Practice (N. Y. Telephone Co.)	40 h.p.w.

AT M. I. T.

First Term	6·333	Electrical Com. Lab	6–6
	6·781	Electrical Eng. Lab.	3–4
	8·05	Vibrations and Sound	3–6
	8·50	Heat & Thermodynamics	3–4
	Ec12	Economic Principles	3–3
		General Study	3–3
			21–26

AT WORKS

Second Term	6·32	Electrical Com., Prin.	3–5
	6·943	Communications Practice (Bell Telephone Lab.)	40 h.p.w.
		Grad. Study	8

Graduate Year

AT M. I. T.

Summer	6·501	Seminar	2–10
Term		Graduate Study & Thesis	22
			34

AT WORKS

First Term	6·944	Communications Practice (Bell Telephone System)	40 h.p.w.
		Thesis	14

AT M. I. T.

Second Term	6·502	Seminar	2–2
	15·64	Law of Business Organization	3–6
		General Study	3–3
		Grad. Study & Thesis	30
			49

GROUP B—OPTION 1. MANUFACTURING

Second Year

AT M. I. T.

First Term		Same as Course VI	

AT WORKS

Second Term	6·00T	Electrical Eng., Prin.	4–6
	M22	Differential Equations	3–6
	6·901	Manufacturing Practice (General Electric Co.)	40 h.p.w.

Third Year

AT M. I. T.

Summer	6·01	Electrical Eng., Prin.	4–6
Term	6·75T	Electrical Eng. Lab.	3–4
	8·04	Physics	6–4
	E22	Literature and History	3–5
			16–19

AT M. I. T.

First Term	2·01	Applied Mechanics	3–5
	6·02	Electrical Eng., Prin.	4–6
	6·76	Electrical Eng. Lab.	4–5
	6·77	Electrical Eng. Lab.	4–4
	Ec12	Economic Principles	3–3
	M31	Differential Equations	2–4
	MS22	Military Science	3–0
			23–27

AT WORKS

Second Term	6·03	Electrical Eng., Prin.	6–8
	6·902	Manufacturing Practice (General Electric Co.)	40 h.p.w.

Fourth Year

AT M. I. T.

Summer	2·04	Applied Mechanics	3–5
Term	6·04	Electrical Eng., Prin.	6–9
	6·78	Electrical Eng. Lab.	4–5
			13–19

AT WORKS

First Term	2·40	Heat Engineering	4–5
	6·903	Manufacturing Practice (General Electric Co.)	40 h.p.w.
		Graduate Study	4

VI-A. Electrical Engineering, Fourth Year, Group B—Option 1, Continued

AT M. I. T.

Second Term	1·64	Hydraulics	3–6
	2·07	Applied Mechanics	3–5
	2·371	Testing Materials Lab.	2–1
	2·42	Heat Engineering	4–5
	15·64	Law of Business Organization	3–6
	G12	Biography in Science	3–3
		Graduate Study*	6
			50

Graduate Year

AT WORKS

Summer Term	6·904	Manufacturing Practice (General Electric Co.)	40 h.p.w.
		Seminar* and Thesis	10

AT M. I. T.

First Term		General Study	3–3
		Graduate Study* & Thesis	42
			48

AT M. I. T.

Second Term	6·502	Seminar	2–2
		General Study	3–3
		Graduate Study & Thesis	38
			48

GROUP B—OPTION 2. PUBLIC UTILITIES

Third Year

AT WORKS

Summer Term	6·01	Electrical Eng., Prin.	4–6
	6·911	Public Utility Practice (Boston Edison Co.)	40 h.p.w.
	6·921	Public Utility Practice (Boston Elevated Ry.)	40 h.p.w.

AT M. I. T.

First Term	2·04	Applied Mechanics	3–5
	6·02	Electrical Eng., Prin.	4–6
	6·75T	Electrical Eng. Lab.	3–4
	6·77	Electrical Eng. Lab.	4–4
	Ec12	Economic Principles	3–3
	M31	Differential Equations	2–4
			19–26

AT WORKS

Second Term	6·03	Electrical Eng., Prin.	6–8
	6·912	Public Utility Practice (Boston Edison Co.)	40 h.p.w.
	6·922	Public Utility Practice (Boston Elevated Ry.)	40 h.p.w.

Fourth Year

AT M. I. T.

Summer Term	1·64	Hydraulics	3–6
	6·04	Electrical Eng., Prin.	6–9
	6·78	Electrical Eng. Lab.	4–5
			13–20

*6·501 required some time before the second term of Graduate year.

AT WORKS

First Term	2·40	Heat Engineering	4–5
	6·913	Public Utility Practice (Boston Edison Co.)	40 h.p.w.
	6·923	Public Utility Practice (Boston Elevated Ry.)	40 h.p.w.
		Graduate Study	4

AT M. I. T.

Second Term	2·07	Applied Mechanics	3–5
	2·371	Testing Materials Lab.	2–1
	2·42	Heat Engineering	4–5
	15·64	Law of Business Organization	3–6
	G12	Biography in Science	3–3
		Graduate Study*	14
			49

Graduate Year

AT WORKS

Summer Term	6·914	Public Utility Practice (Boston Edison Co.)	40 h.p.w.
	6·924	Public Utility Practice (Boston Elevated Ry.)	40 h.p.w.
		Seminar* & Thesis	10

AT M. I. T.

First Term		General Study	3–3
		Graduate Study* & Thesis	42
			48

AT M. I. T.

Second Term	6·502	Seminar	2–2
		General Study	3–3
		Graduate Study & Thesis	38
			48

GROUP B—OPTION 3. COMMUNICATIONS

Third Year

AT WORKS

Summer Term	6·01	Electrical Eng., Prin.	4–6
	6·941	Communications Practice (Western Electric Co.)	40 h.p.w.

AT M. I. T.

First Term	6·02	Electrical Eng., Prin.	4–6
	6·75T	Electrical Eng. Lab.	3–4
	6·77	Electrical Eng. Lab.	4–4
	8·50	Heat & Thermodynamics	3–4
	Ec12	Economic Principles	3–3
	M31	Differential Equations	2–4
		General Study	3–3
			22–28

AT WORKS

Second Term	6·03	Electrical Eng., Prin.	6–8
	6·942	Communications Practice (N. Y. Telephone Co.)	40 h.p.w.

VI-A. Electrical Engineering, Group B—Option 3, Continued

Fourth Year

AT M. I. T.

Summer	2·04	Applied Mechanics	3–5
Term	6·31	Electrical Com., Prin.	3–5
	6·333	Electrical Com. Lab.	6–6
	6·781	Electrical Eng. Lab.	3–4
			15–20

AT WORKS

First Term	6·943	Communications Prac. (Bell Telephone Lab.)	40 h.p.w.
	8·05	Vibrations and Sound	3–6
		Graduate Study	4

AT M. I. T.

Second Term	2·371	Testing Materials Lab.	2–1
	6·32	Electrical Com., Prin.	3–5
	8·201	Electronics	3–5
	15·64	Law of Business Organization	3–6
	G12	Biography in Science	3–3
		Graduate Study*	14
			48

Graduate Year

AT WORKS

Summer Term	6·944	Communications Practice (Bell Telephone System)	40 h.p.w.
		Seminar* & Thesis	10

AT M. I. T.

First Term		General Study	3–3
		Graduate Study* & Thesis	42
			48

AT M. I. T.

Second Term	6·502	Seminar	2–2
		General Study	3–3
		Graduate Study* & Thesis	38
			48

VII. BIOLOGY AND PUBLIC HEALTH

THIS Department has as its objective the broad training of students in the biological sciences which may prepare them for positions in biological research, public health administration, and sanitation, or in the numerous technical applications in the food, biochemical, and fermentation industries. The first two years are largely devoted to fundamental subjects in mathematics, physics, chemistry, and an introduction to biology, and to studies of a general cultural character. The later work becomes more specialized and, to meet the various demands, five groups or options of professional studies have been established.

Coöperative arrangements have been set up with the W. K. Kellogg Foundation of Battle Creek, Michigan, by which a few students with special qualifications may undertake field studies and practical training in public health administration; holders of Kellogg Foundation Fellowships may secure credit toward the Master's degree for work done at the Foundation.

Students will begin their work with the Kellogg Foundation in the middle of the senior year, spend one year in the various divisions of the Foundation, followed by a year or more of graduate work at the Institute. This program leads to the degree of Master of Science together with the degree of Bachelor of Science as of the previous year.

OPTION 1a. BIOLOGY AND PUBLIC HEALTH. This option deals primarily with the biological sciences in general, and with their applications to public health administration and sanitation. The official health agencies of the government, states, and cities, as well as private corporations and unofficial health organizations, utilize men well trained in bacteriology, sanitation, and the technique of health administration procedures.

The field of Public Health Administration includes a wide variety of positions, such as those of health officer, epidemiologist, sanitary inspector, statistician, etc., or experts in other phases of municipal sanitation. Closely related is industrial hygiene, which involves special inquiry into the hygiene and sanitation of industry, occupational accidents, industrial hazards, defective ventilation, and control of communicable diseases, and the special health problems in the factory or industrial plant.

This option leads to the degree of Bachelor of Science in Biology and Public Health.

OPTION 1b. BIOLOGY. Students of special promise looking forward to graduate work in Biology without reference to its technical application may be allowed to substitute advanced subjects in biology, physics, and chemistry for those subjects starred in the schedule on page 58.

To such students the degree of Bachelor of Science in Biology may be awarded on satisfactory completion of an approved program.

OPTION 2. INDUSTRIAL BIOLOGY. The course of studies in Industrial Biology is arranged primarily for those intending to follow the growing commercial or industrial applications of biologic processes as in food preservation and manufacture, industrial fermentations, and the control of biochemical processes.

The problems of utilization of microbes in productive enterprises and of the prevention of economic loss through the activity of micro-organisms in many branches of industry demand a knowledge of both microbiology and biochemistry which can be obtained here.

Graduates in this option are especially well fitted to enter the industries dealing with food technology and preservation. There are also openings in connection with the fisheries; the fermentation processes

*6·501 required some time before second term of Graduate year.

VII. Biology and Public Health Continued

yielding glycerin, industrial alcohols, and other solvents, acids or commercial products; and the preservation of wood and textiles, and numerous other technical applications of biochemistry, enzymes, and microbiology.

This option leads to the degree of Bachelor of Science in Industrial Biology.

OPTION 3. PUBLIC HEALTH ENGINEERING. This option is arranged to meet the increasing demand for men trained in the principles of bacteriology and sanitation, industrial hygiene, and public health administration, as well as in engineering. It includes the planning, supervising, and control of water supplies and waste disposal systems; the engineering supervision of milk supply; the development of engineering projects for securing healthful environment through proper housing and working conditions; the elimination of pests; drainage, etc. This type of engineer will probably find a most useful field in state and county health work, in factory sanitation and control, and in the type of work carried out by the United States Public Health Service and some of the large private health organizations.

This option leads to the degree of Bachelor of Science in Public Health Engineering.

VII. BIOLOGY AND PUBLIC HEALTH

OPTION 1 (a). BIOLOGY AND PUBLIC HEALTH
(b). BIOLOGY*

First Year. See page 40

Second Year

First Term	5·11	Qualitative Analysis	7–2
	7·01	Biology, General	5–2
	8·03	Physics	5–5
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
		General Study	2–2
			28–22
Second Term	5·12	Quantitative Analysis	7–2
	7·06	Botany	6–3
	7·14	Comparative Anatomy	8–2
	8·04	Physics	6–4
	E22	Literature and History	3–5
	MS22	Military Science	3–0
			33–16

REQUIRED DURING SUMMER

5·41	Organic Chemistry I	4–3
5·428	Organic Chemistry Lab.	10–0

Third Year

First Term	5·684	Physical Chemistry, Elem.	3–3
	7·10	Invertebrate Zoölogy	8–4
	7·301	Bacteriology	6–4
	7·41	Chem. Water & Sewage*	4–1
	7·50	Communicable Diseases	3–3
	Ec11	Economic Principles	3–3
		General Study	2–2
			29–20
Second Term	7·08	Parasitology	2–4
	7·20	Physiology	6–4
	7·302	Bacteriology	6–3
	7·42	Chemistry of Foods*	5–1
	7·57	Municipal Sanitation*	4–3
	Ec12	Economic Principles	3–3
		General Study	2–2
			28–20

Fourth Year

First Term	7·22	Pers. Hygiene & Nutrition	2–2
	7·36	Microbiology*	3–2
	7·541	Public Health Admin.*	2–3
	7·551	Public Health Lab. Meth.	8–3
	7·58	Vital Statistics*	2–3
	7·80	Biochemistry	8–5
		General Study	2–2
			27–20
Second Term	7·03	Theoretical Biology	2–3
	7·52	Industrial Hygiene*	5–3
	7·542	Public Health Admin.*	2–3
	7·552	Immunological Methods	6–1
		Thesis	16
		Elective	6
			47

OPTION 2. INDUSTRIAL BIOLOGY

First Year. See page 40

Second Year

First Term	5·11	Qualitative Analysis	7–2
	7·01	Biology, General	5–2
	8·03	Physics	5–5
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
		General Study	2–2
			28–22
Second Term	5·12	Quantitative Analysis	7–2
	7·06	Botany	6–3
	7·14	Comparative Anatomy	8–2
	8·04	Physics	6–4
	E22	Literature and History	3–5
	MS22	Military Science	3–0
			33–16

REQUIRED DURING SUMMER

5·41	Organic Chemistry I	4–3
5·428	Organic Chemistry Lab.	10–0

* Option 1 (*b*). BIOLOGY. Students pursuing a course leading to the S.B. degree in *Biology* without reference to Public Health application may substitute with approval of the registration officer courses in biology, chemistry and physics for subjects designated by an asterisk in the above program.

VII. Industrial Biology Continued

Third Year

First Term	5·684	Physical Chemistry, Elem.	3–3
	7·17	Biology of Food Supplies	4–2
	7·301	Bacteriology	6–4
	7·41	Chem. Water & Sewage	4–1
	7·701	Technology & Chem. Food Supplies	7–4
	Ec11	Economic Principles	3–3
		General Study	2–2
			29–19
Second Term	5·141	Analytical Chemistry	4–1
	7·20	Physiology	6–4
	7·302	Bacteriology	6–3
	7·33	Plant Diseases	1–2
	7·57	Municipal Sanitation	4–3
	7·702	Technology & Chem. Food Supplies	4–4
	Ec12	Economic principles	3–3
			28–20

Fourth Year

First Term	2·60	Food Engineering	2–2
	7·22	Pers. Hygiene & Nutrition	2–2
	7·361	Industrial Microbiology	5–2
	7·711	Technology Food Products	6–4
	7·80	Biochemistry	8–5
		General Study	2–2
		Thesis or Elective	6
			48
Second Term	2·601	Food Engineering	3–3
	7·362	Industrial Microbiology	4–4
	7·52	Industrial Hygiene	5–3
	7·712	Technology Food Products	5–4
		Thesis	12
		General Study	2–2
			47

Option 3. Public Health Engineering

First Year. See page 40

Second Year

First Term	5·11	Qualitative Analysis	7–2
	7·01	Biology, General	5–2
	8·03	Physics	5–5
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
		General Study	2–2
			28–22
Second Term	1·18	Map Read. and Top. Draw	2–0
	2·011	Applied Mechanics	3–5
	5·12	Quantitative Analysis	7–2
	8·04	Physics	6–4
	E22	Literature and History	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
			27–22

Required during Summer. At Camp Technology

1·041	Surveying	12–1
1·60	Hydrographic Surveying	5–0
7·34	Limnological Fieldwork	5–0

Third Year

First Term	2·042	Applied Mechanics	3–5
	5·41	Organic Chemistry I	4–3
	7·301	Bacteriology	6–4
	7·41	Chem. Water & Sewage	4–1
	7·50	Communicable Diseases	3–3
	7·53	Air Examination	2–2
	Ec11	Economic Principles	3–3
		General Study	2–2
			27–23
Second Term	1·22	Quantity Surveying	2–2
	1·401	Structures	3–5
	1·62	Hydraulics	4–6
	7·302	Bacteriology	6–3
	7·57	Municipal Sanitation	4–3
	Ec12	Economic Principles	3–3
		General Study	2–2
			24–24

Fourth Year

First Term	1·25	Engineering Construction	4–1
	1·41	Structures	3–6
	1·75	Hydraulic & Sanitary Eng.	4–6
	1·801	Hydraulic & Sanitary Des.	3–0
	7·541	Public Health Admin.	2–3
	7·58	Vital Statistics	2–3
	7·59	Sanitation	5–3
		General Study	2–2
			25–24
Second Term	1·421	Structures	2–4
	1·78	Sanitary Engineering	3–4
	1·802	Sanitary Design	5–0
	2·65	Mech. Equip. Bldgs. H. & V.	4–3
	7·52	Industrial Hygiene	5–3
	7·542	Public Health Admin.	2–3
		Thesis	12
			50

VII-A. BIOPHYSICS AND BIOLOGICAL ENGINEERING

THE purpose of this course of study is to prepare for work in experimental biology of essentially research character. General biology deals with life, the environmental conditions of living matter, and the products of living things. Biochemistry is concerned with the chemistry of these matters, and biophysics with their physical aspects. The application of biological data, often best obtained by utilizing the technics of physics and chemistry for precise measurements, to problems of human welfare with planned method constitutes biological engineering.

Heretofore it has been necessary for those entering upon this field of endeavor to prepare separately in biology, chemistry, and physics. Course VII-A is designed to train the student simultaneously in the essentials of biology and of various theoretical and experimental aspects of related sciences, and to illustrate through the solving of actual research problems,

VII-A. Biophysics and Biological Engineering Continued

under guidance, the methods of applying the various skills he has acquired.

Electives in the fourth and fifth years will permit the selection, subject to approval of the registration officer, of subjects which have a bearing upon the specialized fields of applied biology which are open to an investigator, such as metabolism, preventive or curative medicine, food technology, industrial fermentations, economic entomology, biochemistry, biophysics, or electro-physiology.

Because of the diversified technical courses of study prescribed in this curriculum, only students with a demonstrated ability to handle mathematical and other precise technical subjects with facility are considered qualified to attempt the program. Each applicant for admission to Course VII-A should interview the registration officer for this Course.

This course leads to the degree of Master of Science in Biological Engineering, and the degree of Bachelor of Science in Biophysics as of the preceding year.

Biophysics and Biological Engineering

First Year. See page 40

Second Year

First	5·11	Qualitative Analysis	7–2
Term	7·01	Biology, General	5–2
	8·03	Physics	5–5
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
		General Study	2–2
			28–22
Second	5·12	Quantitative Analysis	7–2
Term	7·14	Comparative Anatomy	8–2
	8·04	Physics	6–4
	E22	Literature and History	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
			30–19

Required during Summer

5·41	Organic Chemistry I	4–3
5·428	Organic Chemistry Lab.	10–0

Third Year

First	5·61	Physical Chemistry I	4–4
Term	5·611	Physical Chemistry Lab. I	4–0
	7·10	Invertebrate Zoölogy	8–4
	7·301	Bacteriology	6–4
	Ec11	Economic Principles	3–3
		Language	3–5
			28–20
Second	5·62	Physical Chemistry II	4–4
Term	5·621	Physical Chemistry Lab. II	4–0
	6·00T	Electrical Engineering Prin.	4–6
	7·20	Physiology	6–4
	Ec12	Economic Principles	3–3
		Language	3–5
			24–22

Fourth Year

First	6·01	Electrical Eng. Prin.	4–6
Term	6·75T	Electrical Eng. Lab.	3–4
	7·80	Biochemistry	8–5
	8·09	Physical Meas.	3–2
	8·161	Optics	3–6
	8·162	Optical Measurements	3–2
			24–25
Second	7·84	Biophysics	6–3
Term	8·311	Atomic Structure	3–5
	8·312	Atomic Structure Lab.	3–2
		General Study	2–2
		Electives	20
			46

Graduate Year

First	7·321	Bacteriology, Adv.	3–4
Term	7·81	Zymology	6–3
	7·91	Biological Eng. I	6–3
	10·661	Intro. Colloid Chemistry	2–4
		Elective	9
		Thesis	10
			50
Second	7·82	Biochemistry, Adv.	6–3
Term	7·92	Biological Eng. II	4–2
	10·662	Colloid Chemistry	2–4
		Elective	9
		Thesis	20
			50

VIII. PHYSICS

PHYSICS in recent years has been one of the most rapidly developing sciences, and at the same time is the basic science for most branches of engineering. The Course in Physics, with its two options, is intended to be sufficiently broad to provide for the needs of those who desire to prepare for graduate work and research in pure physics, either experimental or theoretical, as well as for those who desire to go into work in industrial and applied physics. Students are given a sound fundamental training in the various branches of physics, as well as in mathematics, chemistry, and liberal subjects. Laboratory instruction is given in the more important phases of experimental physics, including modern physics, and training in theoretical physics is provided.

Option 1. General Physics. This option is for students preparing for a career of research and teaching of physics, often after pursuing graduate work. There is thorough training in the classical foundations of physics, but also much work in modern physics, atomic structure, and similar fields in which most of the recent progress of physics has been made. Mathematics and mathematical physics, as well as experimental physics of all types, are stressed. In the third and fourth years considerable elective work is included, some of which may be taken in other

VIII. Physics Continued

departments. Electives are to be chosen in consultation with the registration officer, who can give specific suggestions regarding them. A few types of electives follow:

Experimental or theoretical subjects in physics, such as optics, acoustics, electricity and electronics, X-rays, spectroscopy, and various topics in theoretical physics; mathematical subjects, such as mechanics, analysis, advanced calculus, higher algebra; chemical subjects, such as quantitative analysis, organic chemistry, and physical chemistry.

Option 2. Applied Physics. Physics is fundamental to engineering, and the techniques of physics are tools of great value in many branches of industry. For effective industrial work, however, physics, particularly in its more classical and experimental phases, should be supplemented with chemistry, metallurgy, and electrical engineering, all of which are essential in industrial laboratories. The option in applied physics includes thorough training in these fields, and graduates of the option should have just the sort of training needed for a wide variety of industrial openings, while being well prepared at the same time for further graduate study.

Electives are included in the fourth year, some of which may be taken outside the department, in fields of scientific or engineering interest. In some cases, minor rearrangements and substitutions of required subjects and electives may be made to fit in with special programs of work. The registration officer should be consulted in regard to such rearrangements.

Both options of Course VIII lead to the degree of Bachelor of Science in Physics.

Option 1. General Physics

First Year. See page 40

Second Year

First Term	5·11	Qualitative Analysis	7–2
	8·03	Physics	5–5
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
		Language	3–5
			24–23
Second Term	6·00T	Electrical Eng., Prin.	4–6
	8·04	Physics	6–4
	E22	Literature and History	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
		Language	3–5
			22–26

Third Year

First Term	6·01	Electrical Eng., Prin.	4–6
	8·09	Physical Measurements	3–2
	8·161	Optics	3–6
	8·162	Optical Measurements	3–2
	8·50	Heat and Thermodynamics	3–4
	Ec11	Economic Principles	3–3
		Elective	8
			50
Second Term	8·201	Electronics	3–5
	8·202	Electronics Laboratory	3–2
	8·311	Atomic Structure	3–5
	8·312	Atomic Structure Lab.	3–2
	Ec12	Economic Principles	3–3
	M77	Vector Analysis	3–6
		Elective	6
			47

Fourth Year

First Term	8·11	Experimental Physics	8–4
	8·461	Int. Theoretical Physics	4–8
	8·471	Hist. Develop. Physics	3–6
		General Study	2–2
		Elective and Thesis	12
			49
Second Term	8·12	Experimental Physics	2–4
	8·13	Colloquium	2–2
	8·462	Int. Theoretical Physics	4–8
		General Study	2–2
		Elective and Thesis	23
			49

Option 2. Applied Physics

First Year. See page 40

Required during Summer

	5·11	Qualitative Analysis	7–2

Second Year

First Term	5·12	Quantitative Analysis	7–2
	8·03	Physics	5–5
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
		Language	3–5
			24–23
Second Term	6·00T	Electrical Eng., Prin.	4–6
	8·04	Physics	6–4
	E22	Literature and History	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
		Language	3–5
			22–26

Third Year

First Term	5·61	Physical Chemistry I	4–4
	6·01	Electrical Eng., Prin.	4–6
	8·09	Physical Measurements	3–2
	8·161	Optics	3–6
	8·162	Optical Measurements	3–2
	Ec11	Economic Principles	3–3
		Elective	6
			49

VIII. Applied Physics Third Year Continued

Second	5·62	Physical Chemistry II	4–4
Term	8·201	Electronics	3–5
	8·202	Electronics Lab.	3–2
	8·311	Atomic Structure	3–5
	8·312	Atomic Structure Lab.	3–2
	19·50	Metallography	4–1
	Ec12	Economic Principles	3–3
		Elective	5
			50

Fourth Year

First	5·41	Organic Chemistry I	4–3
Term	5·418	Organic Chemistry Lab.	6–0
	8·11	Experimental Physics	8–4
	8·461	Int. Theoretical Physics	4–8
		General Study	2–2
		Elective and Thesis	8
			49
Second	8·12	Experimental Physics	2–4
Term	8·13	Colloquium	2–2
	8·462	Int. Theoretical Physics	4–8
		General Study	2–2
		Elective and Thesis	23
			49

IX-A. GENERAL SCIENCE

(ADMINISTERED BY A COMMITTEE OF THE FACULTY)

THE Course in General Science provides an opportunity for the study of all the fundamental sciences. It is designed to develop in the student a comprehensive sense of the orientation and coördination of science in general. Since one-third of the units required for graduation are elective, opportunity is also offered for specialization in that branch of science in which the student by contact and trial becomes most interested.

The Course occupies a position in the technical school similar to those courses in the university leading to the degree of bachelor of arts. In one case the student acquires a general knowledge of many of the sciences with considerable emphasis upon one. In the university the student graduates with a general knowledge of many of the liberal arts with some degree of specialization in one.

The choice of electives is subject to the approval of the Committee on Course IX and in all cases must follow a definite objective. The composite group of science subjects must comprise an amount of scientific training equivalent to that obtained in the standard science Courses.

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

First Year. See page 40

Second Year

First	5·11	Qualitative Analysis	7–2
Term	8·03	Physics	5–5
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
		Language†	3–5
			24–23
Second	5·12	Quantitative Analysis	7–2
Term	8·04	Physics	6–4
	E22	Literature and History	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
		Language	3–5
			25–22

Third Year

First	2·501	Heat Measurements	2–1
Term	5·41	Organic Chemistry I	4–3
	7·01	Biology, General	5–2
	12·01	Mineralogy	8–2
	12·321	App. Engineering Geology	5–2
	Ec11	Economic Principles	3–3
		Elective*	6
			46
Second	5·418	Organic Chemistry Lab.	6–0
Term	Ec12	Economic Principles	3–3
		Elective*	35
			47

Fourth Year

First Term	Elective* and Thesis	50
Second Term	Elective* and Thesis	50

IX-B. GENERAL ENGINEERING

(ADMINISTERED BY A COMMITTEE OF THE FACULTY)

THE Course in General Engineering contains a comprehensive survey of the applications of science to the primary branches of engineering. It is designed to develop in its graduates the ability to visualize and adjust the correlated problems encountered in all fields of engineering. Since nearly one-third of the units required for graduation are elective, opportunity is also provided for specialization in that branch of engineering in which the student by contact and trial becomes most interested.

Standard engineering courses cannot be expected to embrace all of the technical requirements of the industrial world. The demand for new courses in special fields of engineering will constantly arise and the educational opportunity is provided in this Course for their introduction and development.

* Electives must include a total of not less than 8 units of General Study; 16 units if language omitted.
† Accepted as a General Study.

IX-B. General Engineering Continued

The choice of electives is subject to the approval of the Committee on Course IX and in all cases must follow a definite engineering objective. The composite group of engineering subjects must also comprise an amount of professional engineering training equivalent to that obtained in the standard engineering curricula.

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

First Year. See page 40

Second Year

First Term	2·00	Applied Mechanics	3–5
	2·701	Machine Drawing	6–0
	8·03	Physics	5–5
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
		Elective*	6
			50
Second Term	1·02	Surveying	3–1
	2·01	Applied Mechanics	3–5
	2·854	Machine Tool Laboratory	3–0
	8·04	Physics	6–4
	E22	Literature and History	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
			24–21

Third Year

First Term	2·04	Applied Mechanics	3–5
	2·40	Heat Engineering	4–5
	Ec11	Economic Principles	3–3
		Elective*	24
			47
Second Term	1·401	Structures	3–5
	1·62	Hydraulics	4–6
	2·42	Heat Engineering	4–5
	6·40	Electrical Eng. Elem.	4–6
	Ec12	Economic Principles	3–3
		Elective*	6
			49

Fourth Year

First Term	2·686	Engineering Laboratory	3–3
	6·85	Electrical Eng. Lab.	2–3
		Elective* and Thesis	37
			48
Second Term		Elective* and Thesis	48

* Electives must include a total of not less than 16 units of General Study.

X. CHEMICAL ENGINEERING

THE needs of chemical industry for men competent to develop, design and operate new processes and to improve existing ones requires a training which combines knowledge both of the underlying chemical reactions and of the mechanical 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, organic and industrial chemistry is practically the same as that given to students in Chemistry during the first three years, except for some reduction in laboratory requirements. The subjects in Mechanical and Electrical Engineering are intended to supply the fundamentals which are needed by the chemical engineer and the instruction is adapted to his requirements. The work in Chemical Engineering and in Industrial Chemistry is of a distinctly professional nature and is designed to develop capacity for original thought. Competent students may make substitutions in the curriculum with approval of the Head of the Department.

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

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

First Year. See page 40

REQUIRED DURING SUMMER

	5·10	Qualitative Analysis	14–4

Second Year

First Term	5·12	Quantitative Analysis	7–2
	8·03	Physics	5–5
	10·11	Prob. of the Chem. Engr.	1–0
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
		Language	3–5
			25–23
Second Term	5·131	Quantitative Analysis	5–2
	8·04	Physics	6–4
	E22	Literature and History	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
		Language	3–5
		General Study	2–2
			25–24

Students not credited with German will take Elementary German. Students credited with German but not with French will take Elementary French. Other students are to consult with their Registration Officer.

X. Chemical Engineering Continued

Third Year

First	2·011	Applied Mechanics	3–5
Term	5·41	Organic Chemistry I	4–3
	5·416	Organic Chemistry Lab.	7–0
	5·61	Physical Chemistry I	4–4
	5·612	Physical Chem. Lab. I	2–0
	10·28	Chemical Engineering	4–6
	Ec11	Economic Principles	3–3
			27–21
Second	2·042	Applied Mechanics	3–5
Term	5·42	Organic Chemistry I	4–2
	5·426	Organic Chemistry Lab.	5–0
	5·62	Physical Chemistry II	4–4
	5·622	Physical Chem. Lab. II	2–0
	10·17	Industrial Chemistry	3–2
	10·29	Chemical Engineering	3–6
	Ec12	Economic Principles	3–3
			27–22

Fourth Year

First	2·371	Testing Materials Lab.	2–1
Term	6·40	Electrical Eng. Elem.	4–6
	6·85	Electrical Eng. Lab.	2–3
	10·18	Industrial Chemistry	4–6
	10·26	Industrial Chemical Lab.	5–1
	10·31	Chemical Engineering	4–5
		General Study	2–2
		Thesis	3
			50
Second	2·686	Engineering Laboratory	3–3
Term	10·15	Thesis Reports	2–2
	10·21	Industrial Chemistry	2–2
	10·32	Chemical Engineering	4–5
		Prof. Elective and Thesis	22
		General Study	2–2
			49

The time devoted to Electives must be not less than 8 units and not more than 12 units, the time adjustment being made with the hours assigned to thesis. Students admitted to Course X-A should take Analytical Chemistry 5·16 (4–1) as an elective subject in the second term of the fourth year.

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 apply 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, on the program given below. 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.

Fourth Year

SCHOOL CHEMICAL ENGINEERING PRACTICE

Second	10·30	Engineering Equipment	4–1
Term	10·32	Chemical Engineering	4–5
		*Field Station	12
		*Field Station	12
		Thesis	12
			50

* Students will take two of the following Stations:

10·84	Bangor	12
10·85	Parlin	12
10·86	Buffalo	12

XI. SANITARY ENGINEERING

(ADMINISTERED BY THE DEPARTMENT OF CIVIL AND SANITARY ENGINEERING)

THE Course in Sanitary Engineering is arranged to train students in the principles of design and operation of water works and works for the disposal of sewage and other wastes. Although emphasis is placed upon the design and operation of such works, subjects of a fundamental and broad nature are also included in the curriculum to give the student a working knowledge of the field of sanitation and its relation to the public health.

The course of study includes those civil engineering subjects an understanding of which is required for complete engineering service in connection with the construction of sanitary engineering works, and also such subjects in mechanical and electrical engineering as are necessary to familiarize the student with the principles underlying the selection of pumping and treatment plant equipment. Much time is devoted to instruction and laboratory work in analytical, organic, physical and sanitary chemistry and to the biology and bacteriology of water and sewage. Extended subjects run throughout the fourth year in the principles of the design and operation of modern water works, water treatment plants, sewerage systems and sewage and waste disposal works.

Opportunities are offered to fourth year and graduate students for group inspection of nearby water and sewage works, and arrangements are made which permit fourth year and graduate students to receive several days' training in the operation of a modern water treatment plant and a modern sewage treatment plant in nearby cities.

Facilities are available in the Sanitary Engineering Laboratory and in other laboratories of the Institute for research work in sanitary hydraulics and in the treatment of water and wastes.

Graduates of this Course are prepared for service with private or public engineering organizations engaged in the design and supervision of construction of water and sewage works; for employment with contractors or manufacturers engaged in the building of water and sewage plants or equipment therefor;

XI. Sanitary Engineering Continued

and for entrance into the broader fields of city, state, or national public health work.

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

First Year. See page 40

Second Year

First	5·11	Qualitative Analysis	7–2
Term	7·01	Biology, General	5–2
	8·03	Physics	5–5
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
		General Study	2–2
			28–22
Second	1·18	Map Read. and Top. Draw.	2–0
Term	2·011	Applied Mechanics	3–5
	5·12	Quantitative Analysis	7–2
	8·04	Physics	6–4
	E22	Literature and History	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
			27–22

REQUIRED DURING SUMMER. AT CAMP TECHNOLOGY

1·041	Surveying	12–1
1·60	Hydrographic Surveying	5–0
7·34	Limnological Fieldwork	5–0

Third Year

First	1·21	Rail. and High. Curves	2–2
Term	2·042	Applied Mechanics	3–5
	5·41	Organic Chemistry I	4–3
	5·418	Organic Chemistry, Lab.	6–0
	6·40	Electrical Eng., Elem.	4–6
	6·89	Electrical Eng. Lab.	2–2
	7·41	Chem. of Water & Sewage	4–1
	Ec11	Economic Principles	3–3
			28–22
Second	1·22	Quantity Surveying	2–2
Term	1·40	Structures	7–4
	1·62	Hydraulics	4–6
	2·371	Testing Materials Lab.	2–1
	7·29	Bacteriology	5–2
	Ec12	Economic Principles	3–3
		General Study	3–3
			26–21

Fourth Year

First	1·25	Engineering Construction	4–1
Term	1·41	Structures	3–6
	1·48	Foundations	3–4
	1·75	Hydraulic & San. Eng.	4–6
	1·801	Hydraulic & San. Des.	3–0
	2·411	Heat Engineering	2–4
	5·684	Physical Chemistry, Elementary	3–3
		Thesis	2
			48
Second	1·42	Structures	2–4
Term	1·52	Structural Design	3–0
	1·58	Des. Reinf. Concrete Structures	6–0
	1·78	Sanitary Engineering	3–4
	1·802	Sanitary Design	5–0
	2·421	Heat Engineering	2–4
	2·687	Hydraulic Laboratory	2–2
		General Study	3–3
		Thesis	7
			50

XII. GEOLOGY

TWO optional Courses of study are offered in this Department.

OPTION 1, GEOLOGY. This is planned for students who wish to make geology in its theoretical and practical aspects their principal subject of study. An adequate foundation of subjects in physics, chemistry and mathematics is followed by the foundational subjects in geology (general geology and mineralogy), which in turn are followed by more advanced and specialized subjects of the Department.

The option is designed for students seeking a broad general preparation, as well as for those planning to follow one of the several lines of specialization in the field of geology. The schedule of this option is sufficiently flexible to permit an adequate range of specialization by means of substitution of equivalent subjects for those designated, and through the use of electives. Students whose interests and aptitudes have led to a choice of specialization may upon consultation with their major professor arrange a schedule of subjects designed to attain the type of instruction and training desired. The principal lines of specialization are:

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

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

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

Geophysics. In recognition of the growing importance of fundamental research in geophysics and of the demand by petroleum and mineral industries, as well as by certain phases of engineering operations, for men trained along the combined lines of physics and geology, this Department is staffed and equipped

XII. Geology Continued

to provide sound fundamental training in geology and geophysics. The training designed for this objective places special emphasis on physics, mathematics and certain phases of electrical engineering.

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

Option 2, Mineral Resources. Planned to afford a suitable schedule of subjects for students desiring to prepare for professional work in the mineral industries. This schedule of subjects provides a thorough preparation in the fundamentals of mathematics, physics, chemistry, and geology, with emphasis on the economic aspects of mineral resources. The course is made sufficiently flexible, particularly in the last year, for such specialization as the individual student may desire.

XII. Option 1. Geology

First Year. See page 40

Second Year

First Term	5·11	Qualitative Analysis	7–2
	8·03	Physics	5–5
	12·301T	General Geology	7–2
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
			28–20
Second Term	8·04	Physics	6–4
	12·302	General Geology	7–2
	E22	Literature and History	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
		Elective	9
			48

Third Year

First Term	12·01	Mineralogy	8–2
	12·211	Optical Crystallography	5–2
	12·70	Structural Geology	3–6
	Ec11	Economic Principles	3–3
		Language	3–5
		Elective	8
			48
Second Term	12·15	Petrography	8–2
	12·40	Economic Geology	3–6
	Ec12	Economic Principles	3–3
		General Study	3–3
		Language	3–5
		Elective	9
			48

Fourth Year

First Term	12·38	Geomorphology	3–6
	12·581	Sedimentation	5–2
		General Study	3–3
		Elective and Thesis*	26
			48
Second Term		Elective and Thesis*	48

XII. Option 2. Mineral Resources

First Year. See page 40

Second Year

First Term	5·11	Qualitative Analysis	7–2
	8·03	Physics	5–5
	12·301T	General Geology	7–2
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
			28–20
Second Term	2·011	Applied Mechanics	3–5
	8·04	Physics	6–4
	12·302	General Geology	7–2
	E22	Literature and History	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
			25–22

Third Year

First Term	2·042	Applied Mechanics	3–5
	5·61	Physical Chemistry I	4–4
	12·01	Mineralogy	8–2
	12·70	Structural Geology	3–6
	Ec11	Economic Principles	3–3
		Elective	7
			48
Second Term	5·62	Physical Chemistry II	4–4
	12·15	Petrography	8–2
	12·40	Economic Geology	3–6
	Ec12	Economic Principles	3–3
	Ec32	Statistics	3–3
		Elective	9
			48

Fourth Year

First Term	6·40	Electrical Eng., Elem.	4–6
	6·85	Electrical Eng. Lab.	2–3
	15·11	Int. Business Management	3–3
		General Study	10
		Elective and Thesis*	17
			48
Second Term	15·12	Int. Business Management	3–3
		General Study	3–3
		Elective and Thesis*	36
			48

*Total Thesis not less than 15 units.

XIII. NAVAL ARCHITECTURE AND MARINE ENGINEERING

THE Course in Naval Architecture and Marine Engineering provides instruction in the theory and methods of designing and building ships, together with a study of the properties requisite for safety and steadiness at sea. It aims to furnish a well-rounded training for those who expect to be shipbuilders, ship designers or marine engine builders, or who desire to enter allied industries.

In addition to the literary, mathematical and scientific studies requisite for a general training and for preparation for the special work of the course, instruction is given in heat engineering, applied mechanics, fluid mechanics, steam turbines, electrical engineering and marine engineering. It is believed that a proper coördination of the design of a steamship and its propelling machinery can be attained only by a naval architect who is familiar with both branches of his profession.

Lectures are given on theoretical naval architecture and marine engineering, treating of displacement and stability, launching, theory of waves, rolling of ships, strength of ships, propulsion of ships, steering and maneuvering, and also of power, proportions and strength of marine engines, auxiliary machinery and the application of steam turbines and Diesel engines to marine propulsion.

After preliminary instruction in ship drawing, each student carries through the design of a ship and its machinery for a given service in a systematic manner as in good practice, giving attention both to the logical development of the design and to the requirements for registration, for insurance and governmental inspection. Drawings and all customary computations are made of the structure and arrangements of hull, engines and propellers. To explain and unify the work of design, lectures are given on the materials and methods of construction of ships of wood and of steel, and on their equipment.

Such items as economy of cost during construction, the influence of marine insurance, and the rules of the Registration Societies, the stability at beginning and end of voyage and its effect on the behavior of the ship at sea, the freeboard and tonnage laws, types of propelling machinery and the general sequence of work in the shipbuilding yard are described, and their effects on the problems of design are discussed.

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

First Year. See page 40

Second Year

First	2·00	Applied Mechanics	3–5
Term	2·851	Machine Tool Lab.	4–0
	8·03	Physics	5–5
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
		General Study	3–3
			24–24
Second	2·01	Applied Mechanics	3–5
Term	2·852	Machine Tool Practice	4–0
	8·04	Physics	6–4
	13·40	Yacht Architecture	6–1
	E22	Literature and History	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
			28–21

Third Year

First	2·04	Applied Mechanics	3–5
Term	2·251	Fluid Mechanics	6–2
	2·40	Heat Engineering	4–5
	13·01	Naval Architecture	3–5
	13·34	Ship Construction	4–4
	13·41	Ship Drawing	3–0
	Ec11	Economic Principles	3–3
			26–24
Second	2·06	Applied Mechanics	3–5
Term	2·42	Heat Engineering	4–5
	2·683	Engineering Laboratory	2–2
	13·02	Naval Architecture	3–5
	13·43	Ship Design	6–0
	13·52	Marine Engineering	4–4
	Ec12	Economic Principles	3–3
			25–24

Fourth Year

First	6·40	Electrical Eng., Elem.	4–6
Term	6·89	Electrical Eng. Lab.	2–2
	13·45	Ship Design	8–0
	13·54	Marine Engineering	2–3
	13·61	Marine Engineering Design	4–1
	15·11	Int. Business Management	3–3
		General Study	3–3
		Elective	6
			50
Second	2·32T	Engineering Metals	3–2
Term	2·351	Materials of Eng.	2–2
	2·371	Testing Materials Lab.	2–1
	2·684	Engineering Laboratory	2–2
	13·55	Marine Engineering	2–3
	13·62	Marine Engineering Design	6–0
		Thesis and Elective	16
		General Study	3–3
			49

XIII-C. MARINE TRANSPORTATION

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

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

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

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

The studies at the Institute are arranged to coördinate with the year at sea. In the second and third year, subjects are given in heat engineering, marine engineering, terminal operation, 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. Electives are also offered in the fifth year to allow the student to specialize in some phase of marine transportation.

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

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

The Course covers five years and leads to the degree of Bachelor of Science in Marine Transportation.

First Year. See page 40

Second Year

First Term	2·00	Applied Mechanics	3–5
	2·854	Machine Tool Lab.	3–0
	8·03	Physics	5–5
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
		Language	3–5
			23–26
Second Term	2·01	Applied Mechanics	3–5
	8·04	Physics	6–4
	15·52	Accounting	4–2
	E22	Literature and History	3–5
	G28	Economic Geography	3–3
	MS22	Military Science	3–0
		Language	3–5
			25–24

Third Year

First Term	2·04	Applied Mechanics	3–5
	2·40	Heat Engineering	4–5
	13·01	Naval Architecture	3–5
	13·83	Port Facilities	3–4
	15·61	Law of Contracts	3–6
	Ec11	Economic Principles	3–3
			19–28
Second Term	2·42	Heat Engineering	4–5
	2·685	Engineering Laboratory	4–4
	13·021	Naval Architecture	2–3
	13·52	Marine Engineering	4–4
	Ec12	Economic Principles	3–3
		General Study	2–2
		Elective	6
			46

Fourth Year

Students spend the fourth year (12 months) in practical work with a steamship company, with nine months' service at sea. After this year, they return to the Institute for the work of the fifth year.

Fifth Year

First Term	6·40	Electrical Eng. Elem.	4–6
	6·89	Electrical Eng. Lab.	2–2
	13·34	Ship Construction	4–4
	13·56	Marine Engineering	3–3
	13·81	Ship Operation	3–5
	Ec61	Labor Relations	2–4
		Elective	6
			48
Second Term	13·47	Ship Design	6–0
	13·82	Ship Operation	3–5
	15·20	Ocean Shipping Administration	2–4
	Ec54	Corporations	3–3
		Thesis and Elective	18
		General Study	3–3
			50

XIV. ELECTROCHEMICAL ENGINEERING

(Administered by the Department of Metallurgy)

ELECTROCHEMICAL Engineering is a composite Course in which most of the fundamental work of electrical engineering is combined with basic courses in chemistry as preparation for the more specialized work in electrochemistry and the related field of electrothermics. The Course aims primarily to prepare students to enter the various electrochemical, electrothermic and electrometallurgical industries. The instruction given in this Course is, however, of so broad a character that students completing it should be well prepared to enter various fields related to electrochemical work.

Throughout the third year the principles of physical chemistry are treated from the kinetic and thermodynamic points of view both in lecture room and laboratory. The application of these principles to electrochemical processes is continued in the first term of the fourth year, the classroom work being accompanied by laboratory practice in electrochemical measurements. In the second term this work is concluded by a course in applied electrochemistry including electrodeposition, accumulators, electric furnaces and their products, electrolytic processes and electrometallurgy. The latter part of the Course is devoted principally to the preparation of a thesis on some electrochemical topic.

In the third and fourth year elective studies are offered in the field of physics, chemistry, metallurgy, and electrical engineering, for those who desire to specialize along particular lines of work.

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

Note.—The need for more specialized training in the applications of electricity to electrometallurgical and electrothermic processes on the one hand and the preparation of inorganic and organic compounds on the other has made it impossible to include in one course adequate instruction in both lines of study, together with the intensive training in Electrical Engineering which is now included in Course XIV. The course will, therefore, be discontinued in 1940, but the subject matter will be included and enlarged in scope by a division between Courses X and XIX. This will make it possible for a student to specialize in one branch or the other and will bring the advantages of training in electrochemical subjects to a much larger circle of students.

Third Year (1938–39 only)

First	5·41	Organic Chemistry I	4–3
Term	5·418	Organic Chemistry Lab.	6–0
	5·61	Physical Chemistry I	4–4
	5·611	Physical Chemistry Lab. I	4–0
	6·031	Electrical Eng., Prin.	4–6
	6·77	Electrical Eng. Lab.	4–4
	Ec11	Economic Principles	3–3
			29–20
Second	5·62	Physical Chemistry II	4–4
Term	5·621	Physical Chem. Lab. II	4–0
	6·12	Electrical Eng., Prin.	5–6
	6·84	Electrical Eng. Lab.	5–5
	Ec12	Economic Principles	3–3
		Elective	8
			47

Fourth Year

First	2·50	Heat Measurements	3–1
Term	8·07	Precision of Measure	1–1
	8·82	Electrochemistry	3–6
	19·09	Metallurgy	4–4
	19·11	Metal. & Electroch. Lab.	4–0
	19·83	Electrochemical Lab.	9–3
		General Study	2–2
		Elective	6
			49
Second	19·82	App. Electrochemistry	3–6
Term		General Study	2–2
		Elective	22
		Thesis	13
			48

XV. BUSINESS AND ENGINEERING ADMINISTRATION

THE Course in Business and Engineering Administration provides a special curriculum for men who combine an aptitude for engineering with a potential capacity for important managerial responsibility. It was first established and has continued 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.

Students enrolled in Course XV 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 and the general public. The program of required business subjects is the same for all students; in the second year there is a choice between two options, depending upon whether the student desires to base his technical work on the physical or the chemical sciences.

In Option 1, in which the engineering subjects are based on the physical sciences, the student is offered in his last two years a considerable amount of latitude as to the particular type of engineering which he desires to study. He may, for example, follow a program of subjects in the fields of Mechanical Engineering or Civil Engineering, or Electrical Engineering. Or if he has definite industrial interests, he may

XV. Business and Engineering Administration Continued

elect to take his advanced engineering work in such fields as Textile Engineering, Aeronautical Engineering, or Automotive Engineering. This flexibility is accomplished by the provision of a considerable number of elective hours in the third and fourth years. These elective hours are used for engineering subjects, and a coördinated program of study in some particular branch of engineering is worked out by the student, prior to the third year, in collaboration with his registration officer.

In Option 2, 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 second-year student electing the Chemical Option undertakes a dependent sequence of technical subjects which begins the coördinated three-year program:

Physics (two terms)
Qualitative Analysis
Quantitative Analysis

With this background, he is prepared to undertake, in the third year, the following subjects:

Organic Chemistry
Organic Chemistry Laboratory
Physical Chemistry
Chemical Engineering (two terms)
Elements of Electrical Engineering

In the final year, the applications of chemistry and chemical engineering in industry are presented as follows:

Industrial Chemistry (two terms)
Industrial Chemistry Laboratory
Industrial Chemical Engineering (two terms)

Both options of the Course have been approved by the Engineers' Committee for Professional Development, and thus fulfil state requirements for the practice of engineering.

The program of business and economic subjects offered in the undergraduate course covers external as well as internal aspects of management. It aims to encourage a modern and enlightened attitude toward business problems as they relate to economic, sociological, and political trends. Thus it stresses the responsibilities of business to the consumer (in Marketing), to the employee (in Labor Relations), to the investor (in Finance), and to other business men (in Business Law). Although current techniques are discussed, there is no attempt to create narrow trade skills.

First the student is introduced through the course in Production to the nature of modern factory operations. He then undertakes the study of Economics, in which he learns the nature of the forces which underlie business phenomena. At an early stage he is introduced to Statistics, which later serves as a useful analytical tool. In his third year he begins his study of business relationships, with Marketing, Law of Contracts, and Banking. He also becomes familiar with Accounting, another device for analysis and control. In his last year he studies the more involved relationships in Finance and Labor Relations. Finally, after studying the various individual business functions, he takes a subject, Industrial Problems, which serves to integrate them into a coördinated understanding of business as a whole.

In addition to this basic program, the student is permitted in his last 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 term in residence, 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 options of the Course lead to the degree of Bachelor of Science in Business and Engineering Administration.

XV. Option 1.

(Engineering—Based on Physical Sciences)

First Year. See page 40

Second Year

First	2·00	Applied Mechanics	3–5
Term	8·03	Physics	5–5
	15·70	Production	3–6
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
			20–27
Second	2·01	Applied Mechanics	3–5
Term	8·04	Physics	6–4
	Ec11	Economic Principles	3–3
	Ec32	Statistics	3–3
	E22	Literature and History	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
			24–26

Required during Summer

Reading in Economics or Business Literature

Third Year

First	2·04	Applied Mechanics	3–5
Term	15·61	Law of Contracts	3–6
	15·81	Marketing	3–6
	Ec12	Economic Principles	3–3
	E35	Reports	2–4
		Engineering Electives†	10
			48

† Engineering Electives are to form a coördinated program of study in some field of engineering or science. The student's entire program of electives is to be approved by his registration officer prior to the beginning of the *first term of the third year.*

XV. Business and Engineering Administration Continued

Second	6·40	Electrical Eng., Elem.	4–6
Term	6·89	Electrical Eng. Lab.	2–2
	15·50	Accounting	5–4
	Ec40	Money and Banking	3–3
		Engineering Electives†	15
		General Study*	3–3
			50

REQUIRED DURING SUMMER

Business experience approved by the Department as to amount and nature. May include employment in industry or commerce, reports on industrial plants or communities, or an advanced course of reading.

Fourth Year

First	1·63	Hydraulics	2–3
Term	15·41	Finance	3–6
	Ec61	Labor Relations	2–4
		General Study	3–3
		Business or Econ. Elective	9
		Engineering Electives†	14
			49
Second	15·92	Industrial Problems	2–6
Term		Business or Econ. Electives	18
		Engineering Elective†	8
		General Study*	3–3
		Thesis	10
			50

XV. OPTION 2.

(ENGINEERING—BASED ON CHEMICAL SCIENCES)

First Year. See page 40

Second Year

First	5·11	Qualitative Analysis	7–2
Term	8·03	Physics	5–5
	15·70	Production	3–6
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
			24–24
Second	5·12	Quantitative Analysis	7–2
Term	8·04	Physics	6–4
	Ec11	Economic Principles	3–3
	Ec32	Statistics	3–3
	E22	Literature and History	3–5
	MS22	Military Science	3–0
		General Study	3–3
			28–20

REQUIRED DURING SUMMER

Reading in Economics or Business Subjects

Third Year

First	5·41	Organic Chemistry I	4–3
Term	5·61	Physical Chemistry I	4–4
	10·28	Chemical Eng.	4–6
	15·50	Accounting	5–4
	15·61	Law of Contracts	3–6
	Ec12	Economic Principles	3–3
			23–26
Second	5·416	Organic Chemistry Lab.	7–0
Term	6·40	Electrical Eng., Elem.	4–6
	10·29	Chemical Eng.	3–6
	15·81	Marketing	3–6
	Ec40	Money and Banking	3–3
	E35	Reports	2–4
			22–25

REQUIRED DURING SUMMER

Business experience approved by the Department as to amount and nature. May include employment in industry or commerce, reports on industrial plants or communities, or an advanced course of reading.

Fourth Year

First	10·201	Industrial Chemistry	4–4
Term	10·26	Industrial Chemical Lab.	5–1
	10·35	Industrial Chemical Eng.	3–6
	15·41	Finance	3–6
	Ec61	Labor Relations	2–4
		Business or Econ. Elective	9
			47
Second	10·21	Industrial Chemistry	2–2
Term	10·36	Industrial Chemical Eng.	3–6
	15·92	Industrial Problems	2–6
		Business or Econ. Electives	9
		General Study*	3–3
		Thesis	10
			46

XVI. AERONAUTICAL ENGINEERING

(ADMINISTERED BY THE DEPARTMENT OF MECHANICAL 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 of all types of aircraft 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 some related professional field, such as internal combustion engines and meteorology. In this connection attention is invited to the work preparatory to graduate specialization in Meteorology, offered by the Department of Physics.

† Engineering Electives are to form a coördinated program of study in some field of engineering or science. The student's entire program of electives is to be approved by his registration officer prior to the beginning of the *first term of the third year.*

* Each student must have taken 16 units of General Study to meet requirements for graduation.

* Each student must have taken 16 units of General Study to meet requirements for graduation.

XVI. Aeronautical Engineering Continued

On account of the large number of students who wish to take the Course in Aeronautical Engineering, and on account of the limited facilities available, it has been found necessary to limit the number of men who may transfer into it from other institutions or from other Courses at the Institute. Applications will be received during the second term of the first year, and notifications of admission or refusal will be issued shortly after the spring examinations. Toward the end of the second year, a limited number of additional applications will be considered. Students whose work has been unsatisfactory may be required to withdraw from the course at any time in favor of better qualified men. Students not enrolled in the course are admitted to subjects only when facilities permit and if their records are good.

Students who wish to enter this Course by transfer from other colleges, unless their previous work has been of unusual distinction, are required to enter the Institute as unclassified students. They may then take the subjects for which they are prepared and will be permitted to enroll in Course XVI only if they show themselves capable of doing work of the required standard. This requirement may be waived, at the discretion of the head of the Course, for students holding degrees from accredited colleges.

The professional work of the fourth year presupposes preparation in theoretical and applied aerodynamics and structures (16·01, 16·02, and 16·10 and 16·20). *These subjects are offered during the summer session for transferring students who are otherwise prepared for fourth year work, if there is sufficient demand.*

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

Aeronautical Engineering

First Year. See page 40

Second Year

First	2·00	Applied Mechanics	3–5
Term	5·683	Physical Chemistry, Elem.	2–2
	8·03	Physics	5–5
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
		Language	3–5
			22–28
Second	2·01	Applied Mechanics	3–5
Term	8·04	Physics	6–4
	10·16	Applied Chemistry	2–2
	E22	Literature and History	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
		Language	3–5
			23–27

Students credited with French will take German. Students credited with German will take French. Students credited with neither will take German.

Required during Summer

	16·71	Airplane Shopwork	8–2
	16·72	Aircraft Production Methods	8–2

Third Year

First	2·04	Applied Mechanics	3–5
Term	2·351	Materials of Eng.	2–2
	2·40	Heat Engineering	4–5
	2·701	Machine Drawing	6–0
	6·40	Electrical Eng., Elem.	4–6
	16·01	Int. Aero. Mechanics	6–6
			25–24
Second	2·37	Testing Materials Lab.	4–2
Term	2·42	Heat Engineering	4–5
	2·686	Engineering Laboratory	3–3
	6·89	Electrical Eng. Lab.	2–2
	16·02	Int. Aero. Mechanics	6–4
	16·10	Aerodyn. Airplane Des.	3–3
	16·20	Structures	3–5
			25–24

Fourth Year

First	16·11	Aerodyn. Airplane Des.	6–4
Term	16·17	Airplane Des. Practice	8–0
	16·21	Structures	3–5
	16·62	Aeronautical Laboratory	4–3
	Ec11	Economic Principles	3–3
		Elective	8
			47
Second	16·22	Aircraft Structures	3–5
Term	16·75	Const. Details Aircraft	7–2
	Ec12	Economic Principles	3–3
		General Study	3–3
		Thesis & Elective*	18
			47

Electives

First	1·135	Int. to Vibration Theory	3–2
Term	2·791	Automotive Engines	4–4
	15·11	Int. Business Manage.	3–3
	16·901	Meteorology, Introduct.	2–2
	19·50	Metallography	4–1
		General Study	2–2

Electives

Second	2·792	Automotive Engines	4–4
Term	15·12	Int. Business Manage.	3–3
	16·14	Airplane Des. Problems	6–6
	16·63	Aero. Lab. & Res. Meth.	4–2

*Thesis not less than 10 units.

XVII. BUILDING ENGINEERING AND CONSTRUCTION

(ADMINISTERED BY THE DEPARTMENT OF CIVIL AND SANITARY ENGINEERING)

THE objective of the Course in Building Engineering and Construction is to provide a sound training in subjects basic to the engineering design and construction of buildings. It should develop in the student a conception of the related problems of the architect, the engineer, the builder and the materials manufacturer in the process of planning and erecting structures, to the end that he may eventually become either a principal or a responsible manager in any of these fields.

About three-fourths of the entire Course is devoted to fundamental and applied science. The strictly professional work is provided in progressive and correlated courses in engineering, construction and materials during the third and fourth years.

In his senior year the student may direct his efforts toward building engineering or building construction by the selection of structural design or construction problems with such additional electives as will best fit his needs.

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

First Year. See page 40

Second Year

First	2·00	Applied Mechanics	3–5
Term	4·43	Architectural History	3–3
	5·844	Engineering Chemistry	3–3
	8·03	Physics	5–5
	E21	Literature and History	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
			23–27
Second	2·01	Applied Mechanics	3–5
Term	4·78	Planning Principles	3–1
	8·04	Physics	6–4
	17·22T	Building Construction	6–2
	E22	Literature and History	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
			27–23

REQUIRED DURING SUMMER

1·042	Surveying (At Camp Technology)	22–1
2·04	Applied Mechanics (At M. I. T.)	3–5

Third Year

First	2·373	Testing Materials Lab.	5–3
Term	2·41	Heat Engineering	3–5
	6·40	Electrical Eng., Elem.	4–6
	17·31	Building Construction	6–2
	17·73T	Materials	2–2
	E35	Reports	2–4
	Ec11	Economic Principles	3–3
			25–25
Second	1·401	Structures	3–5
Term	6·89	Electrical Eng. Lab.	2–2
	17·32	Building Construction	6–2
	17·52T	Structural Problems	7–3
	17·74T	Materials	4–4
	Ec12	Economic Principles	3–3
		General Study	3–3
			28–22

Fourth Year (For 1938–39 only)

First	1·41	Structures	3–6
Term	2·371	Testing Materials Lab.	2–1
	17·41	Building Construction	6–2
	17·53	Structural Analysis	5–1
		General Study	3–3
		Elective	12
		Thesis	4
			48
Second	1·42	Structures	2–4
Term	17·42	Building Construction	6–2
	17·50	Job Management	2–0
	17·54	Structural Analysis	5–1
		Thesis	10
		General Study	3–3
		Elective	10
			48

Fourth Year (In effect 1939–40)

First	1·41	Structures	3–6
Term	1·48	Foundations	3–4
	2·66	Heat. Vent. & Air Cond.	3–5
		General Study	2–2
		Thesis* & Elective†	22
			50
Second	1·422	Structures	3–6
Term	15·52	Accounting	4–2
	17·40	Estim. & Job Manage	5–1
		Thesis* & Elective†	29
			50

* 11 Thesis units required.

† Required for the Engineer.

First Term	17·53T	Structural Design	11–3
Second Term	17·54T	Structural Design	11–3

Required for the Constructor.

First Term	17·41T	Construction Prob.	4–0
	17·531	Structural Design	7–3
Second Term	17·42T	Construction Prob.	4–0
	17·541	Structural Design	7–3

XVIII. MATHEMATICS

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

The Course outlined is for men who desire to study more mathematics than is contained in the professional Courses. It is well adapted to serve as a preparation for specialization in pure 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, applied statistics, or actuarial work.

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

The following schedules show merely one arrangement in which the various subjects may be taken. Some of these subjects are offered only in alternate years, but the precise order in which they are taken is not important and an equivalent schedule will be arranged for a student entering at the beginning of any year.

Students preparing for actuarial or statistical work are permitted to substitute courses in statistics and probability for some of these subjects. Similarly those who desire to specialize in applied mathematics may substitute courses in fluid dynamics, theory of elasticity, or more advanced work in mechanics. Students interested in making such substitutions should consult the registration officer.

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

First Year. See page 40

Second Year

First Term	8·03	Physics	5–5
	E21	Literature and History	3–5
	M21	Calculus	3–6
	M23	Algebra and Geometry	3–6
	MS21	Military Science	3–0
		Language	3–5
			20–27
Second Term	8·04	Physics	6–4
	E22	Literature and History	3–5
	M22	Differential Equations	3–6
	M24	Algebra and Geometry	3–6
	MS22	Military Science	3–0
		Language	3–5
			21–26

Third Year

First Term	Ec11	Economic Principles	3–3
	M731	Mechanics	3–6
	M77	Vector Analysis	3–6
	M831	Analysis	3–6
		Language	3–5
		General Study	2–2
		Elective	4
			49
Second Term	Ec12	Economic Principles	3–3
	M62	Modern Algebra	3–6
	M732	Mechanics	3–6
	M832	Analysis	3–6
		Language	3–5
		General Study	2–2
			17–28

Fourth Year

First Term	8·50	Heat & Thermodynamics	3–4
	M441	Projective Geometry	3–6
	M841	Analysis	3–6
		Elective and Thesis	24
			49
Second Term	8·54	Electromagnetic Theory	3–6
	M442	Elem. Diff. Geometry	3–6
	M842	Analysis	3–6
		Elective and Thesis	22
			49

XIX. METALLURGY

Including Ceramics

THE course in metallurgy provides training in the production and uses of metals and alloys. Throughout the four years emphasis is laid on the basic sciences: mathematics, physics, chemistry and economics with special attention to physical chemistry. No attempt is made to distinguish between process metallurgy, which is concerned primarily with the winning of the metals from their ores and the making of steel and other alloys, and physical metallurgy, which stresses the physical properties, structure, testing and uses of metals and alloys. The two subdivisions of metallurgy are so closely interrelated that a sharp separation is not possible. A limited amount of specialization in one of the two fields is made possible by the freedom of choice in the selection of a thesis subject in the fourth year. Class and laboratory work in electrometallurgy are included in the curriculum.

The course leads 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 undergradaute student interested in this subject to register in Course IX-B, General En-

XIX. Metallurgy Continued

gineering 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 the testing of raw materials and finished ware.

First Year. See page 40

Second Year

First	5·11	Qualitative Analysis	7–2
Term	8·03	Physics	5–5
	19·01	Intro. to Metallurgy	1–0
	E21	Literature and History	3–5
	L	German	3–5
	M21	Calculus	3–6
	MS21	Military Science	3–0
			25–23
Second	2·854	Machine Tool Laboratory	3–0
Term	5·12	Quantitative Analysis	7–2
	8·04	Physics	6–4
	E22	Literature and History	3–5
	L	German	3–5
	M22	Differential Equations	3–6
	MS22	Military Science	3–0
			28–22

Third Year

First	2·011	Applied Mechanics	3–5
Term	5·61	Physical Chemistry I	4–4
	5·612	Physical Chem. Lab. I	2–0
	10·28	Chemical Engineering	4–6
	19·51T	Metallography I	5–2
	19·901	Ceramics	5–3
	Ec11	Economic Principles	3–3
			26–23
Second	2·042	Applied Mechanics	3–5
Term	3·23	Ore Dressing	3–2
	5·62	Physical Chem. II	4–4
	5·622	Physical Chem. Lab. II	2–0
	19·03	Fire Assaying	5–1
	19·52T	Metallography II	5–2
	19·66T	Heat Treatment	3–1
	Ec12	Economic Principles	3–3
		General Study	2–2
			30–20

REQUIRED DURING SUMMER

19·22	Metallurgical Plants Visit	3–1

Fourth Year

First	2·371	Testing Materials Lab.	2–1
Term	2·50	Heat Measurements	3–1
	19·07	Metallurgy: Cop. & Lead	5–4
	19·11	Metall. & Electro. Lab.	4–0
	19·19	Metall.: Iron & Steel	4–3
	19·31T	Metall. Thermodynamics	3–6
	19·54T	App. of Metallography	3–2
	19·70	X-Ray Metallography	3–3
			27–20
Second	6·40	Electrical Engineering Elem.	4–6
Term	6·81	Electrical Engineering, Lab.	2–2
	19·12T	Metall.: Gen. Zinc & M.M.	4–4
	19·32T	Principles Steel Making	2–4
	19·69	Physics of Metals	2–4
		General Study	2–2
		Thesis	12
			50

UNDERGRADUATE SCHEDULES FOR RESERVE OFFICERS' TRAINING CORPS

THE general object of the Reserve Officers' Training Corps is to qualify students for positions of leadership in time of national emergency. For this purpose, five units of the senior division of the R. O. T. C. are maintained. The instruction consists of two courses, the basic course and the advanced course, each of two academic years. The basic course is required; the advanced course is elective and includes one summer camp period.

BASIC COURSE

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

For instruction in the first year of the basic course, the students are organized as an infantry regiment. Cadet sergeants and corporals are selected from first-year students who demonstrate especial aptitude for military instruction. Cadet sergeants may be selected for appointment from such second-year students as are especially qualified and who volunteer to attend drill. A band of about forty instruments is organized from qualified members of the R. O. T. C.

The instruction in the second year of the basic course is mainly theoretical. During the year, opportunity is given the student to elect the unit in which he prefers to continue his instruction.

First Year

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

Reserve Officers' Training Corps Continued

Second Year

First Term	MS21	Military map reading, field engineering and basic military subjects	3–0
Second Term	MS221	Coast Artillery Unit: Elements of heavy artillery	3–0
	MS222	Engineer Unit: Elements of engineer training	3–0
	MS223	Signal Unit: Tactics and signal communications	3–0
	MS224	Ordnance Unit: General characteristics of Ordnance matériel and ammunition	3–0
	MS226	Chemical Warfare Unit: Elements of chemical warfare training	3–0

Advanced Course

The object of the advanced course is to qualify for a commission in the Officers' Reserve Corps of the Army of the United States a limited number of students who have demonstrated exceptional qualities of leadership. Graduates of the four-year course (including the advanced camp) should be reasonably well qualified to perform the duties of a second lieutenant of the branch in which they have been trained.

The course is open to students who have satisfactorily completed two years in the basic course at this Institute or elsewhere, who are acceptable to the Professor of Military Science and Tactics, and who have received the approval of the professor in charge of the course in which they are registered. A student enrolled in the advanced course receives commutation of uniform at the approximate rate of twenty-nine dollars for the first year and seven dollars for the second year, and commutation of subsistence at the rate of twenty-five 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 will be subsisted by the Government. To enroll, he must execute a contract to continue the course of instruction for two years, should he remain that length of time at the Institute, and the fulfillment of this contract then becomes a prerequisite for graduation. The contract includes the obligation to attend a six weeks' 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 very exceptional cases, attendance at camp may be postponed until after the senior year.

A student enrolled in the R. O. T. C., in order to obtain his M. I. T. degree and his commission in the Army, must have fulfilled all the requirements set down by the Faculty and, in addition, he must have obtained a clear record in military taught subjects and have fulfilled all military obligations.

The head of a department is authorized to allow, at his option, credit towards graduation for military taught subjects.

G27 (3–3) (for one term only) Military History and Policy of the United States is required of all students taking the Advanced Course.

Coast Artillery Unit

Open to students in all courses. Omissions and other approved changes in Course schedules are noted on page 77 under the number of the Course.

Third Year

First Term	MS31	Leadership	1–0
	MS311	Fire control and gunnery for heavy artillery	2–1
Second Term	MS32	Leadership	1–0
	MS321	Fire control and gunnery for antiaircraft artillery	2–1

Fourth Year

First Term	MS41	Leadership	1–0
	MS411A	Applied gunnery for seacoast and antiaircraft artillery	2–1
	MS411B	Artillery matériel; organization, administration, and duties of the Coast Artillery Corps	2–2
Second Term	MS42	Leadership	1–0
	MS421	Tactical employment of antiaircraft and heavy artillery	2–1

Engineer Unit

Open only to students in Courses I, II, III, VI, VI-A, VII_3, IX-B, X, XI, XIII, XIII-C, XV_1, XVI, XVII and XIX.

Third Year

First Term	MS31	Leadership	1–0
	MS312	Combat principles of small units; to include the infantry and engineer platoon.	2–1
Second Term	MS32	Leadership	1–0
	MS322	Military Engineering; including problems in field engineering	2–1

Fourth Year

First Term	MS41	Leadership	1–0
	MS412	Military engineering and tactical problems	1–1
Second Term	MS42	Leadership	1–0
	MS422	Military engineering and problems applying principles of field engineering	1–1

Signal Unit

Open only to students in Courses VI, VI-A, VI-B, VI-C, VIII, IX-B, XIV, XV_1, and XVI. Except in the subjects indicated below, instruction is given by Institute personnel. Approved changes in schedules are noted on page 77 under the number of the Course.

Third Year

First Term	MS31	Leadership	1–0
	MS313	Signal Corps tactics; message centers; elements of cryptanalysis; code practice	2–1
Second Term	MS32	Leadership	1–0
	MS323	Military telegraphy and telephony; radio sets	2–1

Fourth Year

First Term	MS41	Leadership	1–0
	MS413	Training methods; Reserve Corps regulations; procurement	1–1
Second Term	MS42	Leadership	1–0
	MS423	Maintenance of Signal Transportation	1–1

Reserve Officers' Training Corps Continued

Ordnance Unit

Open only to students in Courses $II_{1, 2, 3, 5}$, V, VIII, X, X-B, XIV, XV_1, XV_2, XVI and XIX. Except in the subjects indicated below, instruction is given by Institute personnel.

Third Year

First Term	MS31	Leadership	1–0
	MS314	Organization and duties of the Ordnance Department; ordnance engineering	2–1
Second Term	MS32	Leadership	1–0
	MS324	Ordnance matériel; storage and handling of ammunition	2–1

Fourth Year

First Term	MS41	Leadership	1–0
	MS414	Storage, issue and maintenance of ordnance supplies	1–1
Second Term	MS42	Leadership	1–0
	MS424	Storage, issue and maintenance of ordnance supplies	1–1

Chemical Warfare Unit

Open only to students in Courses V, VII, X, X-B, XIV and XV_2. Except in the subjects indicated below, instruction is given by Institute personnel. Approved changes in schedules are noted below under the number of the Course.

Third Year

First Term	MS31	Leadership	1–0
	MS316	Combat principles of infantry and the chemical platoon	2–1
Second Term	MS32	Leadership	1–0
	MS326	Tactics and technique of chemical warfare	2–1

Fourth Year

First Term	MS41	Leadership	1–0
	MS416	Tactical employment of infantry and chemical troops	1–1
Second Term	MS42	Leadership	1–0
	MS426	Tactical employment of infantry and chemical troops	1–1

CHANGES IN COURSE SCHEDULES FOR R. O. T. C.

The following table shows approved changes in Course Schedules for the various units of the R. O. T. C. *Changes shown in italics are required.* In all other cases, if advantage is taken of an omission, any accompanying addition becomes required.

Course	*Yr.*	*Tm.*		*Change*	*Units*
I			C. A. C.	See note at foot of page.	
$II_{1, 2, 3, 4}$	4	1	C. A. C.	Omit: App. of Electricity in Industry 6·47	4–4
			C. A. C.	Add: Elec. Eng. Lab. 6·89	2–2
III	4	1	C. A. C.	Omit: Elec. Eng. Lab. 6·85	2–3
V	3 or 4	1 or 1	C. A. C.	Omit: Elective	4
	4	2	C. W. S.	Omit: Elective	4
				Add: *Powder, Explosives and War Agents 5·43*	2–2
VI	4	1	C. A. C.	Omit: Elective	3–6
				Add: Storage Batteries 6·29	1–2
$VII_{1, 3}$			C. A. C.	See note at foot of page.	
VII_2	4	1	C. A. C.	Omit: Thesis or Elective	6
VIII	4	1	C. A. C.	Omit: Elective and Thesis	4
	4	1	S. C.	*Include an Elec. that meets S. C. requirements*	3–6
	4	2	S. C.	*Include an Elec. that meets S. C. requirements*	3–6
IX	3 or 4	1 or 1	C. A. C.	Omit: Elective	4
	4	1	S. C.	*Include an Elec. that meets S. C. requirements*	3–6
	4	2	S. C.	*Include an Elec. that meets S. C. requirements*	3–6
X	4	1	C. A. C.	Omit: General Study	2–2
	4	2	C. A. C.	Omit: Prof. Elective	2
	4	2	C. W. S.	Omit: Prof. Elective	4
				Add: *Powder, Explosives and War Agents 5·43*	2–2
XI			C. A. C.	See note at foot of page.	
XII	3	1	C. A. C.	Omit: Elective	4
XIII	4	2	C. A. C.	Omit: Thesis and Elective	4
XIII-C			C. A. C.	Omit: Elective	4
XIV	4	1	C. A. C.	Omit: Elective	6
	4	2	C. W. S.	Omit: Elective	4
				Add: *Powder, Explosives and War Agents 5·43*	2–2
XV_1	3 or 4	1 or 1	C. A. C.	Omit: Engineering Elective	4
XV_2			C. A. C.	Students should consult the department head for special arrangements.	
XVI	4	1	C. A. C.	Omit: Elective	4
XVII	4	1	C. A. C.	Omit: Elective	4
XVIII	4	1	C. A. C.	Omit: Elective	4
XIX	4	1	C. A. C.	Omit: Heat Measurements 2·50	3–1

Note.—Students in the Coast Artillery will be allowed to omit four units from the required course schedule in the term in which they take MS411B or a corresponding readjustment of time will be made in some other term by special arrangement in individual cases.

THE LOWELL INSTITUTE

LOWELL INSTITUTE LECTURES

The Lowell Institute offers courses of Free Lectures, open to the public, on selected subjects dealing with Science, History, Philosophy and the Fine Arts. The lectures are given in the lecture hall of the Boston Public Library with entrance on Boylston Street, near Copley Square, Boston. Each request for programs or tickets should be accompanied by a stamped, self-addressed envelope and mailed to W. H. Lawrence, Curator of the Lowell Institute, Boston Public Library.

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

The School comprises three courses—Mechanical Course, Electrical Course and Structural Course, each extending over two years.

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

A circular giving detailed information regarding the nature of the entrance examinations and other requirements may be obtained by sending a stamped, addressed envelope to Prof. Charles F. Park, Director, The Lowell Institute School, Massachusetts Institute of Technology, Cambridge.

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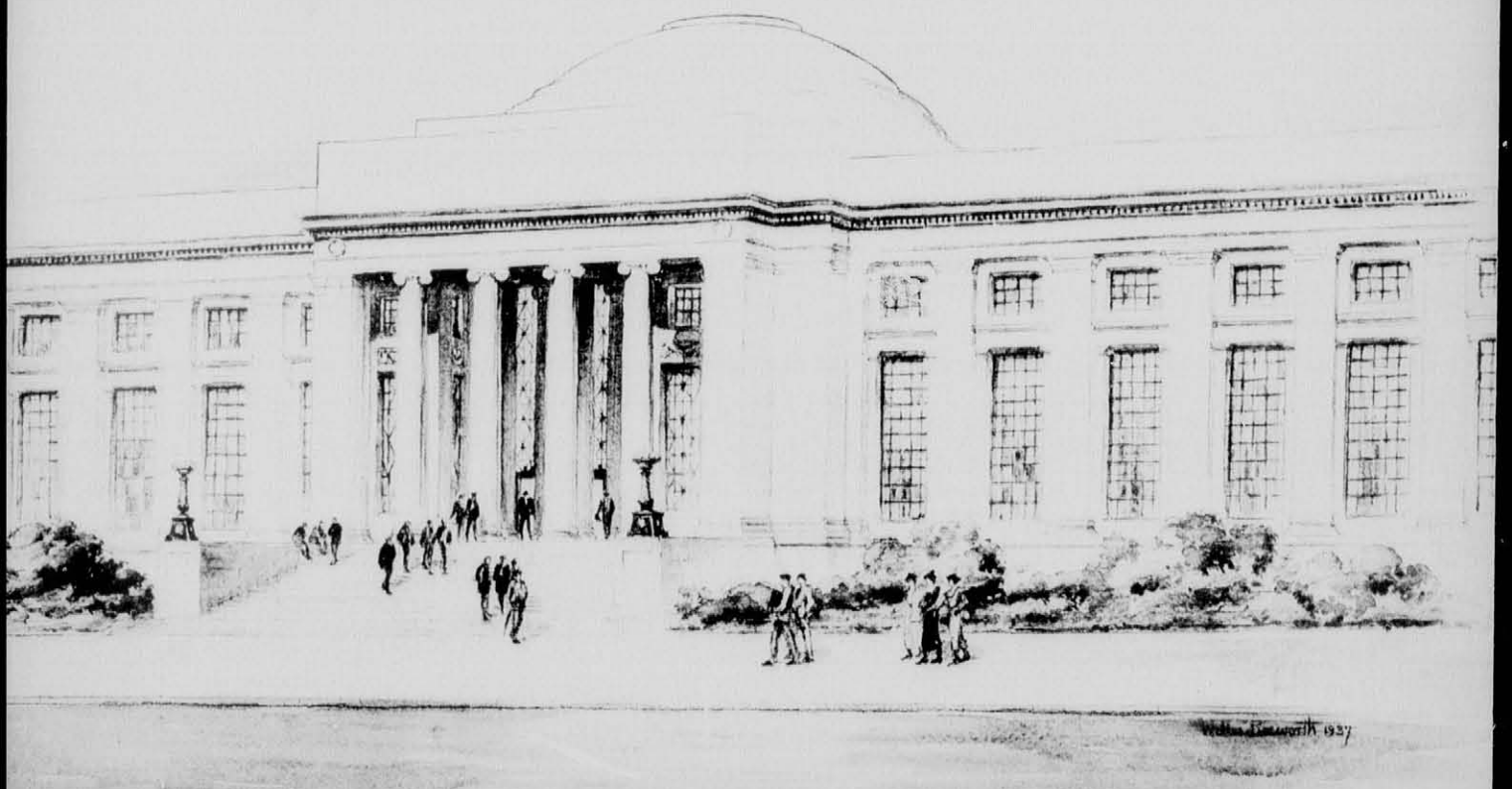
* Correspondence regarding work of the Graduate School and graduate scholarships and fellowships should be addressed to the Dean of the Graduate School.

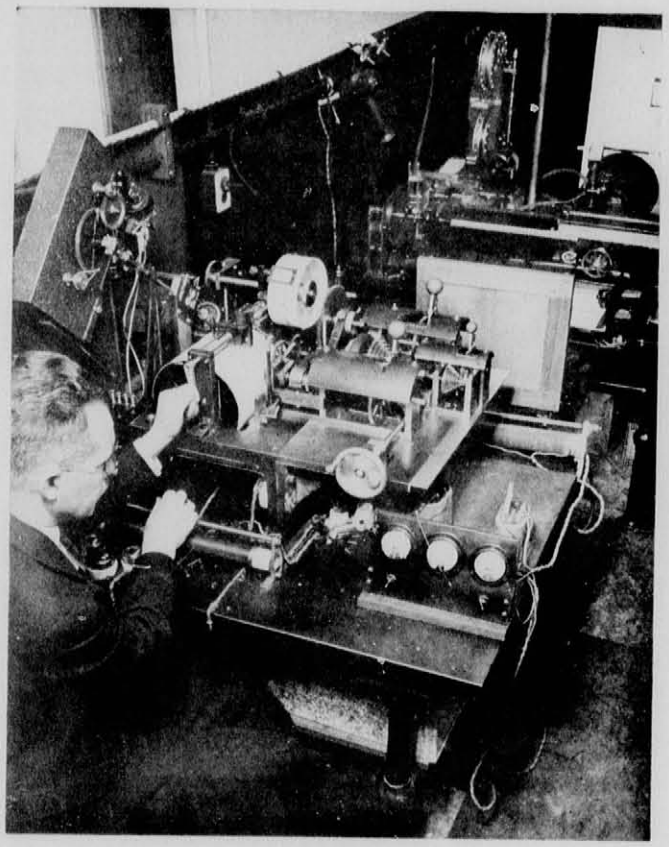
† Inquiries regarding prerequisites for graduate subjects and programs of graduate work in any field of study, should be addressed to the Chairman of the Committee on Graduate Students of the respective department.

...ntical Association offers crew students an opportunity to learn rowing

Walker Memorial, the student union, center of undergraduate activities. It contains dining halls, a browsing library, activity offices, and lounging rooms

Ready for occupancy this fall will be this addition to the Institute plant, the new Rogers Building. It will house the School of Architecture and provide new facilities for many other departments

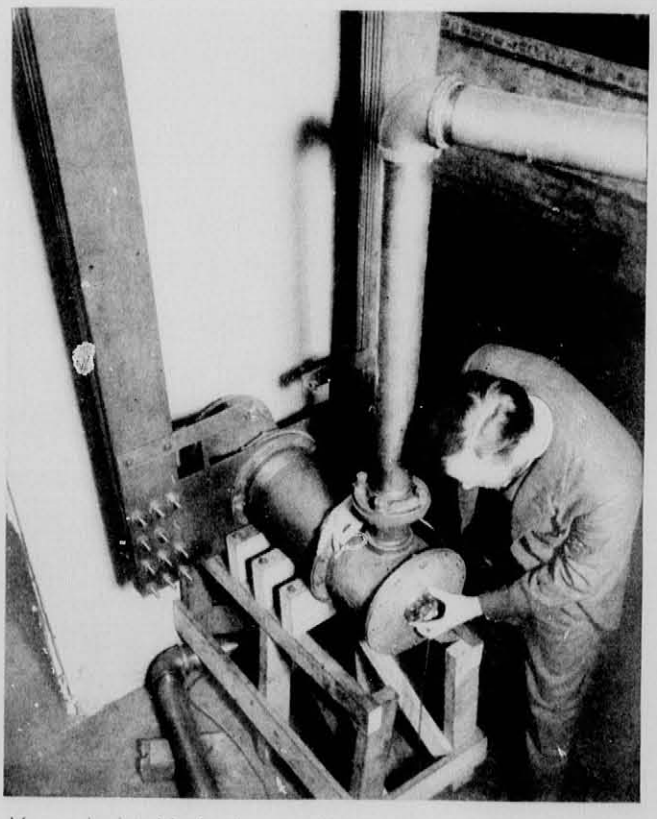




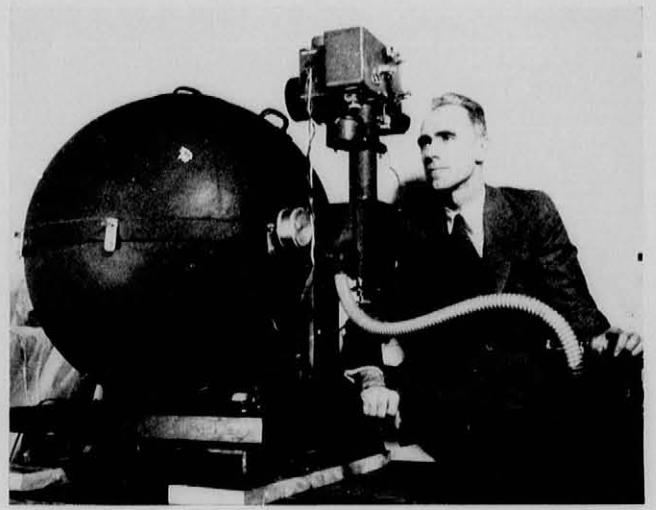
Above, *Geophysicists of the Department of Geology developed this seismograph which is responsive to earth displacements of less than a millionth of an inch or to forces corresponding to a small fraction of the weight of a pinhead*

Left, *In the Institute's unique Spectroscopic Laboratory two machines, of which this is one, are being used in a colossal project of remeasuring three million wavelengths of the spectra of elements*

Testing water tanks with synthetic earthquakes. The white shadowgraph in the right foreground represents an actual quake, and through an electrical system causes the table upon which the tank stands to move as the ground did in the actual quake



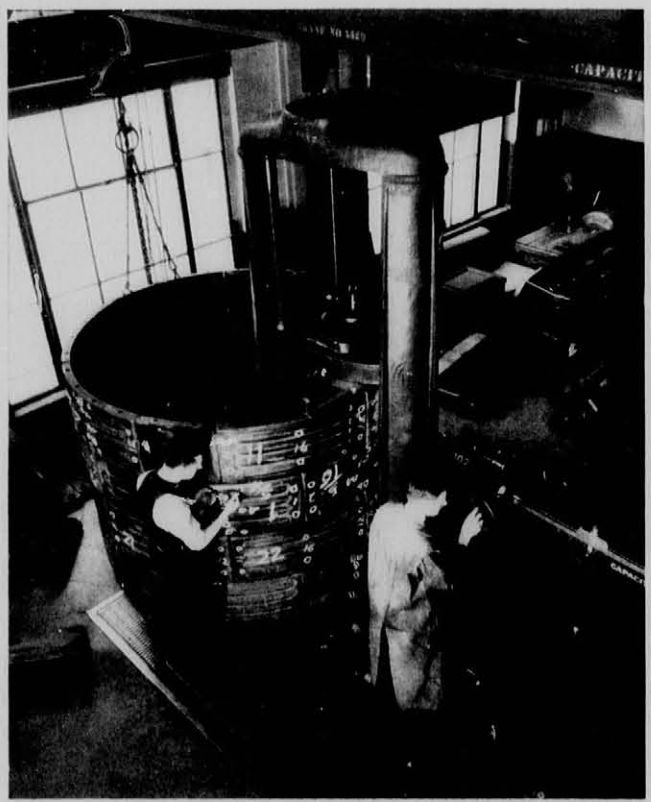
Magnet developed by Institute metallurgists which produces a field of at least 100,000 gauss, the highest permanent field ever attained. The magnet will be used to study the behavior of matter at temperatures below one degree absolute



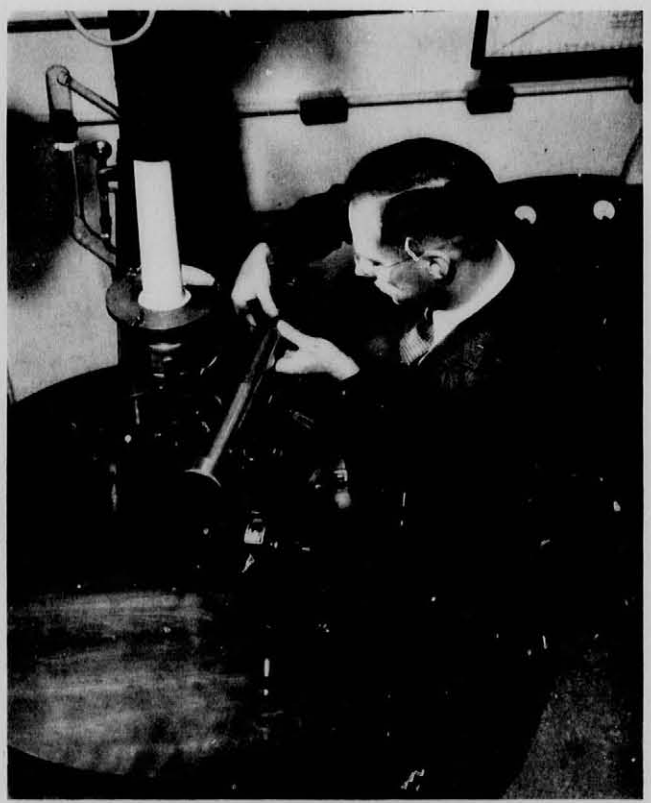
FOR COSMIC RAYS

Left. *On the peak of Mount Evans in Colorado at an altitude of 14,265 feet, M. I. T. and the University of Denver have built this copper-sheathed laboratory for joint research on cosmic radiation and the biological effects of high altitudes.* Right. *The Institute joined in the design of this "jumbo" cosmic-ray intensity meter of which seven have been built for use in a world-wide survey of cosmic radiation*

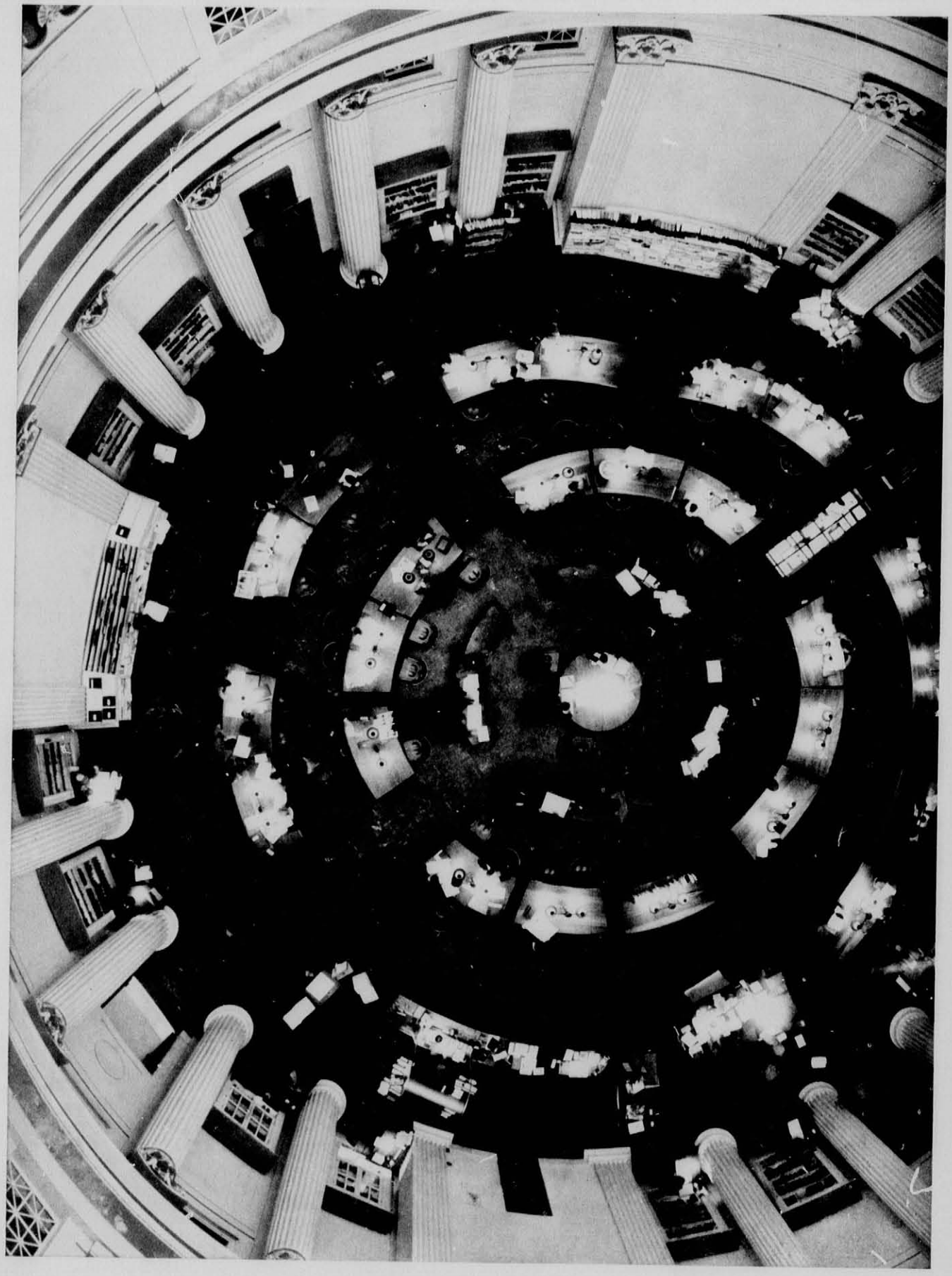
EXTENDING THE FRONTIERS OF KNOWLEDGE BY RESEARCH



In the Strength of Materials Laboratory a graduate student investigates the strength of the lining used in tunnel boring. Graduate degrees offered include Doctor of Science, of Philosophy, of Public Health, Master of Science, Master in Architecture, and Master in City Planning



Final settings are being made on an instrument which might aptly be called an atomic-pattern analyzer. This instrument maps the distribution of atoms in a crystal and presents the record in such a form that the atomic design is easily determined



MAIN READING ROOM

. . . of the Institute Library, one of the leading collections in the literature of science, engineering, and architecture in the United States

THE GRADUATE SCHOOL

GENERAL INFORMATION

THE Graduate School of the Massachusetts Institute of Technology, including Science, Engineering, and Architecture, was established, upon the recommendation of the Faculty Council, by the Corporation of the Institute in 1932. The School is a natural development of the policy regarding advanced study and research approved by the Corporation as early as 1872. In that year it was announced in the catalogue that "advanced courses have been established by a recent vote of the Corporation and are intended to afford Bachelors of Science of this Institute—and others of equal attainment—the means of continuing their studies. For proficiency in these courses the degree of Doctor of Science has been authorized." The minimum term of residence for this degree was fixed at two years.

The registration in the Graduate School for 1937–1938 was 661 students, approximately one-fifth of the total registration of the Institute. Of these, 265 were pursuing courses leading to the Doctorate, 341 to the degree of Master of Science, 19 to the degree of Master in Architecture and in City Planning, and 36 were engaged with special programs.

The cosmopolitan character of the School is indicated by the fact that the students were graduates from 216 universities, technical schools, or institutions of higher learning, distributed among 46 states and 21 foreign countries.

The advanced courses open to graduate students together with brief descriptions of some of the special laboratories and equipment provided for research will be found described in the following pages under the respective departments in which the work is given. Particular attention is called to the facilities provided in the following laboratories which are devoted primarily or exclusively to research:

The George Eastman Research Laboratories opened in 1932, completely equipped for research in modern Physics, Physical Chemistry, Organic Chemistry, and Inorganic Chemistry; the Spectroscopic Laboratory housed in a separate vibration-proof, constant temperature building; the Daniel Guggenheim Aeronautical Laboratory and the research laboratories in Industrial Physics, Applied Chemistry, Electrical Engineering, and Hydraulics. Facilities for investigation are also amply provided in the extensive laboratories of the other scientific and engineering departments.

Administration. The work of the Graduate School is administered as follows: The Dean of the Graduate School is executive officer and chairman ex-officio of a Faculty Committee on the Graduate School, elected annually by the Faculty and responsible to it. This Committee consists of a representative of each department offering graduate work leading to a higher degree, and such other members as the Faculty may elect. Sub-committees appointed by the Dean consider and report to the main Committee on such business as educational policy, admissions, graduate courses, scholarships, etc. The Committee acts with power on all matters delegated to it by the Faculty. The Faculty recommends all degrees.

Degrees Awarded. At the present time the Institute awards the following higher degrees:

To students in the Departments of Science, Engineering, and Economics, the degree of Master of Science, with designation of the field of study, or without such designation, depending upon the character of the course pursued; in the Department of Architecture, the degrees of Master in Architecture and Master in City Planning; in the Departments of Science, namely, Biology, Chemistry, Geology, Mathematics, and Physics, the degrees of Doctor of Philosophy and Doctor of Science; in the fields of Applied Science and Engineering, namely, Aeronautical Engineering, Meteorology, Chemical Engineering, Civil Engineering, Electrical Engineering, Electrochemical Engineering, Mechanical Engineering, Mining Engineering, Petroleum Engineering, Metallurgy, Ceramics, Naval Architecture, Marine Engineering, Sanitary Engineering, the degree of Doctor of Science; in the Department of Biology and Public Health, the degree of Doctor of Public Health.

Scholarships and Fellowships. The Graduate School has available in 1938–39 over $115,000 dollars for scholarships and fellowships. For a detailed list of these funds and the regulations governing their award see page 213.

REQUIREMENTS FOR ADMISSION

To be admitted to the Graduate School the applicant must, except in cases of unusual attainments, have received his Bachelor's degree in a four years' course of a college, university or technical school of recognized standing, and his scholarship records and credentials must be such as to indicate that he has the ability to meet the requirements of a higher degree. Applicants whose scholastic rating is low will not be admitted. Students who are pursuing programs of work leading towards a higher degree will be classified as graduate students. College graduates who pursue courses of study leading to the Bachelor's degree will be registered as undergraduates and those admitted without reference to meeting the requirements of any degree as special students.

Correspondence relating to the Graduate School should be addressed to the Dean of the Graduate School. The graduate work of each department is in charge of a Departmental Committee on Graduate Students, one member of which, usually the Chairman, is the representative of the Department on the Committee on the Graduate School. Inquiry regarding specific subjects of instruction, prerequisites and programs of work, should be addressed to the chairman of the Departmental Committee concerned.

Applications for admission to the Graduate School are to be made in duplicate on blanks obtainable from the Secretary of the Graduate School, except those of Naval Constructors appointed by the United States Government. Applications should, if possible, be filed with the Secretary not later than May 1, in order that applicants may be advised regarding their standing before the beginning of the Summer Session. Frequently it is very desirable that deficiencies in undergraduate work be made up during the summer; in any case applications and credentials should be submitted *not less than three weeks before the opening of the term* in which the student expects to register. Applications from students who have not previously been in residence at the Institute must be accompanied by a certified transcript of their college records; also three or more professors acquainted with their work, should be requested to send letters of recommendation to the Secretary. As soon as applications for admission have been acted upon students will be notified. Since the number of graduate students who will be admitted in a number of departments has been limited, those whose admission has been approved, should confirm their intention to register by so notifying the Secretary in order that vacancies may be filled by others on the waiting list. All new students other than Institute graduates should plan to reach Cambridge several days before the opening of the term and, upon their arrival at the Institute, *should consult the Dean of the Graduate School before filing their registration cards*. The Dean is the general consulting officer for graduate students on all matters pertaining to graduate work. Institute graduates, before registering, should consult the chairman of the Committee on Graduate Students of the Department in which they elect their major work.

Undergraduate Prerequisites

An applicant for admission to the Graduate School is expected to meet requirements in the following undergraduate subjects common to all curricula (except Architecture*):

Language. The equivalent of Intermediate French or Intermediate German or Elementary French and Elementary German is desirable and in any case either Elementary French or Elementary German is required in addition to some language other than English. In place of this requirement, the applicant may satisfy the Department in which he wishes to take advanced work leading to the Master's degree that he has a good reading knowledge of scientific French or German.* For language requirements for the Doctor's degree see page 85.

In exceptional cases Spanish may be accepted as meeting the language requirement. This will be allowed, however, only by petition which must have the endorsement of the Committee on Graduate Students of the Department in which the student is registered and the approval of the Committee on the Graduate School. In each case the student must satisfy the Department of Modern Languages of his proficiency in Spanish by examination.

Mathematics. The equivalent of the Institute subjects in Mathematics in the first and second years, namely: calculus, M11, M12, M21, and differential equations M22, except as specific exception may be made in the statement of further requirements peculiar to each field of science or engineering.

Chemistry. One or more years of college chemistry, passed with such grades that it may be accepted as meeting the requirements of first-year chemistry, 5·01, 5·02.

Physics. Two or more years of college physics, passed with such grades that it may be accepted as meeting the requirements of first and second-year physics, 8·01, 8·02, 8·03, 8·04.

Cultural Subjects and Economics. It is expected that the applicant shall have a knowledge of English, history, economics and general studies, similar to those included in the undergraduate curricula at the Institute. If the applicant is unusually deficient in meeting this requirement, he may be required to take subjects in these fields.

Professional Subjects. The applicant must, in addition, have completed such professional subjects as may be required by the Department in which he desires to take his Master's degree. Such subjects will be found listed below under each Department respectively. Deficiencies in required undergraduate subjects must be removed before proceeding with dependent graduate work.

In exceptional cases the Committee on the Graduate School will give due consideration to a proposal for modification of certain specified requirements initiated by a department committee in behalf of an applicant desiring to work toward an advanced degree in a specialized field within a department.

Coöperation with Harvard University. Graduate students are given the opportunity of taking at Harvard University a limited number of subjects under a coöperative agreement between Harvard

* For requirements in the School of Architecture see page 93.

University and the Massachusetts Institute of Technology, which provides that "Advanced courses other than courses prescribed in undergraduate programs or courses in research, may, with the consent of the Instructor and the Dean or the Head of the Department in which the student wishes to work, be taken in either institution by students of the other without payment of fees."

A graduate student at the Institute desiring to take advantage of this privilege must present to the Dean of the Graduate School, from the chairman of his department committee, a request for admission to the desired subject, stating the catalogue number and title, together with the name of the instructor giving it. It should also be stated whether the subject is to be taken for credit or audited. The Dean will give the student a letter of recommendation, to be presented to the Dean of that School at Harvard in which he desires to register.

THE MASTER'S DEGREE

The degree of Master of Science is awarded upon the satisfactory completion of a course of advanced study and research approved by the Faculty and extending over not less than one year in residence. The degree of Master in Architecture or Master in City Planning is awarded to students completing the requirements for these degrees in the Department of Architecture. (See under School of Architecture).

Graduates of the Institute, or of other institutions which award the Bachelor's degree on the basis of a four years' course essentially equivalent in breadth and training to that offered by the Institute, may obtain the Master's degree in from one to two years, depending upon preparation. Graduates of colleges or technical schools offering less extensive preparation in science or engineering will in general require two or more years to fulfill the requirements for the degree.

College students intending to enter the Institute for a course of study leading to the Master's degree will find it advantageous to make their selection of college electives correspond as nearly as possible to the undergraduate work of the Institute. If in doubt in regard to any courses of study, they should write to the Dean of the Graduate School or to the chairman of the Committee on Graduate Students of the department they wish to enter.

Graduate Requirements

The degree of Master of Science is awarded upon the satisfactory completion of an approved program of 96 units† of advanced study and research, three-quarters of which, or 72 units including thesis, are chosen from "A" subjects primarily for graduates, and the remaining 24 units are chosen from "A" subjects, or from "B" subjects open to graduates and undergraduates. The number of units credited to thesis shall not be less than 20 or more than 40. If 64 units of the required "A" subjects, including thesis, are chosen from subjects in a single field of science or engineering, the degree will be recommended with designation of the field in which the student has thus specialized, otherwise the degree will be awarded without specification of field. All theses must be carried out under supervision of a member of the Institute Staff.

To be recommended for the Master's degree, a student must not only have completed the program of graduate study and research approved by his Department Committee, *but his scholastic standing must be of a distinctly high grade.* His academic rating will be based on records received in all "A" and "B" subjects taken while registered as a graduate student, or credited to him by the committee in charge of his course.

Choice of Program. The choice of subjects for a program of studies leading to a Master's degree either with or without designation of field, must be made in consultation with and must be approved by the Committee on Graduate Students of the department in which the student is taking his principal work or by its duly authorized representative.

Graduate subjects are arranged on the following pages under the Department in which they are given. The number of "units" of exercise and preparation are indicated. They are divided into two groups:

"A" Subjects Primarily for Graduates. These are more advanced in character than those required for the degree of Bachelor of Science. They are presented for mature students.

"B" Subjects Open to Graduates and Undergraduates. These are chosen from elective and professional subjects of the fourth or senior year and, to a very limited extent, from certain subjects given in the third year. Not over twenty-five per cent of the work for the Master's degree may be chosen from subjects in this group.

A description of all "A" and "B" subjects will be found under the Description of Subjects on pages 117–178. The units assigned to each subject, the instructor in charge of the subject, and the required preparatory subjects will be found under the Tabulation of Subjects, pages 179–206.

Students in doubt as to their preparation for any graduate course should correspond with the chairman of their respective Department Committee. Many of the subjects which are prerequisites are offered in the Summer Session. Subjects listed under "B" in one department shall not be counted as "A" subjects in another department.

The number of units allotted to each subject of instruction is shown in the schedules; for instance,

† A unit represents 15 hours work.

on page 89 under the subject of 1·141 Geodesy, 2 units are devoted to classroom work and 4 units are assigned for outside preparation. The subject would therefore count for 6 units in making up the 96 units required for the degree. Where no division of time between exercise and preparation is indicated, the total number of units devoted to the subject is given.

In arranging a program of studies leading to the Master's degree the choice of subjects is not necessarily restricted to those given in one department, but subjects in other departments may be included provided an integrated and well-balanced program of study results. It is expected that graduate students will concentrate their attention on a few important subjects, together with their research work, rather than attempt to cover a wide range in a less thorough manner.

Each student should decide when beginning his graduate work whether he wishes to become a candidate for a degree in a specified field or for a degree without designation of field, as his program of study will depend upon this decision.

The Degree List. Each graduate student who expects to have met all requirements for the Master's or Doctor's degree in June, October, December, or February, and who desires recommendation for such degree at one of these times, must file with the Registrar, not later than the Wednesday following the Spring Recess, or the first Wednesday of October, December, or January, on a blank furnished therefor by the Registrar, a request to be considered at a designated time for recommendation for the degree. The names of applicants, when approved by departments concerned, will be placed by the Registrar upon a *Degree List*, and such names may not be withdrawn except by petition granted by the Committee on Petitions. All names upon a Degree List, and *only such names*, will be acted upon and reported to the Faculty by the Committee on the Graduate School at its meetings in May, October, December, or February. Each applicant will be notified promptly by the Registrar in case department approval is withheld from his application. *Masters' theses are due not later than one week before the first day of the regular term examination periods.*

Prescribed Curricula. In addition to the elective graduate courses leading to the degree of Master of Science the Institute awards the degree for the satisfactory completion of prescribed curricula in the following fields:

A three-year course (XIII-A) in Naval Architecture leading to the degree of Master of Science in Naval Construction open to officers of the United States Navy who prepare for service as Naval Constructors. This course is open only to graduates of the Naval Academy, assigned to that duty by the Navy Department.

A two-year course in Torpedo Engineering open to officers of the United States Navy and leading to the degree of Master of Science in Mechanical Engineering.

A course of one year and one summer leading to the degree of Master of Science in Civil Engineering arranged for Army Officers of the United States Engineer Corps designated by the War Department.

A course of one year and one summer in Army Ordnance leading to the degree of Master of Science arranged for officers designated by the War Department.

A course of one and one-half years' duration leading to the degree of Master of Science, for Chemical Warfare Officers detailed to the Institute by the United States Army.

A course of one and one-half years' duration in Chemical Engineering Practice (X-A) leading to the degree of Master of Science in Chemical Engineering Practice.

A five-year coöperative course is offered leading to the degrees of Bachelor of Science and Master of Science in Electrical Engineering (VI-A) and also one in Mechanical Engineering (II-A).

A six-year Course (IV-C), offered in the Department of Architecture, leading to the degrees of Bachelor of Architecture in City Planning, and Master in City Planning.

A five-year Course (VII-A), in the Department of Biology, leading to the degrees of Bachelor of Science in Biophysics, and Master of Science in Biological Engineering.

A five-year course in Economics and Engineering or Natural Science leading to the degrees of Bachelor of Science in the professional course, and Master of Science in Economics and Engineering or Master of Science in Economics and Natural Science, depending upon whether the professional course pursued was Engineering or Science. (See Department of Economics and Social Science.)

Program of Studies for Teaching Fellows and Assistants. Members of the teaching staff may work towards a Master's or a Doctor's degree by following a program of study and research approved by the Committee on Graduate Students of their respective departments. The length of time needed for completing the requirements will depend upon the amount of work undertaken.

THE DEGREE OF DOCTOR OF SCIENCE, DOCTOR OF PHILOSOPHY OR DOCTOR OF PUBLIC HEALTH *

The study and research leading to the Doctor's degree are especially valuable to those who wish to engage in original investigation or to teach at higher institutions of learning. Moreover, the increasing

* The specific requirements for the degree of Doctor of Public Health are given on page 103.

demand in the industries for men who have had extended scientific training and have also the attitude of mind impelling them to attack new problems, opens special advantages to those who have obtained a Doctor's degree.

The degree of Doctor of Science or Doctor of Philosophy certifies to the creditable completion of a program of advanced studies, and to the performance of an investigation of high grade. The degree of Doctor of Science may be taken when the course of study is in a department of either science or engineering; the degree of Doctor of Philosophy may be taken only in a department of pure science or mathematics. The requirements for both degrees are essentially the same. These degrees will be conferred only upon candidates who have not only breadth of scientific attainment, but have also shown the power of dealing with new problems in an independent and original manner.

Admission. The general requirements for admission to the Graduate School will be found on page 81. In addition, an applicant for admission to a course of graduate study leading to the Doctor's degree must include on his application blank a general statement of his proposed course of study and field of research, and indicate the choice of Major and Minor fields in which he desires to specialize. If not a graduate of the Institute of Technology, his application must contain a full statement of his preparation for undertaking work leading to the doctorate.

The approval of a student's application for admission to a course of study and research leading to the Doctor's degree is provisional. If his work in residence is of such a character as to indicate that he does not possess those abilities which warrant his continuance toward the doctorate, he will be required to limit his graduate study to the attainment of the Master's degree or to discontinue graduate work.

Period of Residence. The Doctor's degree is not conferred after any definite period of study, but only when the candidate has given evidence of ability to conduct original research by the presentation of a satisfactory thesis embodying a contribution to knowledge in the field of pure or applied science.

A rule of the Faculty, however, requires that not less than two years must be devoted to advanced study and research for the Doctor's degree. Ordinarily, at least three years will be found necessary to meet the requirements, but students pursuing their researches during the summer may be able to complete the work for the degree in less than this time. Credit will be given for graduate work of high grade carried out at another institution before coming to the Institute in determining the requirements for the degree, but in every case *at least one academic year must be spent in residence, and the thesis submitted must be carried out under the direction of a member of the Institute Faculty. The Doctor's degree is not conferred for research done in absentia.*

It is sometimes advisable for a candidate to qualify for the Master's degree before proceeding towards the Doctorate. The advice of the Departmental Committee on Graduate Students should be followed in these cases, but a student may not register for both degrees at the same time.

The four basic requirements for obtaining a doctorate include proficiency in languages, completion of a Minor, completion of a Major, and preparation of a thesis.

Language. All candidates for the Doctor's degree must possess a good reading knowledge of scientific French and scientific German as shown by a reading test given by the Department of Modern Languages. *This test should be passed as early as possible, and must be passed not less than seven months before the award of the degree.*

Students desiring an examination should consult the head of the Department of Modern Languages at least one week before the date set for the test. In the case of a student working for the degree of Doctor of Science in the field of engineering, exception may be made and only one of the above languages required if approved by the Departmental Committee on Graduate Students in charge of the student's Major work.

Major and Minor. While the work for the degree consists mainly of scientific research, this must be supplemented by systematic studies of an advanced character in some branch of science or engineering, which is termed the Major. Thus, chemistry, physics, geology, biology, mathematics, or some branch of engineering may be chosen as the Major field. In exceptional cases in which the desired program of graduate study does not fit in with the above definition of a major, the student may present and defend his program before the Committee on the Graduate School, and if it be approved, may proceed with this program under the supervision of a special committee of the Faculty appointed by the Dean of the Graduate School.

In addition to the Major, a Minor must be completed in at least one other branch of science or engineering or in mathematics. In general only one Minor is required, consisting of at least twenty-five units of work, more advanced in character than required in the undergraduate curriculum of the department in which the student is majoring. Subjects should be chosen from the B or A groups. The program for the minor requirement must be submitted to and approved by the Committee on Graduate Students of the department in which the Minor is taken, soon after the student has registered for the Doctorate. In approving a schedule of studies for a Minor in a given field of science or engineering,

a department committee may include subjects offered in other departments provided these subjects lie within the field of the Minor and form, with other subjects, a logical program.

Examinations. The requirements for a Minor may be met by passing with grades satisfactory to the Committee in charge of the Minor all subjects in the previously approved Minor program. The Committee may, however, require an oral or written comprehensive examination on the field of the Minor if it so elects. Students who request full credit for a Minor based upon work done at another Institution may be required to pass such an examination. *Minor requirements must be passed at least seven months before the completion of the work for the degree* in order that the latter part of the student's period of study may be devoted exclusively to his research.

As soon as a student has completed all subjects required for his Minor he must so notify the Registrar in writing. The Registrar will then submit his complete record to the Committee in charge of the Minor, which will report its decision as to the manner in which the requirements have been met. No final record will be reported on a Minor until the student has initiated a request for this record through the Registrar's office.

General examinations for the Doctor's degree on the field of the Major will be held in October or early November for those who anticipate completing requirements for the degree the following June and at such other times as Departmental Committees may approve. Application for an examination must be made by the student to the Committee on Graduate Students of the Department in which he is majoring and the approval of this Committee must be obtained before the examination will be given. The general examination shall be both written and oral. It must be passed at least seven months before the student may come up for a degree.

Candidacy for the Doctorate. Applicants for the Doctorate must be enrolled on the *list of Candidates* in general at least seven months prior to the award of the degree. The status of Candidate may be attained only by favorable vote of the Committee on the Graduate School in confirmation of departmental endorsement of a request, *initiated by the student himself*, that he be so enrolled. This request must be made in writing to the Registrar who will transmit the applicant's complete graduate record to the Chairman of his Departmental Committee. Favorable action on such a request may be expected if there be a record of completion of Minor requirements and of having passed the prescribed Language requirement and the General Examination, and if the student has demonstrated his ability to carry on research.

Degree List. When a candidate expects to complete his thesis and to come up for his degree he must apply to the Registrar to have his name placed on the *Degree List* as explained under Degree List on page 84. No candidate will be considered for a degree until his name has been placed on this list.

Thesis. Each candidate for the Doctor's degree must deposit with the Chairman of the Committee on Graduate Students of his Department one original and one carbon copy of his thesis; also an abstract of approximately one thousand words, suitable for publication, summarizing in readable form the main results and conclusions of the research. Theses and abstracts must be typewritten and conform to the regulations of the Graduate School.

A short biographical sketch of the candidate's academic career and activities subsequent to the award of the Bachelor's degree must accompany each copy of the thesis. Theses must be submitted in final form at least *two weeks* before the first annual examination, if the candidate expects to receive his degree at Commencement. *Theses must be based on research done in residence under the direction of a member of the Institute staff.*

Final Examination and Degree. The final examination is oral and held after the completed thesis has been handed in. It is limited to the thesis and the special field of science or engineering in which it lies and to such other phases of the major field as the Department Committee may require. When the thesis has been accepted and the final examination passed, the candidate, upon recommendation of his Departmental Committee and of the Committee on the Graduate School, will be recommended to the Faculty for the degree.

In conferring the Doctor's degree, the Doctor's hood is presented by the Institute to those candidates who receive their degree in person at Commencement.

CIVIL AND SANITARY ENGINEERING

ADVANCED work in the Department of Civil and Sanitary Engineering may be pursued to advantage in the fields of Structural Engineering (including Foundation Engineering), Hydraulic Engineering, Railway and Highway Transportation, Sanitary Engineering, Geodetic Surveying and Seismology.

In Structural Engineering a number of advanced subjects are offered in which modern methods of investigating stresses in complicated structures, both of steel and reinforced concrete, are presented in detail and applied to structures of various types, such as arches, suspension bridges, continuous bridges, frameworks of high buildings and high masonry arched dams. Experimental research has been carried on in the past, and is now being conducted with the object of verifying mathematical investigations and formulas pertaining to such structures, and further research may be profitably made in this field by interested students. Other research work consists of the design and investigation of the economy and suitability of various types of construction for particular structures and investigations of properties of soils which may be of interest in engineering construction. The number of separate graduate subjects offered in Structural Engineering is considerable, and the student wishing to specialize in this subject has a wide field open to him. Students seeking admission to these graduate courses should have a thorough training in the fundamental principles of structures equivalent to that covered by subjects 1·40, 1·41, 1·42, 1·58.

In the field of Foundation Engineering, unusual opportunities for research are possible in the laboratory of Soil Mechanics, which is well equipped with apparatus of various types for determining the properties of soils, and in the retaining wall laboratory.

In Water Power Engineering, students investigate existing water power plants and make detailed studies and designs for a water power project. Studies are also made of the comparative economy and the valuation of various water power developments. Experimental investigations may be carried on in the Hydraulic Laboratory, and the cordial relations between water power companies in New England and the Institute have made it possible for students to conduct certain investigations at existing commercial plants. The graduate subjects are dependent upon the undergraduate subjects of Water Power Engineering (1·70, 1·71) and students wishing to take the graduate work should have had the full equivalent of these.

In the field of Theoretical Hydraulics, advanced work is given, in which the whole subject of hydraulic flow is reviewed and the relation between fundamental formulas and experimental results discussed. Subject matter, not ordinarily included in elementary courses in hydraulics, includes a discussion of open channel flow with special reference to the alternate and critical stages and to the occurrence of the hydraulic jump and its utilization as an absorber of energy; the flow of water at velocities below the critical and the determination of the value of the critical velocity; recent developments in the art of measuring the flow of water in closed conduits; and the dynamic action of streams upon immersed surfaces and solids.

Research has been conducted in recent years to develop a method for reducing or preventing silting under a floating dry dock in New York Harbor; to calibrate sewer nozzles for the Metropolitan District Water Supply Commission; to determine the shape of a mooring basin for the Cape Cod Canal which will give a minimum eddy motion; and to determine the high and low water profiles of the enlarged canal. These last two studies were for the Corps of Engineers, U. S. Army. Other subjects investigated include the character of aprons best fitted to resist erosion for certain proposed dams and the fundamental laws governing the transportation of the bed load of rivers.

Advanced courses in Railway and Highway Transportation such as experimental work in the Highway Testing Laboratory, investigations of highway traffic control, design and operation studies for improvements of existing railway terminals and other special problems have in the past been done as advanced work, and the department is prepared to offer similar opportunities if sufficient demand exists. Students taking these subjects should have had the full equivalent of the undergraduate subjects in Transportation Engineering (1·271, 1·272).

Advanced subjects in the theory of Geodesy are offered in Cambridge during the regular school year, and field practice in geodetic work is given at Camp Technology during the summer. Subjects in Seismology, with particular emphasis upon seismological instruments and vibration problems are also available for graduate students interested in this field.

Graduate work in Sanitary Engineering may be carried on in connection with the purification and other treatment of water, the disposal of sewage, and the treatment and disposal of industrial wastes and garbage. A course in Advanced Sanitary Design is given in connection with the study of the theoretical principles involved in the foregoing fields and designs are worked out for typical problems.

Arrangements are made for graduate students in Sanitary Engineering to receive several days' instruction in the operation of a modern rapid sand water treatment plant and a modern sewage treatment plant at nearby cities.

Civil and Sanitary Engineering Continued

Opportunities are also available to the student for inspecting typical plants in the vicinity of Boston for the purification of water supplies; the special treatment of water for certain industrial uses; the disposal of sewage; and the treatment of wastes from tanneries, woolen mills, cotton mills, paper mills and other industrial plants.

Research in the hydraulic, chemical and biological processes relating to Sanitary Engineering may be carried on in the Hydraulic, Sanitary Engineering, Chemical and Bacteriological laboratories of the Institute.

Undergraduate Prerequisites for Civil Engineering

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

1·00, 1·01, 1·05	Surveying
1·20, 1·21	Railway and Highway Engineering
2·04	Applied Mechanics
1·62	Hydraulics
12·321	Applied Engineering Geology
1·40, 1·41, 1·421	Structures
1·501	Bridge Design

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

For
- (*a*) Structural Engineering
  - 1·42 Structures
  - 1·502 Structural Design
  - 1·58 Design Reinforced Concrete Structures
- (*b*) Transportation Engineering
  - 1·25 Engineering Construction
  - 1·271, 1·272 Transportation Engineering
- (*c*) Hydroelectric Engineering
  - 6·40 Elements of Electrical Engineering
  - 1·70, 1·71 Water Power Engineering
- (*d*) Water Supply and Sewage Works
  - 1·75 Hydraulic and Sanitary Engineering
  - 1·76 Sanitary Engineering

If a student has not had, before entering the Institute, the special training in his chosen field of study listed under (*a*), (*b*), (*c*), or (*d*), such training may be acquired during attendance at the Institute and all subjects in these lists except the third year subject, Elements of Electrical Engineering, 6·40, may be taken as B subjects and (up to a total of 24 units) counted for credit toward the Master's degree.

Undergraduate Prerequisites for Sanitary Engineering

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

1·041	Surveying
7·29	Bacteriology
7·41	Chemistry
1·40, (1·41), (1·421)	Structures
1·62	Hydraulics
2·04	Applied Mechanics
(1·75), (1·76), (1·79)	Sanitary Engineering

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

UNITED STATES ENGINEER CORPS

Graduate course leading to the degree of Master of Science in Civil Engineering, especially arranged for officers in the United States Army. The course is open only to officers designated by the War Department.

First Term	1·22	Quantity Surveying	2–2
	1·402	Structures	4–8
	1·491	Soil Mechanics	3–6
	1·493	Soil Mechanics Lab	3–3
	1·68	Theory of Models	2–4
	1·70	Water Power Engineering	7–4
	2·38	Test. Mat. Lab. (Conc.)	3–2
			53
Second Term	1·273	Transportation Eng.	4–5
	1·411	Structures	3–6
	1·492	Soil Mechanics	3–6
	1·691	River Hydraulic Lab.	9–0
	1·72	Flood Control	6–3
	12·79	Applied Eng. Geology	3–3
		Thesis	2
			53
Summer Term	1·25	Eng. Construction	4–1
	1·51	Structural Theory, Adv.	3–6
	1·541	Reinforced Concrete Des.	6–2
		Thesis	18
			40

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Civil and Sanitary Engineering Continued

GRADUATE SUBJECTS IN CIVIL AND SANITARY ENGINEERING

"A" Subjects. Primarily for Graduates

Available for graduates in either Civil or Sanitary Engineering.

First	1·141	Geodesy, Adv.	2–4
Term	1·301	Railway Trans., Adv.	2–4
	1·32	Design of Harbor Works	4–3
	1·371	Highway Trans., Adv.	2–4
	1·491	Soil Mechanics	3–6
	1·493	Soil Mechanics Lab.	3–3
	1·541	Reinf. Concrete Des., Adv.	6–2
	1·551	Structural Design, Adv.	6–0
	1·561	Structural Theory, Adv.	4–8
	1·571	Statically Indeter. Struct.	3–6
	1·59	Concrete Research	Time arr.
	1·66	Hydraulics Advanced	2–6
	1·68	Theory of Models	2–4
	1·691	River Hydraulic Lab.	9–0
	1·731	Water Power Eng., Adv.	3–6
	1·811	Sanitary Eng., Adv.	3–6
	1·851	Water Power Design, Adv.	8–0
	1·881	Sanitary Design, Adv.	6–0
Second	1·136	Vibration Problems	3–6
Term	1·142	Geodesy, Adv.	3–6
	1·302	Railway Trans., Adv.	2–4
	1·372	Highway Trans., Adv.	2–4
	1·492	Soil Mechanics	3–6
	1·51	Structural Theory, Adv.	3–6
	1·542	Reinf. Concrete Des., Adv.	6–0
	1·552	Structural Design, Adv.	6–0
	1·562	Structural Theory, Adv.	2–6
	1·572	Statically Indeter. Struct.	3–6
	1·59	Concrete Research	Time arr.
	1·692	River Engineering	2–4
	1·732	Water Power Eng., Adv.	3–6
	1·812	Sanitary Eng., Adv.	3–6
	1·852	Water Power Design, Adv.	8–0
	1·882	Sanitary Design, Adv.	6–0
	1·90	Prof. Practice in Civil Eng.	1–2

"B" Subjects. Open to Graduates and Undergraduates

First	1·135	Intr. to Vibration Theory	3–2
Term	1·138	Seismological Lab.	Time arr.
	1·16	Aerial Surveying	2–2
	1·25	Engineering Construction	4–1
	1·271	Transportation Eng.	6–5
	1·34	Municipal Engineering	3–4
	1·41	Structures	3–6
	1·48	Foundations	3–4
	1·501	Bridge Design	8–0
	1·531	Reinf. Concrete Design	10–0
	1·70	Water Power Eng.	7–4
	1·75	Hydraulic & San. Eng.	4–6
	1·801	Hydraulic & Sanitary Design	3–0
Second	1·138	Seismological Lab.	Time arr.
Term	1·26	Railway Signaling	2–3
	1·272	Transportation Eng.	5–4
	1·273	Transportation Eng.	4–5
	1·28	Railway Design	5–0
	1·38	Highway Design	5–0
	1·411	Structures	3–6
	1·42	Structures	2–4
	1·421	Structures	2–4
	1·502	Structural Design	6–0
	1·52	Structural Design	3–0
	1·532	Reinf. Concrete Design	8–0
	1·58	Des. Reinf. Conc. Struct.	6–0
	1·71	Water Power Engineering	6–3
	1·72	Flood Control	6–3
	1·76	Sanitary Engineering	2–3
	1·78	Sanitary Engineering	3–4
	1·79	Sanitary Design	2–0
	1·802	Sanitary Design	5–0
Summer	1·07†	Geodetic Surveying (B)	10–0
	1·25	Engineering Construction (B)	4–1
	1·51	Structural Theory, Adv. (A)	3–6
	1·541	Reinforced Concrete Des., Adv. (A)	6–2
	1·68	Theory of Models (A)	2–4
	1·691	River Hydraulic Lab. (A)	9–0

†Given if sufficient number of students apply.

MECHANICAL ENGINEERING

The Department of Mechanical Engineering offers many opportunities for graduate work leading to the degrees of Master of Science and Doctor of Science in Mechanical Engineering. Advanced study and research may be pursued in one or more of the following fields: applied mechanics, theory of elasticity, vibration, properties of materials, plasticity, photoelasticity, rigid dynamics, fluid mechanics, machine design, automatic machinery, physical metallurgy and heat treatment of metals and alloys, metal processing, theoretical thermodynamics, refrigeration, heat transmission, air conditioning, design of power plants and prime movers, automotive engineering and design, textile engineering, and metrology and engineering standards.

Graduate studies in the fields of mathematics, aerodynamics, hydraulic engineering, and business and engineering administration, may be included in the candidate's program.

Requirements for Advanced Degrees

In addition to the general requirements for the Master of Science and Doctor of Science degrees, candidates for the degree of Doctor of Science in the major field of Mechanical Engineering will be required to pass satisfactorily scientific reading tests in two modern languages, one of which must be French or German. There must be included in the major field graduate studies in mathematics, mechanics and thermodynamics; except that a student wishing to specialize in the field of engineering mechanics may limit his major field of study to graduate subjects in mathematics and mechanics. In general, not less than three years of graduate study are necessary for the Doctor's degree.

Laboratory Equipment

For research there is available the extensive equipment of the Mechanical Engineering Laboratories which include:

A Steam Laboratory, with a variety of engines, turbines, condensers and other equipment.

A Compressed Air Laboratory, with compressors of various capacities.

A Refrigeration Laboratory, with six ice-making machines of different types, a number of refrigerator units with considerable auxiliary equipment and a constant-temperature room.

An Air Conditioning Laboratory containing winter, summer, and year round air conditioning units with considerable auxiliary equipment. A special insulated room for study of lower temperature air conditioning problems.

A Hydraulic Laboratory, with high and low pressure pumps, measuring tanks, flumes, wheel pit and other extensive equipment.

An Internal Combustion Engine Laboratory, housed in a specially designed building and equipped with a variety of internal combustion engines, eleven dynamometers ranging from 10 to 300 horsepower in capacity, a small high-speed wind tunnel, a dark room, and a machine and instrument shop.

A Heat Measurements Laboratory specially equipped for research in pyrometry, thermal conductivity and expansion, specific heat, heat of combustion, and refractories. In addition to furnaces and kilns, the laboratory contains a refrigerating unit and an insulated room which can be cooled to −40° C.

A Power Measurements Laboratory, with a number of dynamometers ranging up to a capacity of 100 horsepower, dynamic balancing machines, and gear testing machines specially arranged for testing power plant transmission devices.

The Engineering Metals Laboratories. (1) The Foundry Laboratory equipped with sand control apparatus, molding equipment, gas and oil fired furnaces and cupolas; (2) The Metal Working Laboratory equipped with forges, drop hammer, forging hammer, rolling mill, punch presses, controlled temperature heating furnaces, and metallographic and physical testing equipment for control tests; (3) The Welding Laboratory equipped with A.C. and D.C. arc welding machines, gas welding and cutting apparatus, and resistance welding machines.

A Testing Materials Laboratory, fully equipped with testing machines ranging from 10,000 lbs. to 1,000,000 lbs. capacity, impact testing machines, hardness testing machines, and extensive equipment for testing cement, concrete and road materials, including special storage rooms which can be maintained under constant temperatures ranging from −15° F. to 80° F., and constant humidity ranging from zero to 100%. This laboratory also contains completely equipped photoelastic apparatus, extensometers and special strain measuring devices.

A Textile Laboratory, with a full equipment of textile testing machines capable of varying rates of load application and supplied with autographic recording apparatus; machines for measuring wear, resilience and moisture effects. The laboratory is under full moisture control, with automatic humidification apparatus; also a fully equipped microscopic laboratory for the examination of the structure of textiles and textile fibers.

A Machine Tool Laboratory equipped with a large variety of modern machine tools is available for machine work in connection with research, as well as a machine shop, manned by expert machinists.

In addition to the foregoing laboratories, there are available, for research work in physical metallurgy and heat treatment, the extensive laboratories of the Metallurgy Department fully equipped for heat treatment, metallography and X-ray analysis.

GRADUATE SUBJECTS IN MECHANICAL ENGINEERING

"A" Subjects. Primarily for Graduates

First Term	2·125	Res. Photoelas.	Time arr.
	2·131	Dynamics of Engines	2–4
	2·201	Adv. Mech. & Th. of Elast.	3–9
	2·221	Plasticity	3–6
	2·223	Plasticity Research	Time arr.
	2·271	Hydromechanics	3–6
	2·273	Adv. Hydromech. Prob.	Time arr.
	2·304	Foundry Engineering	3–6
	2·391	Dyn. Strength of Metals	Time arr.
	2·461	Refrigeration, Adv.	3–9
	2·53	Heat Measurements	Time arr.
	2·57	Power Plants, Adv.	3–6
	2·63	Storage & Trans. of Foodstuffs	3–6
	2·671	Air Conditioning, Adv.	3–6
	2·751	Machine Design, Adv.	8–2
	2·801	Auto. Engine Prob., Adv.	Time arr.
	2·803	Automotive Engineering	Time arr.
	2·88	Met. & Dimens. Eng. Stand.	3–6
	2·905	Textile Tech. Anal.	3–5
	2·907	Textile Microscopy	5–2
	2·911	Textile Research Lab. Research	6–0
Second Term	2·125	Research in Photoelasticity	Time arr.
	2·202	Adv. Mech. & Th. of Elast.	3–9
	2·222	Adv. Plasticity Prob.	3–6
	2·223	Plasticity Research	Time arr.
	2·272	App. Hydromechanics	3–6
	2·273	Adv. Hydromech. Prob.	Time arr.
	2·34	Properties of Metals under Stress	3–3
	2·392	Dyn. Strength of Metals	Time arr.
	2·45	Eng. Thermodynamics, Adv.	3–9
	2·462	Heat Transmission, Adv.	3–9
	2·64	Refrigeration Eng.	3–6
	2·672	Heating & Vent. Design	4–4
	2·692	Refrig. & Air Cond. Lab.	4–6
	2·752	Machine Design, Adv.	8–2
	2·802	Auto. Eng. Prob., Adv.	Time arr.
	2·804	Automotive Eng.	Time arr.

Mechanical Engineering Continued

	2·906	Textile Tech. Anal.	3–5
	2·908	Textile Microscopy	5–2
	2·912	Textile Research Lab. Research	6–0
Summer	2·361	Adv. Strength of Materials	5–4

A number of Group A subjects listed in other Courses may be taken for credit in the field of Mechanical Engineering. Such, for example, as

First	1·59	Concrete Research	Time arr.
Term	13·73	Mechanical Vibration	3–6
	16·41	Instrumentation	3–9
	19·61	Physical Metallurgy, Adv.	Time arr.
	M36	Calculus, Adv.	3–6
Second	1·59	Concrete Research	Time arr.
Term	13·74	Mechanical Vibration	3–6
	16·46	Vibration Measurements	5–6
	19·62	Physical Metallurgy, Adv.	Time arr.
	M37	Calculus, Adv.	3–6

"B" Subjects. Open to Graduates and Undergraduates

First	2·082	Applied Mechanics	3–5
Term	2·10	Ordnance Engineering	3–3
	2·121	Applied Photoelasticity	3–2
	2·35	Engineering Materials	3–3
	2·43	Heat Engineering	3–5
	2·44	Thermodynamics of Mixtures	2–4
	2·51	Heat Measurements	3–3
	2·621	Refrigeration Engineering	3–3
	2·66	Heat., Vent. & Air Cond.	3–5
	2·681	Engineering Lab.	3–3
	2·682	Engineering Lab.	3–3
	2·732	Machine Design	5–3
	2·791	Automotive Engines	4–4
	2·793	Automotive Eng. Des.	4–0
	2·795	Automotive Vehicles	3–3
	2·797	Automotive Vehicle Des.	4–0
	2·871	Manufacturing Eng.	2–4
	2·872	Preparation for Manufac.	2–4
	2·901	Prin. of Fabric Structure	3–6
	2·903	Elem. of Textile Manufact.	3–6
Second	2·082	Applied Mechanics	3–5
Term	2·11	Industrial Plant Eng.	3–3
	2·121	Applied Photoelasticity	3–2
	2·33T	Engineering Metals	4–2
	2·332	Welding Eng., Adv.	4–2
	2·52	Heat Measurements	5–2
	2·56T	Power Plant Engineering	5–7
	2·58	Heat Eng. in Ind. Plants	3–5
	2·622	Refrigeration Eng.	3–5
	2·681	Engineering Lab.	3–3
	2·69	Refrig. & Air Cond. Lab.	6–6
	2·691	Refrigeration Lab.	2–2
	2·792	Automotive Engines	4–4
	2·794	Automotive Engine Des.	4–0
	2·796	Automotive Vehicles	3–3
	2·798	Automotive Vehicle Des.	4–0
	2·82	Diesel Engine Design	6–0
	2·83	Steam Turbine Eng.	4–2
	2·872	Preparation for Manufac.	2–4
	2·902	Prin. of Fabric Structure	3–6
	2·904	Prin. of Textile Manufac.	3–6

Automotive Engineering. Students desiring to specialize in Automotive Engineering for a year of graduate study, leading to the degree of Master of Science in Mechanical Engineering, should register for Subjects 2·801, 2·802, 2·803, 2·804, 2·131, 2·871, 2·872, 10·79, 19·68 and such other subjects as may be approved by the Department Committee on Graduate Students.

Heating and Ventilating Engineering. Students desiring to specialize in Heating and Ventilation and Air Conditioning for a year of graduate study leading to the degree of Master of Science in Mechanical Engineering, should register for Subjects 2·53, 2·671, 2·672, 2·692, 7·531 and such other subjects as may be approved by the Department Committee on Graduate Students.

Refrigeration Engineering. Students desiring to specialize in Refrigeration Engineering for a year of graduate study leading to the degree of Master of Science in Mechanical Engineering, should register for Subjects 2·461, 2·462, 2·63, 2·64, 2·692 and such other subjects as may be approved by the Department Committee on Graduate Students.

Textile Engineering. To meet the demand for opportunities to study advanced textile questions the Institute has fully equipped a Textile Laboratory where the physical study of textile fibers, yarns and fabrics is carried out in detail. Students desiring to specialize in Textile Engineering for a year of graduate study leading to the degree of Master of Science in Mechanical Engineering, should register for subjects 2·905, 2·906, 2·907, 2·908, 2·911 and 2·912, and such other subjects as may be approved by the Department Committee on Graduate Students.

Torpedo Engineering. A graduate course in Torpedo Engineering, leading to the degree of Master of Science in Mechanical Engineering, has been arranged for officers in the United States Navy. This course is open only to officers designated by the Navy Department.

Torpedo Engineering, United States Navy

First Year

First	2·151	Dynamics	2–4
Term	2·271	Hydromechanics	3–6
	2·59	Torpedoes	2–4
	2·761	Machine Design	6–2
	13·73	Mechanical Vibration	3–6
	19·59	Physical Metallurgy, Adv.	4–4
	19·67	Heat Treatment	3–2
			23–28
Second	2·152	Dynamics	2–4
Term	2·272	App. Hydromechanics	3–6
	2·45	Adv. Eng. Thermodynamics	3–9
	2·762	Machine Design	3–2
	10·50	Heat Transmission	2–4
	13·74	Mechanical Vibration	3–6
	19·60	Physical Metallurgy, Adv.	6–2
			22–33

Second Year

First Term		Research and Thesis	48
Second Term		Research and Thesis	48

Army Ordnance. A graduate course leading to the degree of Master of Science, especially arranged for officers in the United States Army. The course is open only to officers designated by the War Department.

Army Ordnance, United States Army

Summer	2·05	Applied Mechanics	4–6
Term	2·203	Theory of Elasticity	3–5
	5·04	Chemistry	4–5
	5·412	Organic Chemistry and Lab.	6–4
	M75	Mathematics	5–7
			22–27

Mechanical Engineering (Army Ordnance) Continued

First	2·71	Theory and Appl. of Mech.	6–8
Term	5·413	Organic Chem. and Lab.	6–0
	6·42	Electrical Eng., Elem.	5–5
	10·38	Explosives Plant Engineering	5–3
	19·15	Production Metallurgy	3–5
	19·57	Physical Metallurgy	4–6
			29–27
Second	6·88	Electrical Eng. Lab.	3–6
Term	10·39	Theory of Interior Ballistics	4–6
	19·58	Physical Metallurgy, Adv.	4–6
		Thesis	25
			54

MINING ENGINEERING AND PETROLEUM ENGINEERING

Graduates of other colleges taking subjects leading to the Master's degree in these fields must, in addition to the undergraduate requirements for the Master's degree, have taken other subjects in drawing, science and engineering equivalent in quantity and quality, broadly interpreted, to those in the curriculum of the option in which they desire to specialize. Deficiencies in these subjects may be made up in the summer or during the regular school year.

In order to register for "A" subjects in Mining Engineering or Petroleum Engineering, the candidate must have taken the undergraduate professional subjects set up as required preparation; without these or their equivalent, he will be required to take additional undergraduate work which will be credited as "B" subjects or not, according as the rules require.

Mining Engineering

Graduate instruction in mining engineering is dependent upon the subjects covered in the undergraduate courses of that name and students wishing to enter the graduate subjects should have had the equivalent of the undergraduate course. Instruction is offered in advanced mining engineering, mine valuation, mining economics, mining law, and in special branches of ore dressing. Such studies may lead to the degree of Master of Science or Doctor of Science.

Note.—In accordance with the changes noted on page 45, graduate degrees under the arrangements treated on this page will not be awarded after 1940. Students who wish after that time to pursue graduate work in the field of discovery, recovery, and processing of metals, petroleum or other mineral products should consider the graduate programs offered by the Departments of Metallurgy, Geology, and Chemical Engineering.

"A" Subjects. Primarily for Graduates

First	3·061	Mining Eng., Adv.	Time arr.
Term	3·101	Mine Valuation	3–8
	3·241	Ore Dressing, Adv.	Time arr.
	3·251	Th. & Prac. of Flotation	Time arr.
	3·26	Ore Dressing Econ.	Time arr.
	3·271	Ore Dressing Des.	Time arr.
		Research	
Second	3·062	Mining Eng., Adv.	Time arr.
Term	3·102	Mine Valuation	3–8
	3·12	Econ. of Mining, Adv.	Time arr.
	3·242	Ore Dressing, Adv.	Time arr.
	3·252	Th. & Prac. of Flotation	Time arr.
	3·26	Ore Dressing Econ.	Time arr.
	3·272	Ore Dressing Des.	Time arr.
		Research	

"B" Subjects. Open to Graduates and Undergraduates

First	3·03	Economics of Mining	2–4
Term	3·13T	Mining III	4–2
	19·09	Metallurgy	4–4
Second	3·04	Principles of Mining	2–4
Term	3·14	Mining IV	2–6
	3·21	Ore Dressing II	3–2
	3·22	Ore Dressing Lab	8–2

Petroleum Engineering

The petroleum engineer finds it necessary to be conversant not only with his own specialty but with other branches of science and engineering. If engaged in operating, he is faced almost daily with problems calling for a comprehensive knowledge of science, engineering, and sanitation and health.

Generally a student having completed the regular course of four years finds it advantageous to begin practice in the oil fields. After such experience in practical work the graduate may desire to enter upon postgraduate studies which may lead to the degree of Master of Science or Doctor of Science.

"A" Subjects. Primarily for Graduates

First	3·901	Oil & Gas Land Val.	3–8
Term	3·911	Petroleum Eng., Adv.	Time arr.
	3·921	Oil & Gas Law	2–4
		Research	
Second	3·12	Econ. of Mining, Adv.	Time arr.
Term	3·902	Oil & Gas Land Val.	3–8
	3·912	Petroleum Eng., Adv.	Time arr.
	3·922	Oil & Gas Law	2–4
		Research	

The following "A" subjects offered in other departments are related to Petroleum Production and may be included as a part of a program of study leading toward the Master's degree in this field.

First	10·68	Corrosion	2–4
Term	12·52	Paleontology, Adv.	4–3
	12·54	Micropaleontology	4–2
	Ec37T	Statis. Meth. for Quality Control	3–6
Second	12·52	Paleontology, Adv.	4–3
Term	12·53	Index Fossils	6–2
	12·582	Sedimentation	5–2
	12·81	Geology of Petroleum, Adv.	3–6

"B" Subjects. Open to Graduates and Undergraduates

First	3·03	Economics of Mining	2–4
Term	3·13T	Mining III	4–2
	3·85T	Petroleum III	3–5
	19·63	Cor. & Heat Resisting Alloys	2–4
Second	3·04	Principles of Mining	2–4
Term	3·86T	Petroleum IV	3–4

CHEMISTRY

The recent rise of chemistry in the United States has made it almost necessary for one who looks forward to a life work in the study or application of the science to give more than four years to preparation. For those whose time is limited, a program of work has been arranged which leads to the degree of Master of Science. The requirements are designed to make it possible for the candidate to specialize in any field of particular interest. The program of studies may be chosen with the approval of the Department of Chemistry from the list of senior and graduate studies offered in the Department. About one-third of a year is devoted to research for the S.M. degree. The degree of Doctor of Philosophy, on the other hand, is awarded to the candidate who has a broad scientific education in the fundamental branches of chemistry, and who has given evidence of the ability to carry on independent research by presenting a thesis which is a definite contribution to scientific knowledge.

Special Requirements for the Degree of Master of Science with Specification of Field

In addition to the general requirements for graduate work, candidates must present equivalents for the following subjects in Course V.

5·10	Qualitative Analysis
5·12	Quantitative Analysis
5·13	Quantitative Analysis
5·41	Organic Chemistry I
5·42	Organic Chemistry I
5·414	Organic Chemistry Laboratory
5·424	Organic Chemistry Laboratory
5·61	Physical Chemistry I
5·62	Physical Chemistry II
L11, L12	Elementary German
L51, L52	Elementary French

(Differential Equations M22 is not required of students specializing in Inorganic or Organic Chemistry.)

Special Requirements for the Degree of Doctor of Philosophy

Candidates must pass written examinations in French and German, complete a minor equivalent to at least 25 units, to be taken outside the Department of Chemistry, and complete with creditable records certain subjects as specified by the Committee on Graduate Students of the Department of Chemistry. A special folder giving in detail requirements for the advanced degree in Physical Chemistry, Organic Chemistry, or Inorganic Chemistry is available on application to the Chairman of the Graduate Committee of the Department. The examination in the branch of Chemistry in which the candidate is carrying out his research is both written and oral, and must be taken in October of the last academic year of residence in order that the final year may be devoted to research. The final examination on the research is oral and is devoted to the investigation and that part of the science which is closely related to the candidate's experimental work. Research, under direction, may be carried out in the summer months without tuition charge. A registration fee of five dollars is required.

Teaching Fellows

The Department appoints a limited number of Teaching Fellows who are candidates for the degree of Doctor of Philosophy in Chemistry. Teaching Fellows serve in the laboratories of the Department, or in such other capacity as may be advisable, on a part time regular schedule throughout the scholastic year. The appointment is subject to renewal for one year. It is recommended that the candidate finance the last year of graduate work from personal sources, from a graduate scholarship, or from a loan under the Technology Loan fund so that his entire time may be devoted to research and the completion of his graduate study.

The Research Laboratory of Physical Chemistry

A considerable portion of the more recent advance in science has been in fields lying between the divisions of science as they were originally established. One of the most important of these developments is physical chemistry, which has come into existence as a result of investigations lying between the previously loosely defined borders of the sciences of physics and chemistry.

There is a demand for men of mature scientific education to serve as investigators and to direct investigational work in industry, in endowed research institutions, in government bureaus and in academic institutions. The numerous industries in particular have nearly all come to realize the desirability and even neccessity of supporting fundamental scientific investigations relative to their processes as a basis for future development. In consequence of the benefits already derived from systematic investigation, many industrial research laboratories have been and are being organized. It is universally agreed that graduate work is an essential preparation for positions in connection with these divisions. Since the work involved is of a widely varying nature, a student considering the possibilities in this field of activity should endeavor to pursue an educational course which will give him a broad lasting foundation and a wide scientific perspective. In respect to the latter, physical chemistry with its outlook on two or more fundamental sciences is particularly useful.

Equipment. The work in progress in the Laboratory of Physical Chemistry can be roughly divided

Chemistry Continued

into five parts, including investigations (a) on the physical properties of pure substances and mixtures of pure substances under wide variations of temperature and pressure for the purpose of broadening the present thermodynamic interpretation of chemical reactions, (b) on chemical equilibria under extremes of pressure and temperature to obtain special data for extending the theoretical treatment of equilibria, and on heats of reaction in solution, (c) on liquid solutions and liquid mixtures, (d) on the absorption of radiation by gases and the chemical reactivity induced as related to atomic structure, and (e) cryogenic research at liquid hydrogen and liquid helium temperatures.

Researches in Progress. A comprehensive study of the pressure-volume-temperature relations of substances, involving wide temperature and pressure ranges, is being carried out for both gaseous and liquid systems. The investigations are being conducted in the light of modern concepts regarding the kinetic theory and the electronic structure of atoms and molecules. Connected with these studies are investigations concerning the absolute temperature scale. Measurements are also being carried out on other thermodynamic properties of substances, such as latent and specific heats at low temperatures.

Researches on the properties of liquid solutions which have been carried on since the founding of the laboratory, consist, at present, of investigations of the electromotive force of concentration cells, the potentials at the junctions of salt solutions, the freezing points of aqueous solutions and the vapor pressures of solutions. Extensive new equipment has been added in recent years which is being used to secure very precise data for use in consolidating and extending the theory of solutions.

The structure of compounds and their reactivity are studied with the aid of spectroscopic and photochemical data. New primary and secondary standards of high sensitivity and reproducibility for measurement of radiation are being developed.

Using a new method, a systematic program is in progress having for its object the highly precise direct experimental determination of the effects of molecular forces for pure substances and mixtures from the lowest temperatures to four hundred degrees. The data is of immediate use for the correlation of physico-chemical equilibrium data but the more fundamental objective will be the development of the means of transforming the experimental data into intermolecular potential-distance relationships.

Ample facilities for measurements to 2° K are now available and the design of a high field magnet, 120 kilogauss, is in progress whereby electro-magnetic research may be carried on and sub-helium temperatures realized. At the moment calorimetric measurements on salts are in progress and also determinations of various physical properties. Cryogenic research is being extended as rapidly as facilities can be acquired.

The Doctor's Degree with Major in Physical Chemistry

Candidates for the Doctor's Degree with Major in Physical Chemistry will take courses 5·76, 5·77, 5·79, 5·741, 5·742, 5·931, and 5·932, and will take their Minor in Mathematics or in Physics. A suggested arrangement of these courses is shown below.

In addition to the subjects here scheduled, as much as possible of the required 25 units of minor and the written examinations in modern languages, should be passed during the first year. The minor may be completed and optional subjects taken during the second year.

First Year

5·76	Thermodyn. and Chemistry	3–6
5·77	Thermodyn. and Chemistry	2–4
5·79	Theory of Solutions	2–4
5·98	Research	

Second Year

5·741	Adv. Radiation Chemistry	2–4
5·742	Statistical Mechanics	2–4
5·98	Research	

Third Year

5·98	Research	

Attendance at subjects 5·931 Journal Meeting in Physical Chemistry, 1–1, and 5·943 Research Conference in Physical Chemistry, 1–1, is required in the first term of each year.

Attendance at subjects 5·932 Journal Meeting in Physical Chemistry, 1–1, and 5·944 Research Conference in Physical Chemistry, 1–1, is required in the second term of each year.

Students whose preparation in physical chemistry is not equivalent to courses 5·61, 5·62, 5·63 will take 5·71, 5·72 and postpone 5·76, 5·77, and 5·79 until the second year.

The Research Laboratory of Organic Chemistry

A number of rooms are specially equipped for work in organic chemistry. The laboratories are open at all times. The division is well supplied with vacuum pumps, thermostats, electrical measuring instruments, mercury arcs, electrically heated closets and combustion furnaces, autoclaves, standardized thermometers, etc. A large variety of organic chemicals is available.

The offering of a number of advanced courses in organic chemistry makes it possible for the student to devote attention to those branches of the subject in which he is particularly interested.

Researches in Progress. Investigations in Organic Chemistry are directed by members of the instructing corps whose special interests lie in widely different fields. The chief investigations now in progress are as follows:

A comprehensive study is being made of the factors

Chemistry Continued

influencing the reactivity of atoms and groups in organic compounds. The problem is being investigated from the point of view of physical chemistry.

The carbohydrates are being studied with particular emphasis on methods of preparing rare and little-known members of the group, both from natural sources and by synthetic methods, with the purpose of making these substances available for biological study. Derivatives are being prepared, whose properties throw light upon the relations between various isomeric forms of carbohydrates and their mode of reaction, fundamental reaction mechanisms are being investigated, and relationships sought between configuration and physical properties.

A study of the chemistry of cellulose and related substances has also been begun. This work is mainly concerned with the preparation and properties of various partly substituted derivatives and with attempts to determine the exact orientation of such substituents in the carbohydrate chain.

The chemistry of both the naturally occurring and the synthetically produced vitamins and hormones is being actively investigated, and as the result of these investigations vitamins A and D have been isolated from natural sources in substantially pure form. Many useful derivatives of these vitamins have already been produced and accurate physico-chemical methods developed for their quantitative estimation. Important advances towards their syntheses have also been made.

The occurrence and formation of organo-sodium compounds in the Wurtz-Fittig synthesis as well as in other reactions are being carefully examined. Valuable information has already been gained which has led to methods for interrupting the reactions at intermediate points. Application is being made to new methods of synthesis for malonic acids, tertiary carbinols and other compounds.

The correlation of the properties and reactions of organic compounds in the form of an analytical procedure has been studied for many years. The results already published have proved invaluable to chemists concerned with the identification of organic substances. This work is being actively continued for the purpose of further developing the system and keeping it abreast of the rapid advances in synthetic and analytical chemistry. Particular attention is now being given to the systematic separation and identification of the components of mixtures.

Urea, thiourea and guanidine and their derivatives are being actively investigated with the result that considerable new information has been gained about the reactions of the simpler organic compounds of nitrogen such as cyanic acid and cyanamide. It has been shown that many reactions consist in the direct combination and subsequent breaking apart of molecules, and physico-chemical methods are showing the factors which determine the ease and extent of such reactions. An understanding of the mechanism in these cases has made possible a number of new syntheses. Other researches are devoted to the factors which determine the possibility of tautomerism and to the effect of groups on the reactivity of quinones and to the effect of polarized light in the synthesis and in the decomposition of asymmetric molecules.

The following subjects, in addition to those noted above, are being investigated.

Oxidation of meta-diphenols.
Complex metal-pyridine compounds.
Physical and chemical properties of triarylmethyls.
Action of ultra-violet radiation on organic reactions.
Diphenic acid and its derivatives.
Catalysis in homogeneous systems.
Auto-oxidation reactions in organic chemistry.
Mechanism of the Friedel-Crafts reaction.
Fluorenone and its derivatives.
Chemiluminescence.
Structure of the guanidonium ion.
Cycloparaffins.
Analogues of carbonyls.
Cancer producing hydrocarbons.
Organic peroxides.
Effect of electric discharges on organic compounds.
Preparation and derivatives of tetroses.
Synthesis of lactoflavin analogues.
Action of triphenylchloromethane on carbohydrates.
Oxidation of carbohydrate derivatives with lead tetraacetate.
Reaction between porphyrin pigments and substances of protein nature.
Hydroxylation of unsaturated substances.
Catalytic oxidation of lignin.

The Research Laboratory of Inorganic Chemistry

(Including Analytical Chemistry)

Although inorganic chemistry was the first of the various branches of the science to attain a high degree of development with an attendant wealth of experimental detail, it is nevertheless true that this field is very far from exhausted; a practically unlimited opportunity for further investigation remains, not only in the chemistry of the less common and the rare elements, but also in the elaboration of the chemistry of the commoner elements. Furthermore, much of the data accumulated in the past century is in need of revision; for example, in much of the earlier work, the necessity for the rigid exclusion of air and of moisture was often overlooked in the study of various reactions, resulting in erroneous conclusions concerning their nature. The availability of modern research tools and the application of precision methods to numerous problems hitherto studied only in a superficial manner, are constantly exposing serious inaccuracies both in the observation and the interpretation of various inorganic phenomena.

The desirability of devising new methods of analy-

Chemistry Continued

sis, as well as of improving existing methods, has given rise to a number of analytical investigations, among which may be mentioned the determination of zirconium in ores and steels, the determination of small quantities of selenium in sulfur and in alloy steels, electrometric methods of analysis, and methods of analysis and purification of gas mixtures.

Some of the other subjects which have been investigated recently in the laboratory are as follows:

Artificial radioactivity and the isolation of elements heavier than uranium.

Preparation and properties of various halides of silicon and silico-organic compounds.

Reactions of anhydrous halides in liquid ammonia and the formation of lower valence compounds.

Preparation and properties of the hydrides of boron.

Preparation of metal carbonyls and nitrosyl-carbonyls at ordinary temperature and atmospheric pressure.

Chemical reactions induced by the electrodeless discharge in gases; the dissociation of ammonia and of carbon dioxide.

Influence of sonic and supersonic vibrations upon chemical reactions.

Preparation of rare earth metals and pure compounds.

Organo-metallic compounds of indium.

Elaboration of the chemistry of rhenium and of hafnium.

Equilibrium of the reaction between ferric ion and silver.

The Laboratory is equipped to carry on a wide variety of inorganic research, including high vacuum technique, operations at high temperatures and at low temperatures, and electrolytic oxidations and reductions. Apparatus for precise determination of melting points at low temperatures is available as an aid in the determination of the purity of volatile substances.

Research in nuclear chemistry is facilitated by the possession of a powerful source of neutrons and the availability of alpha and beta counters. In these studies the Laboratory has coöperated with the research laboratories of the Department of Physics.

GRADUATE SUBJECTS IN CHEMISTRY

"A" Subjects. Primarily for Graduates

First	‡5·071	Seminar Inorg. Chemistry	2–3
Term	5·08	Inorganic Lab., Adv.	6–0
	5·18	Qualitative Anal., Adv.	9–1
	5·51	Organic Chemistry II	2–3
	5·53	Organic Chemistry III	2–4
	5·55	Ident. Org. Compounds	10–0
	5·562	Carbohydrates	2–4
	*5·574	Free Rad. & Org. Met. Comp.	2–2
	*5·58	Chemistry of Natural Products	3–3
	5·581	Organic Lab., Adv.	6–1
	‡5·583	Organic Physical Chem.	2–2
	‡5·584	Mol. St. of Carbon Comp.	2–4
	‡5·585	Th. & App. of Catalysis	2–2
	5·71	Physical Chemistry	3–5
	5·741	Adv. Radiation Chem.	2–4
	5·76	Thermodyn. & Chemistry	3–6
	5·911	Jour. Meet. Inorg. Chem.	1–1
	5·98	Research	Time arr.
Second	‡5·072	Seminar Inorg. Chemistry	2–3
Term	5·08	Inorganic Lab., Adv.	6–0
	5·52	Organic Chemistry II	2–3
	5·54	Organic Chemistry III	2–4
	‡5·56	Chem. Heterocyclic Comp.	2–2
	5·563	Cellulose & Polysaccharides	2–4
	*5·57	Chemistry of Dyes	2–4
	5·582	Organic Lab., Adv.	5–1
	5·72	Physical Chemistry	3–5
	5·742	Statistical Mechanics	2–4
	5·77	Thermodyn. & Chemistry	2–4
	5·79	Theory of Solutions	2–4
	5·912	Jour. Meet. Inorg. Chem.	1–1
	5·98	Research	Time arr.

No grades are given in the following subjects: 5·591, 5·592, 5·921, 5·922, 5·931, 5·932, 5·941, 5·942, 5·943, 5·944. Units are not accepted as requirements for the Master's degree.

"B" Subjects. Open to Graduates and Undergraduates

First	5·061	Inorganic Chemistry	2–3
Term	5·26	Food Analysis	5–0
	5·63	Int. to Thermodynamics	3–5
	5·842	Optical Methods	2–1
Second	5·062	Inorganic Chemistry	2–3
Term	5·26	Food Analysis	5–0
	5·43	Powder, Explosives & War Agents	2–2
	5·64	Int. to Radiation Chem.	2–3
	5·66	Surface & Colloid Chem.	2–3
	5·83	History of Chemistry	2–2
	5·842	Optical Methods	2–1

* Offered in alternate years. 1938–39.
‡ Offered in alternate years. Not 1938–39.

ELECTRICAL ENGINEERING

The Department of Electrical Engineering offers advanced work leading to the degrees of Doctor of Science and Master of Science. The general rules governing the granting of these degrees are set forth on pages 83–86, while such special rules as apply to the Department of Electrical Engineering are given below.

It is expected that only properly qualified students of more than average capacity will enter upon courses of advanced study. In order to be accepted for graduate study in the Department of Electrical Engineering an applicant must have completed the fundamental requirements common to all courses, and in addition must have covered the substantial equivalent of the undergraduate professional subjects in Electrical Engineering as offered in Course VI, in the Illuminating Engineering Option, VI-B or the Communications Option, VI-C.

It is expected that the student entering upon graduate work in Electrical Engineering will have completed professional subjects in engineering other than Electrical Engineering to an extent substantially equivalent in total amount to that contemplated in the undergraduate curriculum of any of the options of Course VI. It is also expected that he will have completed non-technical subjects to a similar extent, and that he will have a knowledge of general economics substantially equivalent to that gained by a year's study of this subject at the ordinary rate. In case a student registers for graduate work while deficient in any one of these respects, the Department Committee on Graduate Study will ordinarily insist that he remove such deficiencies by special study while in residence.

It is expected that the candidate for the Master's degree in Electrical Engineering will, at the time that he is recommended for the degree, be able to read either technical German or technical French to an extent sufficient to enable him to consult freely, along the lines of his graduate work, the literature in the language concerned. An entering student who offers the equivalent of elementary and intermediate German or French will be considered to have satisfied this requirement, but in cases of doubt the Department will test proficiency in modern language by special examination. Proficiency in this regard may often be obtained while in residence, by special study and reading.

It is expected that candidates for the Doctor's degree in Electrical Engineering will have a good reading knowledge of *both* technical German and technical French. General language requirements for the doctorate are given on page 85.

The Department is especially insistent that a student's preparation in mathematics and physics be excellent. He should have fully covered the equivalent of first-year and second-year mathematics and physics as given in Course VI. In addition he should offer further work in mathematics substantially equivalent to that covered in the subject M31. In the absence of such special preparation, he will be expected to remove this deficiency while in residence.

Entering students who are deficient in preparation, especially in mathematical and professional electrical-engineering subjects, are urged to make up this deficiency before entrance by attendance at summer session. Furthermore, graduate study in certain subjects, and also graduate research, may be carried on during the summer. The Summer Session issue of the general catalogue should be consulted on these matters.

Students working for the Master's degree are expected to devote themselves to a few subjects, not more than three, in addition to their seminar and research. The subjects of study are wholly elective, with the exception of Electrical Engineering Seminar, as stated below, 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.

Simultaneously with the lecture subjects the student carries on research work, thus beginning his training as an independent investigator. He selects his own research subject, which should be one in which he is vitally interested. After suitable preliminary study he must submit an outline of the proposed investigation to the Department Committee on Graduate Study. This outline is critically examined with regard to the scientific and educational value of the subject and the possibility of accomplishing the investigation in a reasonable time and with the facilities available. This outline must be approved before further independent work is commenced.

In thesis work graduate students are expected in the main to rely on their own resourcefulness, the professor in charge of the particular research exercising only a general supervision. It is usual for the student to construct any special apparatus needed for his research, but, in cases where it is likely to form a permanent addition to the laboratory equipment, he may be assisted by a laboratory mechanician. A student shop is available to those who are required to construct apparatus.

All graduate students in the Department who have not had equivalent experience in the preparation and oral presentation of technical papers are required to register for Seminar 6·501, 6·502. In the seminar meetings, papers on the historical aspects of electrical engineering are presented and discussed. Entering

Electrical Engineering Continued

students should select seminar subjects early. Regulations concerning the seminar are available in the Department, and should be followed in making selections. The seminar and thesis subjects of a student should be so related that the former lays the foundation for the latter.

The entire work of each student is carefully scrutinized to determine whether he is obtaining in full measure the advantages which should be derived from advanced study and research, and he is advised accordingly. Students should realize that the fulfillment in a merely routine manner of the requirements for the degree as stated in this catalogue is not considered by the department as a satisfactory realization of the advantages which should accrue from advanced study.

Students working for advanced degrees in electrical engineering are encouraged to acquire additional training in mathematics and physics. Those proceeding toward the doctorate may well elect one of these fields as a minor. The advanced mathematics subjects are listed on page 115, those in physics on page 106 of this catalogue. The Chairman of the Departmental Committee on Graduate Study should be consulted by the student when planning his work.

Facilities for Research

The Graduate Laboratory of Electrical Engineering was established in 1913 as an educational agency to stimulate the students and the staff by bringing them into contact with problems on the front line of their profession and to train the students in methods of research. Most of the graduate students and a number of undergraduates utilize the facilities of this laboratory. The direction of the research work is not confined to any particular group of professors, as many members of the instructing staff aid in the work and are actively interested in the laboratory as a whole and particularly in those researches which lie within their own special fields of endeavor. The laboratory equipment is of a comprehensive nature, permitting all of the ordinary, and many unusual, electrical measurements to be made with facility.

Though the Graduate Laboratory was established as a purely educational agency, noteworthy contributions to knowledge have been made and to date one hundred thirty-three bulletins describing the researches have been published.

Each year there are usually a limited number of appointments as research assistants which are available for persons especially qualified by training and natural endowment for the work of investigation. These assistants may study toward an advanced degree, and may utilize appropriate portions of the work covered by their research as a part of their thesis.

The problems assigned to research assistants and also those elected by the students working for the doctorate are such as require for their solution a high degree of scientific skill and long-continued investigation. Frequently these problems are suggested by engineers in practice, thus bringing the department into additional touch with the advanced problems of the profession.

An idea of the scope of the research work carried on under the general supervision of the Department may be gained by reference to the research bulletins previously mentioned. The following paragraphs describe a few of the major research problems which have received and are receiving the attention of the laboratory and which in general have resulted in the design and construction of permanent laboratory equipment of great utility.

As a result of much study given to the problem of constructing artificial transmission lines and cables with distributed constants, a method of design has been developed and several lines constructed, single-phase as well as three-phase. These lines are used for studies of direct- and alternating-current transients, and now comprise part of the equipment of a special laboratory used for both research and instruction purposes.

Extensive investigations were made to demonstrate the feasibility of representing entire power systems artificially. This has resulted in the construction of the M. I. T. Network Analyzer adequate for the single-phase representation on a 60-cycle, 200-volt, 1.0 ampere basis of systems embodying as many as sixteen generating stations with their loads and interconnecting circuits. The network analyzer, with its fast and accurate measuring equipment, provides an exceptional facility for the rapid study of steady-state problems such as voltage regulation, power interchange, power-factor regulation, and system expansion and interconnection, and the transient problems of symmetrical and unsymmetrical short circuits with the accompanying questions of system stability. In addition to its use in research and in connection with class instruction, the network analyzer is available for the solution of commercial power-system problems. The network analyzer was built with the coöperation of the General Electric Company.

The transients, both electrical and mechanical, occurring in electrical machines as a result of short circuit, of sudden terminal voltage changes, or of sudden or periodic load changes, have been analyzed mathematically and the results checked experimentally. To facilitate such studies a special machine-transients laboratory has been established, equipped with motor-generator sets and necessary accessories such as static condensers, reactors, circuit breakers and instruments, including a nine-element oscillograph. In the alternating-current machines,

Electrical Engineering Continued

provision is made for the use of solid cylindrical, squirrel-cage, slip-ring induction, and salient-pole rotors.

An important outgrowth of the machine-transients laboratory is the development of stroboscopes of high light intensity by means of which the behavior of rapidly moving bodies can be observed and photographed. The Department has a diversified collection of high-speed motion-picture machines which are available for use in various investigations. Cameras are available for taking motion pictures up to 6,000 per second with exposures of less than 1/100,000th of a second. These cameras make use of accurately controlled intense sources of stroboscopic light.

An important problem, various phases of which have occupied the attention of the laboratory for a number of years, is the study of the fundamental properties of insulation. This research program is at present primarily directed toward a comprehensive study of the fundamental electrical properties of solid, liquid and gaseous dielectrics.

The increasing interest in electronics led to the establishment of an engineering electronics laboratory for the construction and study of various types of vacuum or gas-filled electronic devices. Facilities are provided for spot welding of electrodes, fabrication of glassware, and sealing and exhausting of tubes.

Mechanical and electrical methods for the solution of differential and integral equations are actively investigated in the laboratory. The complexity of many problems of engineering and physics is such that satisfactory progress in their solution is often dependent upon graphical methods. The Differential Analyzer, which originally was developed here, is designed to perform mechanically the necessary operations required in the solution of differential equations. The coefficients of the equation may be constant or variable, and may be functions of any of the variables. By means of this machine and the product integraph which preceded it, the analysis of numerous problems has been successfully accomplished. These problems include the determination of the transient behavior of transmission lines, power systems, and electrical machinery, the operating characteristics of non-linear circuits, the design of structures, and investigations of certain field distributions in acoustics, and functions of wave mechanics. Much of the mathematical theory of cosmic radiation has been investigated by solving the basic differential equations on this machine. Another machine, called the cinema integraph, utilizing light radiation in its operation, is available for the purpose of solving an integral equation of the type involving the product of two functions with a variable parameter under the integral sign.

The increasing need and interest in higher voltages for power engineering led to the development of a departmental high-voltage research program and a high-voltage research laboratory for experimental investigations employing direct-current voltages up to 750,000. This research program includes the investigation of vacuum and compressed-gas high-voltage insulation and the development of power-engineering and medical applications of electrostatic high-voltage sources. Research in the field of vacuum and compressed-gas insulation and on direct-current corona, material-insulation breakdown, spark discharges in air, the production of high voltages and of high-energy radiation, and on other allied problems can be conducted in this laboratory.

The Vail Library

The need for a special library of electrical literature, which is a necessary adjunct to all research, is satisfied by the Vail Library. The original Vail Collection, comprising 30,000 volumes, was presented to the Department in 1912 through the interest of the late Theodore N. Vail, and is one of the three great electrical libraries in the world. Merged with the other works on electrical subjects in the Central Library, but distinguished by a special binding stamp and a special bookplate, the Vail Collection is the basis upon which the Vail Library as an administrative unit has been developed. The Vail Library now comprises over 40,000 volumes. In the library are the works of all scientists and engineers who have made significant contributions to electrical science from the time of William Gilbert (1600) to the present. Among the rarities are the 1558 edition of Peregrinus, a large number of first editions including Gilbert's *De Magnete*, and a notable autographed collection of original papers.

Modern authorities are even more fully represented. The leading electrical periodicals, in foreign languages as well as English, are kept on file, together with the publications of the principal electrical societies of all countries. These are for the most part in complete sets, and are supplemented by the standard periodical indexes. A selection of books for reference is available in the main reading room, and all graduate students have access to the stacks.

In order that the resources of the Vail Library may be understood and fully utilized, a reference librarian is provided for exclusive service to the Department. This librarian gives instruction in the use of the library by group talks and individually, and offers assistance in the gathering of references and the preparation of bibliographies. The library is kept up to date by the addition of all important publications in the field, and books not in the Institute Library are obtained through the Interlibrary Loan Service.

Colloquia and Special Lectures

Through the courtesy and coöperation of the industries associated with the electrical-engineering field, the Department has been able to arrange a series of colloquia conducted by men of distinguished accomplishment in the practice of electrical engineering. The purpose of the colloquia is to secure the injection into the curriculum of matters showing the relation of science to engineering practice, the Institute instruction itself being concerned chiefly with basic scientific considerations. The colloquia also give graduate and senior students the opportunity to meet prominent engineers and to discuss with each of them that branch of the electrical art in which he is a particular authority.

The Department provides a number of such colloquia each year, treating the economic as well as the technical aspects of such subjects as communications, the design and production of electrical machinery, the design, construction and operation of power-transmission lines, the operation of plant such as public-utility plant or manufacturing plant, electrical measurements, illumination, electronics, and railroad electrification as it affects the electrical engineer.

The colloquia of 1937–38 are listed below:

"Interesting Features Found in Electrical Indicating Instruments," by Mr. H. L. Olesen and Mr. J. H. Miller of the Weston Electrical Instrument Corporation.

"Short-Circuit Protection of Distribution Networks by the Use of Limiters," by Mr. C. P. Xenis and Mr. W. Perine of the Consolidated Edison Company of New York.

"Electrical Methods for the Measurement and Control of Temperature," by Dr. P. H. Dike and Mr. J. C. Peters, Jr., of the Leeds and Northrup Company.

"Short-Wave Reception and Steerable Antennas," by Mr. H. T. Friis of the Bell Telephone Laboratories, Inc.

"Electric Elevators," by Mr. E. M. Bouton and Mr. E. B. Dawson of the Westinghouse Electric Elevator Company.

"Interior Illumination with Special Reference to the Architectural Characteristics," by Mr. A. L. Powell of the General Electric Company.

"Ultra High-Frequency Measurements," by Dr. L. S. Nergaard of the R.C.A. Radiotron Division of the R.C.A. Manufacturing Company, Inc.

"Electrical Measurements," by Mr. Everett S. Lee, Mr. Frank C. Bobier, Mr. J. H. Goss, and Mr. R. Cutts, Jr., of the General Electric Company.

GRADUATE SUBJECTS IN ELECTRICAL ENGINEERING

"A" Subjects. Primarily for Graduates

First Term	6·501	Elec. Eng. Seminar	2–10
	6·511	Electric Power Circuits	3–7
	6·513	Power System Stability	4–6
	6·515	Power Systems Laboratory	Time arr.
	6·521	Alt. Cur. Machinery Adv.	5–5
	6·531	Power System Economics	3–7
	6·541	Electric Power Generation	3–6
	6·551	Railroad Elec. Traction	3–6
	6·561	Adv. Network Theory	5–5
	6·571	Illuminating Eng., Prin.	5–4
	6·58	Transients in Linear Systems	3–7
	6·59	Communications Lab.	Time arr.
	6·60	Math. Anal. by Mech. Meth.	2–4
	6·61	Super. High-Volt Eng.	3–6
	6·631	Engineering Electronics	3–7
	6·651	Electric Power Dist.	3–6
	6·661	Electric Machine Dev. Prin.	4–6
	6·671	Vibrations	4–6
	6·68	Sp. Problems in Electrical Eng.	Time arr.
	6·73	Elec. Meas. Lab., Adv.	Time arr.
	6·74	Elec. Eng. Lab., Adv.	Time arr.
		Research	
Second Term	6·502	Elec. Eng. Seminar	2–2
	6·512	Electric Power Circuits	3–7
	6·514	Power System Stability	4–6
	6·515	Power Systems Laboratory	Time arr.
	6·522	Alt. Cur. Machinery Adv.	5–5
	6·532	Power System Economics	3–7
	6·542	Electric Power Generation	3–6
	6·552	Railroad Elec. Traction	3–6
	6·562	Adv. Network Theory	3–7
	6·572	Illuminating Eng., Prin.	5–4
	6·58	*Transients in Linear Systems	3–7
	6·59	Communications Lab.	Time arr.
	6·62	Elec. Com. Prin.	5–5
	6·632	Engineering Electronics	5–5
	6·64	Electric Insulation	3–6
	6·652	Elec. Power Distribution	3–6
	6·662	Elec. Machine Dev. Prin.	4–6
	6·672	Vibrations	4–6
	6·68	Sp. Problems in Electrical Eng.	Time arr.
	6·69	Sound in Elec. Com.	5–5
	6·73	Elec. Meas. Lab., Adv.	Time arr.
	6·74	Elec. Eng. Lab., Adv.	Time arr.
		Research	

"B" Subjects. Open to Graduates and Undergraduates

First Term	6·211	App. of Elec. in Industry	3–6
	6·221	Electric Power Generation	3–6
	6·241	Electric Railways	3–6
	6·251	Elec. Mach. Design	3–6
	6·26	Electric Insulation	3–6
	6·271	Illuminating Eng., Prin.	5–4
	6·281	Prin. Wire Com.	3–6
	‡6·31	Electrical Com., Prin.	3–5
	6·34	Electrical Com. Lab.	Time arr.
	6·80	Electrical Eng. Lab.	Time arr.
Second Term	†6·04	Electrical Eng. Prin.	6–9
	6·212	App. of Elec. in Industry	3–6
	6·222	Electric Power Generation	3–6
	6·242	Electric Railways	3–6
	6·252	Elec. Mach. Design	3–6
	6·272	Illuminating Eng., Prin.	5–4
	6·282	Prin. Radio Com.	3–6
	‡6·32	Electrical Com., Prin.	3–5
	6·32T	Electrical Com., Prin.	4–8
	6·34	Electrical Com. Lab.	Time arr.
	6·80	Electrical Eng. Lab.	Time arr.

* Usually repeated in second term.
‡ Only for students specializing in Power.
† Only for students specializing in Communications.

BIOLOGY AND PUBLIC HEALTH

Graduate work in this Department may be selected in one of the fields listed below:

Fields of Study

Bacteriology
Basic Biological Science
Biochemistry
Biophysics
Food Technology
Health Education
Industrial Biology
Industrial Hygiene
Microbiology
Public Health Admin. and Practice
Public Health Engineering
Sanitary Biology

Degrees Awarded

Master of Science
Doctor of Science
Doctor of Philosophy
Doctor of Public Health
A Certificate in Public Health is also awarded.

Requirements for the Certificate in Public Health. A candidate for the Certificate in Public Health must hold (1) a bachelor's degree from a recognized institution or, (2) a medical degree from a Class A medical school or (3) have had professional training equivalent thereto. He must have stood in the upper two-thirds of his class at the time of receiving his medical or bachelor's degree, or have demonstrated by professional work the probability that he can profitably undertake advanced academic study. In any case the student must maintain the cumulative rating required of all students in the graduate school if he is to be continued as a candidate for the certificate. In addition, students who have not passed courses of satisfactory grade in anatomy and physiology or other prerequisite subjects will be required to take these subjects before receiving the Certificate.

The work scheduled for the Certificate in Public Health requires: (1) At least one full academic year in residence with the satisfactory completion of 96 units of "A" or "B" subjects, including thesis, of which the following are minimum essentials:

		Units
7·22	Personal Hygiene and Nutrition	4
7·302	Bacteriology	9
7·50	Communicable Diseases	6
7·541	Public Health Administration	5
7·542	Public Health Administration	5
7·551	Public Health Lab. Methods	11
7·552	Immunological Methods	7
7·57	Municipal Sanitation	7
7·58	Vital Statistics	5

(2) The completion of an approved survey, or a research on some phase of public health, of at least 10 units. (3) The creditable passing of an examination covering the general field. (4) At least one month of field work which has the approval of the registration officer.

Students taking the Certificate in Public Health in the field of Health Education may substitute for laboratory work in the field of sanitary and diagnostic bacteriology an equal number of units in the field of health education and school health. Courses in the Harvard Graduate School of Education and in the School of Education of Boston University are available as electives.

The Massachusetts Institute of Technology subjects available as electives include:

"A" subjects. Epidemiology, Advanced Bacteriology, Health Hazards in Special Industries, Advanced Parasitology, Pathology, Public Health Problems, Public Health Field Work, School Health Administration.

"B" subjects. Biochemistry, Food Chemistry, Industrial Hygiene, Theoretical Biology, Parasitology.

For other available electives refer to the Departments of Biology, Chemistry and Physics.

Graduates of Class A medical schools and graduates of the Public Health option of the Department may reasonably expect to secure the Certificate in one year.

Requirements for the Degrees of Doctor of Science or Doctor of Philosophy in Biology, or in Biology and Public Health. The general examinations are held in four divisions, covering approximately fifteen subjects, three divisions being common to all programs, and the fourth varying according to the field of specialization.

Requirements for the Degree of Doctor of Public Health. For this degree the requirements are of the same standard as for the degree of Doctor of Philosophy or Doctor of Science, and will in general presuppose a period of three years of graduate work for those entering upon this course of study directly from college work. To students who have received a Bachelor's degree from an institution of recognized standing or who have received the M.D. degree from Class A medical schools with at least two years of college training before entering the medical school, this degree is oper on the same basis as the Doctor of Science or Doctor of Philosophy.

To be accepted as a candidate for the degree the student must pass a general examination in all the subjects required for the degree, given in four groups at least seven months before the degree is conferred. In view of the wide range of subjects in which the candidate must qualify in his general examination, a special Minor requirement may be waived.

Biology and Public Health Continued

The time required in preparation for the general examination may be reduced in the case of those who have had extensive public health experience involving knowledge of the subjects regarded as essential to this degree, but each case will be considered individually on its merits.

For those who enter upon graduate work for the degree of Doctor of Public Health without actual practical experience it is recommended that a portion of the time in the period preceding the general examination be spent in practical health work, under the direction of the Faculty, in some health department which is willing to coöperate with the Institute in this respect by employing such men on a part-time basis or by offering facilities for securing experience in special fields of public health administration.

Medical officers of the United States Army who are graduates of accepted medical schools and who have in addition had the basic course in public health at the Army Medical School, the special courses required for sanitary officers, and at least five years of practical public health administration in the army, are accepted as applicants for the degree on a one-year basis, but to be accepted as candidates they must pass a general examination in the field of Public Health not less than six months previous to the time it is expected the degree will be received. Their period of residence is devoted largely to advanced professional research.

The Biological Laboratories

The Biological Laboratories offer facilities for advanced work in bacteriology, biochemistry, zymology, industrial hygiene, municipal sanitation, and food conservation and control. Special opportunities for training for the profession of Public Health and for investigation of methods of public health education and administration are available.

Biological Engineering

To be accepted as a graduate student working toward the degree of Master of Science in Biological Engineering, a record of acceptable preparation in subjects substantially equivalent to those prescribed for the first four years of the curriculum of VII-A (see page 60) is required.

GRADUATE SUBJECTS IN BIOLOGY

"A" Subjects. Primarily for Graduates

First Term	7·18	Tech. Aspects of Entom	2–3
	7·321	Bacteriology, Adv.	3–4
	7·35	Planktonology	2–3
	7·371	Industrial Microbiology	5–4
	7·601	Health Education	2–4
	7·63	Public Health Field Work	2–4
	7·66	Epidemiology	2–6
	7·67	Functional Pathology	3–4
	7·721	Food Technology, Adv.	4–2
	7·81	Zymology	6–3
	7·831	Microbiological Chemistry Laboratory	5–1
		Biological Engineering I	6–3
	7·941	Research Problems	Time arr.
Second Term	7·09	Parasitology, Adv.	4–4
	7·132	Histology, Adv.	4–2
	7·201	Physiology, Adv.	7–3
	7·322	Bacteriology, Adv.	5–2
	7·372	Indust. Microbiology	4–4
	7·38	Germicides and Antiseptics	4–4
	7·602	Health Education	3–5
	7·603	Public Health Education	2–4
	7·604	School Health Adm.	2–4
	7·64	Public Health Problems	2–4
	7·65	Health Haz. in Spec. Ind.	2–5
	7·68	Pathology	6–2
	7·722	Food Technology, Adv.	4–2
	7·82	Biochemistry, Adv.	6–3
	7·832	Microbiological Chemistry Laboratory	5–1
		Biological Engineering II	4–2
	7·942	Research Problems	Time arr.

"B" Subjects. Open to Graduates and Undergraduates

First Term	7·131	Histology, Adv.	4–2
	7·22	Personal Hyg. & Nutrition	2–2
	7·50	Communicable Diseases	3–3
	7·531	Air Examination	2–2
	7·541	Public Health Admin.	2–3
	7·551	Public Health Lab. Meth.	8–3
	7·58	Vital Statistics	2–3
	7·59	Sanitation	5–3
	7·711	Tech. of Food Products	6–4
	7·80	Biochemistry	8–5
Second Term	7·03	Theoretical Biology	2–3
	7·08	Parasitology	2–4
	7·23	Applied Nutrition	3–3
	7·302	Bacteriology	6–3
	7·362	Industrial Microbiology	4–4
	7·52	Industrial Hygiene	5–3
	7·542	Public Health Admin.	2–3
	7·552	Immunological Methods	6–1
	7·57	Municipal Sanitation	4–3
	7·712	Tech. of Food Products	5–4
	7·802	Quant. Biochemistry	5–1
	7·84	Biophysics	6–3

PHYSICS

The Department of Physics offers work for the degrees of Master of Science, Doctor of Philosophy and Doctor of Science. 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

The courses in the field of pure physics are intended primarily for students intending to go into teaching and fundamental research. As preparation, in addition to a thorough knowledge of mathematics and chemistry, the student is expected to become well trained in both experimental and theoretical physics. Most of the fields of research of active importance in physics at present are well represented

Physics Continued

at the Institute, and excellent facilities for them are found in the new George Eastman Research Laboratories, and the adjoining Spectroscopy Laboratory. One field of great interest at present is nuclear research, including the following: nuclear research and high voltage, with close contact with the Electrical Engineering Department; a cosmic ray research program, both theoretical and experimental; and radioactive investigations, with particular reference to the age of the earth.

The Spectroscopy Laboratory provides unique equipment. Communicating with the basement by a corridor, but entirely independent of the main building, and located in a court, this building has been designed particularly to provide constant temperature and freedom from vibration. Included in it are complete Paschen circles for both 35-foot and 21-foot gratings, entered from a common source room; several other grating mountings; and separate rooms for vacuum spectrographs and other pieces of apparatus. These include among other things a 21-foot vacuum spectrograph, microphotometers, and various interferometers for work requiring high resolving power. Among the researches in progress are investigations in the line spectra of the elements; the band spectra of molecules; and hyperfine structure and interferometry. Developments of automatic methods of measuring and analyzing spectra, in conjunction with unusually fine diffraction gratings, have made possible new standards of precision in wave-length measurement, and analyses of spectra which were not previously attempted.

Experimental problems in electronic phenomena include studies of thermionic and photoelectric emission from metals, and the mechanism of discharge in gases. The X-ray laboratory is principally concerned with the structure of crystals, as determined by X-ray diffraction. Recently a large part of the research has been concerned with the structure of glasses, other amorphous solids, and liquids. Other work in the structure of solids includes a research program in the properties of dielectrics, including optical, electrical and mechanical behavior, and research in the production of large single crystals. Theoretical research has recently included work in classical physics, as in diffraction problems of sound and light, and hydrodynamics and aerodynamics; the theory of gas discharges, and the scattering of atoms and electrons; the theory of metals and the solid state; and the theory of the motion of high speed particles, as in cosmic rays and nuclear processes.

The Eastman laboratories contain, in addition to the equipment already mentioned, facilities shared jointly by the departments of Physics and Chemistry, including a lecture room, where frequent colloquia and advanced lectures are held; classrooms for graduate subjects; a social room; and a well-equipped research library of physics, chemistry, and mathematics, containing reading room, stack space for thirty thousand volumes, and cubicles for study in the stacks. The Physics department also maintains well-equipped shops, including machine shop, instrument maker's shop, pattern shop, and a staff shop; a research stock room; a glass blower's room; and an optical shop.

Graduate Study and Research in Applied Physics

The course in the field of applied physics is intended primarily for students intending to go into industrial research in physics or engineering. For such a career, a broad training not only in the more classical and experimental parts of physics, but also in engineering, chemistry, and other subjects is essential. For this reason, a student of applied physics will be expected to do a considerable part of his work in other departments. Some of the more important branches of applied physics, with the type of training available and the research opportunities, are enumerated below. The field of physical properties of matter is one of great commercial importance. The student in this field should have thorough grounding in physics, particularly in X-ray crystal structure and thermodynamics, and in chemistry, especially physical and organic. He should also receive training in some of the following fields (in each case the particular subjects which should be emphasized in other departments are given in parentheses): physical metallurgy; geology (crystallography); mechanical engineering (elasticity, plasticity, strength of materials); civil engineering (soil mechanics). Students in acoustics should study physics (mechanics); electrical engineering (oscillating circuits and vacuum tube devices); the mathematics of vibrations and boundary value problems; and should do advanced work and research in acoustics, conducted jointly by the departments of Physics and Electrical Engineering. In several other fields of the application of mechanics and heat, joint work with other departments can easily be arranged. These include heat measurements, in mechanical engineering; ceramics, in mining and metallurgy; and study of heat engines, hydrodynamics, and aerodynamics, in mechanical engineering and aeronautics. In electricity, particularly in electronics, and in the study of dielectrics, joint programs of study and research with the Electrical Engineering department can be worked out. Electrochemistry, in the department of Metallurgy, is closely associated with physics, and may well be pursued by a student of applied physics. The work in applied optics is largely in the Physics department, including study and research in color measurements, design of optical instruments, and related fields, but the student entering this field, as for

Physics Continued

research on color problems, should study the chemistry and chemical engineering of dyes, and textile research, while if he expects to enter the motion picture field, he should study physics and electrical engineering as related to oscillating circuits and vacuum tubes, acoustics, and illumination. Geophysics, the application of physical methods to geology, and particularly to prospecting for ores, demands a good foundation in physics, especially electrical measurements; in mathematical physics, particularly elasticity, wave motion, electromagnetic theory; and in geology. Biophysics can be undertaken jointly with the Biology department, with particular attention to radiation and X-rays in physics, and to biological subjects.

In all of these branches of applied physics, considerable work in other departments is required, and it is very desirable to start the fundamental subjects in these departments as undergraduates. Undergraduates planning to enter applied physics should choose their electives with this in mind.

Requirements for the Doctor's Degree

The following special requirements must be met, in addition to the general requirements:

Undergraduate subjects, which may be taken at the Institute or elsewhere, but may not be counted for an advanced degree:

8·161 Optics
8·201 Electronics
8·311 Atomic Structure
8·50 Heat and Thermodynamics or
5·61 Physical Chemistry I

Undergraduate subjects which may be counted as "B" subjects toward an advanced degree:

8·461, 8·462 Introduction to Theoretical Physics

The further requirements for the doctor's degree are: reading examinations in French and German; a minor of at least 25 units in some other department; a general examination; a thesis; and an examination on the thesis. The student is expected to take graduate subjects to prepare himself for the general examination, but there are no stated required subjects. The first part of the general examination consists of two written papers, one a three hour examination, to be taken without the use of books, and the other a home paper, each question consisting of a small investigation to be made with the use of books and references. There will be different written papers for the degrees in the field of pure physics and in that of applied physics. These written papers are regarded as qualifying examinations, candidates passing them successfully being permitted to take an oral general examination. These examinations are given twice a year, during the latter part of October and the first of May. The oral examination, minor, and language requirements must be passed off before the student is admitted to candidacy for the degree, which must be at least seven months before taking the degree.

The requirements for a doctor's degree in the field of pure physics, tested by the general examination, include a general knowledge of physics of the grade required for a bachelor's degree in Course VIII, Option 1; and a more advanced knowledge of several fields of experimental or theoretical physics.

The requirements for a doctor's degree in the field of applied physics include a general knowledge of physics of the grade required for a bachelor's degree in Course VIII, Option 2; a knowledge of certain fields of science or engineering outside the Physics department, as chemistry, metallurgy, electrical engineering, geology, which have particular bearing on applications of physics; and more advanced knowledge of certain fields of physics or engineering.

GRADUATE SUBJECTS IN PHYSICS

"A" Subjects. Primarily for Graduates

First Term	8·051	Sp. Prob. in Acoustics	Time arr.
	8·21	Electronic Phenomena	2–4
	8·212	Experimental Electronics	4–3
	‡8·213	Advanced Electronics	3–9
	8·215	Sp. Prob. in Electronics	Time arr.
	8·26	Molecular Structure	3–6
	8·341	Spectroscopy Seminar	1–1
	8·343	Sp. Prob. in Spectroscopy	Time arr.
	8·441	Sp. Prob. in Nuclear Res.	Time arr.
	8·463	Int. to Theoret. Phys. III	4–8
	‡8·481	Advanced Mechanics I	3–9
	8·491	Meth. of Theoret. Physics	3–9
	8·56	Electromagnetic Wave Theory	3–9
	‡8·57	Cosmic Rays and High Energy Phenomena	2–6
	8·591	Theoretical Seminar	1–1
	8·60	Sp. Prob. in Theoret. Physics	Time arr.
Second Term	8·051	Sp. Prob. in Acoustics	Time arr.
	8·181	Optics Seminar	2–2
	8·194	Advanced Physical Optics	3–2
	‡8·214	Advanced Electronics	3–9
	8·215	Sp. Prob. in Electronics	Time arr.
	‡8·28	X-Ray Diffraction	2–4
	8·281	Crystal Chemistry	2–4
	‡8·29	Quantum Theory of the Solid State	3–6
	8·30	Sp. Prob. in Crystal Physics	Time arr.
	8·32	Line Spectra	3–6
	8·342	Spectroscopy Seminar	1–1
	8·343	Sp. Prob. in Spectroscopy	Time arr.
	8·35	Excitation of Spectra	5–4
	8·42	Seminar in Nuclear Physics	1–2
	‡8·43	Theory of Nuclear Structures	2–6
	8·442	Sp. Prob. in Nuclear Res.	Time arr.
	‡8·482	Advanced Mechanics II	3–9
	8·512	Statistical Mechanics	3–9
	8·521	Quantum Mechanics	3–9
	8·58	Theory of Relativity	3–9
	8·592	Theoretical Seminar	1–1
	8·60	Sp. Prob. in Theoret. Physics	Time arr.

‡ Not offered 1938–39.

Physics Continued

"B" Subjects. Open to Graduates and Undergraduates

First	8·05	Vibrations and Sound	3–6
Term	8·11	Experimental Physics	8–4
	8·171	Advanced Optics	2–3
	8·174	Motion Picture Photog.	1–3
	8·27	X-Rays & Crystal Physics	4–5
	8·411	Nuclear Physics	5–4
	8·461	Int. to Theoret. Physics I	4–8
	8·471	Hist. Develop. of Physics	3–6
	8·82	Electrochemistry	3–6
Second	8·12	Experimental Physics	2–4
Term	8·13	Undergrad. Colloquium	2–2
	8·173	Color Measurements	3–2
	8·412	Nuclear Physics	5–4
	8·462	Int. to Theoret. Physics II	4–8
	8·54	Electromagnetic Theory	3–6
Summer			
	8·344	Practical Spectroscopy	3–3
	8·345	Applied Spectroscopy	Time arr.
	8·346	Quantitative Spectroscopic Analysis	1–1

CHEMICAL ENGINEERING

Because of the breadth of the field of Chemical Engineering the undergraduate Course must be devoted to training in fundamentals, and strictly professional subjects must be elementary in character. Postgraduate work is therefore of peculiar importance and value to the chemical engineer.

The program for the S.M. degree, particularly in Chemical Engineering Practice, is usually arranged as a continuation of the broad professional training, although individual schedules may be planned to specialize in a given field. Work for the Sc.D. degree is more specific in character and the Department offers coördinated programs in three fields: Engineering Operations of Chemical Engineering, Applied Chemistry, and Fuel Engineering. Special programs are developed for individual cases.

School of Chemical Engineering Practice

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

In the School of Chemical Engineering Practice a carefully selected group of graduate students who have completed at least four years of undergraduate study at the Institute or elsewhere spend six months at three field stations located at Bangor, Me., Parlin, N. J., and Buffalo, N. Y. At these stations four different concerns open their plants for the instruction of students who at each station are under the direct charge of two members of the Institute staff. Since the time is devoted wholly to their education, students receive no compensation. Their attention is directed chiefly to the application of theory to practice and to the cultivation of resourcefulness and of effectiveness in coöperative effort under industrial conditions.

The field of chemical engineering has been divided into a series of unit operations which are studied quantitatively and in detail in the Practice School. Plant investigations are carried out by the students at each of the stations, this work covering two fields: first, investigation of some special phase of one of the unit operations; or second, investigation of some problem of industrial chemistry particularly important at the station in question.

Finally, the School of Chemical Engineering Practice offers exceptional opportunity for graduate engineering research, first by affording an opportunity for comparing laboratory data, formulae, and conclusions with observations on plant apparatus operating under practical working conditions; and second, by extending, from laboratory scale at the Institute to commercial scale in the various plants, the range of investigations possible.

The following program will be taken by men graduating in Chemical Engineering from the Institute.

For twenty-four weeks, from early in July until Christmas, students are at the field stations (10·81, 10·82 and 10·83). They then return to the Institute for intensive work in Chemical Engineering Design (10·53) between the close of the Christmas vacation and the end of the examination period of the first term. The work of the second term, including thesis, is elective, though subject to the approval of the department registration officer of graduate students.

For graduates in chemical engineering from other institutions the usual program of study for the Master's degree involves one school year at the Institute, followed by the seven months in field station work in the Practice School and in the Design course, 10·53. Graduates in chemistry from other institutions usually require an additional half year. A preliminary program in the Summer Session is frequently desirable for new men. Students are usually not permitted to enter the Practice School until they have spent at least one term at the Institute. The student's program is so dependent on previous training and experience that individuals interested are requested to communicate directly with the department.

Fields of Study

Engineering Operations. Graduate subjects in the several important unit operations such as heat transmission, distillation, and absorption are offered, emphasizing the engineering phases of the students' professional training.

Applied Chemistry. A group of subjects in Applied Chemistry, such as colloidal chemistry, catalysis and high pressure processes, comprise an integrated program for students whose primary interests are on the side of Industrial Chemistry.

Fuel Engineering. While the important group of industries involving the processing and utilization

Chemical Engineering Continued

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 School can be utilized for advanced investigations in fuel engineering practice.

Since the program in any of these fields will depend on undergraduate training and industrial experience, any one interested is requested to furnish information permitting individual consideration.

Requirements for Graduate Study

The requirements for graduate study are dependent on the degree to which the student wishes to specialize. The broadest training is required in Chemical Engineering and in Chemical Engineering Practice as it is assumed that the student is preparing himself for any phase of chemical engineering. Students who plan definitely to major in Applied Chemistry or in Fuel Engineering will be expected to meet requirements in chemistry and in engineering to an extent justified by the field of specialization.

The preparation required above that common to all courses of the Institute is outlined below:

Mathematics. Differential Equations equivalent to the undergraduate subject M22.

Chemistry. A training approximately equivalent to that of the undergraduate course, with particular emphasis on physical chemistry.

Engineering. A training which includes preparation in (a) thermodynamics and (b) applied mechanics or elements of electrical engineering.

Graduate students may meet many of these requirements while studying for an advanced degree.

GRADUATE SUBJECTS IN CHEMICAL ENGINEERING

"A" Subjects. Primarily for Graduates

First	10·25	Indust. Chemistry	5–7
Term	10·33	Anal. Treat. of Chem. Eng. Processes	3–6
	10·45	Distillation and Absorption	4–8
	10·52	Chemical Engineering II	3–6
	10·53	Chem. Engineering Design	3–9
	10·54	Econ. Bal. in Chem. Indus.	5–7
	10·661	Int. to Colloid Chemistry	2–4
	10·671	Colloid Seminar	2–4
	10·673	Colloid Chem. Lab.	3–0
	10·674	Colloid Chem. Lab.	3–0
	10·68	Corrosion	2–4
	10·70	Principles of Combustion	4–6
	10·74	Furnace Design	3–6
	10·79	Automotive Fuels	2–4
		School of Chemical Engineering Practice	
	10·81	Bangor Station	12
	10·82	Parlin Station	12
	10·83	Buffalo Station	12
	10·90	Exp. Research Prob.	Time arr.
	10·911	Research Conferences	1–2
	10·991	Seminar in Chem. Eng.	2–4
Second	10·40	Chem. Eng. Thermodyn	3–6
Term	10·41	Distillation	3–5
	10·46	Absorption and Extraction	3–6
	10·50	Heat Transmission	2–4
	10·55	Economic Balance	3–6
	10·62	App. Chem. Thermodyn.	3–6
	10·63T	Industrial Chemistry II	3–6
	10·65	Catalysis & High Pressure Processes	3–6
	10·662	Colloid Chemistry	2–4
	10·672	Colloid Seminar	2–4
	10·673	Colloid Chem. Lab.	3–0
	10·674	Colloid Chem. Lab.	3–0
	10·71	Fuel Engineering	3–6
	10·74	Furnace Design	3–6
	10·76	Seminar in Rad. Heat Trans.	2–4
		School of Chemical Engineering Practice	
	10·81	Bangor Station	12
	10·82	Parlin Station	12
	10·83	Buffalo Station	12
	10·90	Exp. Research Prob.	Time arr.
	10·912	Research Conferences	1–2
	10·992	Seminar in Chem. Eng.	2–4

"B" Subjects. Open to Graduates and Undergraduates

First	10·26	Industrial Chem. Lab.	5–1
Term	10·31	Chemical Engineering	4–5
Second	10·21	Industrial Chemistry	2–2
Term	10·29	Chemical Engineering	3–6
	10·32	Chemical Engineering	4–5

FOR CHEMICAL WARFARE OFFICERS

Course Leading to the Degree of Master of Science

The work begins with the Summer Session in June. The first summer and the first school year are devoted to work of a professional nature preparatory to the more advanced program of the second year, and the School of Chemical Engineering Practice. The student starts the work of the Practice School in July of the second summer, and returns to the Institute the following January to take the course in Chemical Engineering Plant Design, and a term of graduate subjects and thesis. The total time to meet the requirements for the degree is normally 24 months. The subjects to be included in the program depend to a considerable extent on the student's training and experience.

GEOLOGY

In Geology many opportunities are given to pursue advanced work leading to the Master's and Doctor's degree. One line of work is in Economic Geology, and the student may specialize in mining geology, petroleum geology, hydrology, or geology applied to engineering or geophysics. Or again, he may elect to devote the greater part of his time to geology, mineralogy, petrography and paleontology in their more theoretical aspects as preparation for teaching and research.

The advanced work is facilitated by laboratories provided with modern appliances for work in the various phases of geology, mineralogy, petrography,

Geology Continued

geophysics, and paleontology. The collections in economic geology are supplied with material from the mining districts of all parts of the world.

Requirements for the Degree of Master of Science

Candidates for the degree of Master of Science in Geology must present approved equivalents for the subjects of the first and second years in keeping with indicated field of special interest. In the field of Geology they must present a record of attainments satisfactory to the Departmental Committee on graduate work.

Requirements for the Degree of Doctor of Philosophy, or Doctor of Science

The preparation of the candidate for the Doctor's degree must be such as to satisfy the Department Committee on Graduate Students that he is qualified to undertake the course of advanced study and research.

Each candidate upon his entrance in the Department is given a preliminary examination which may be partly oral and partly written. This is designed to survey his training and attainments in the field of geology. This preliminary examination precedes the "major" examination which must be passed at least seven months before the degree is awarded. The "minor" requirement should likewise be passed before the major examination.

A reading knowledge of both French and German is required.

GRADUATE SUBJECTS IN GEOLOGY

"A" Subjects. Primarily for Graduates

First	12·05	Mineralogical Seminar	2–4
Term	12·06	Mineralogical Research	Time arr.
	12·16	Chemical Petrology Seminar	2–4
	12·17	Petrological Research	Time arr.
	12·431	Economic Geol. Lab., Adv.	4–1
	12·433	Economic Geol. Sem., Adv.	2–6
	12·52	Paleontology, Adv.	4–3
	12·54	Micropaleontology	4–2
	12·55	Organic Evolution, Adv.	3–3
	12·63	Physical Geology Seminar	2–5
	12·64	Geology of North America	2–5
	12·851	Theoret. Geophysics, Adv. Research	3–6
Second	12·17	Petrological Research	Time arr.
Term	12·18	Structural Petrology Seminar	2–4
	12·26	Structural Crystallography	Time arr.
	12·432	Economic Geol. Lab., Adv.	4–1
	12·434	Economic Geol. Sem., Adv.	2–6
	12·52	Paleontology, Adv.	4–3
	12·53	Index Fossils	6–2
	12·55	Organic Evolution, Adv.	3–3
	12·582	Sedimentation	5–2
	‡12·62	Geological Climates Seminar	2–5
	12·71	Structural Geology, Adv.	3–6
	‡12·75	Metamorphic Geology	3–6
	12·81	Geology of Petroleum, Adv.	3–6
	12·852	Theoret. Geophysics, Adv. Research	3–6

‡Not offered 1938–39.

Subject to the approval of the Departmental Committee on Graduate Students, other subjects for which a student has adequate preparation may be elected from the subjects primarily for graduates offered by the Mining Department, and by other related departments. A number of advanced subjects in geology and mineralogy, given at Harvard University, are also open to the student.

"B" Subjects. Open to Graduates and Undergraduates

First	12·33	Field Geology	3–2
Term	12·38	Geomorphology	3–6
	12·41	Economic Geology Lab.	8–0
	12·581	Sedimentation	5–2
	12·66	Research	Time arr.
	12·86	Seismology, Elem.	2–2
Second	12·03	Mineralogy, Theoretical	5–1
Term	‡12·42	App. Economic Geology	3–6
	12·44	Economic Geology of Fuels	1–1
	12·60	Glacial Geology	5–6
	12·66	Research	Time arr.
	12·80	Geol. Coal and Petroleum	4–3
	12·87	Intro. Geophys. Prospect	2–2

‡Not offered 1938–39.

MARINE ENGINEERING

The Department of Naval Architecture and Marine Engineering offers opportunities for graduate work in Marine Engineering leading to the degree of Master of Science in Marine Engineering. Advanced study may be pursued in steam engineering; vibrations of ships and their machinery; propeller design and research; and other fields of marine engineering. The Institute's new propeller testing tunnel is now in course of construction and will be available for research work in 1939–40.

In addition to subjects offered in the Department of Naval Architecture and Marine Engineering, the student may elect subjects closely related to marine engineering given in the Department of Mechanical Engineering, or other departments of the Institute, in making up his program of studies such, for example, as: applied mechanics, hydromechanics, thermodynamics, refrigeration, Diesel engineering, steam turbine engineering, heat transmission, air conditioning, advanced machine design, metallurgy, metallography, and advanced mathematics.

The preparation required for graduate work in Marine Engineering is the equivalent of the Institute's undergraduate course in Naval Architecture and Marine Engineering.

In addition to the general requirements for all graduate students, candidates for the degree of Master of Science in Marine Engineering must meet the approximate equivalent of the following undergraduate subjects:

Marine Engineering Continued

2·01, 2·04, 2·06	Applied Mechanics
2·251	Fluid Mechanics
2·351	Materials of Engineering
2·684	Engineering Laboratory
2·852	Machine Tool Practice
2·40, 2·42	Heat Engineering
6·40, 6·89	Electrical Engineering
13·01, 13·02	Naval Architecture
13·54, 13·55	Marine Engineering
13·61, 13·62	Marine Engineering Design

If a student has not had training in all these subjects before entering upon the work for the graduate year, those listed below as "B" subjects may be taken during the graduate year, up to a total of 24 units, and counted as credit towards the Master's degree.

GRADUATE SUBJECTS IN MARINE ENGINEERING

"A" Subjects. Primarily for Graduates

First	13·73	Mechanical Vibration	3–6
Term	13·75	Advanced Marine Engineering	3–9
	‡13·78	Propeller Theory & Exp. Research	Time arr.
	13·90	Experimental Research	Time arr.
Second	13·74	Mechanical Vibration	3–6
Term	13·76	Advanced Marine Engineering	3–9
	13·90	Experimental Research	Time arr.

"B" Subjects. Open to Graduates and Undergraduates

First	13·01	Naval Architecture	3–5
Term	13·54	Marine Engineering	2–3
	13·61	Marine Engineering Design	4–1
	13·81	Ship Operation	3–5
Second	13·02	Naval Architecture	3–5
Term	13·62	Marine Engineering Design	6–0
	13·82	Ship Operation	3–5

‡ Not offered 1938–39.

XIII-A. NAVAL CONSTRUCTION

Course for Naval Constructors

The Department of Naval Architecture and Marine Engineering offers to United States Naval Officers a graduate course (XIII-A) of prescribed studies extending over three years, leading to the degree of Master of Science in Naval Construction. The complete curriculum is given below.

REQUIRED DURING SUMMER PRECEDING JUNIOR YEAR (July to September)

M73	Review of Mathematics (Algebra, Plane and Solid Geometry, Trigonometry, Elementary Calculus, Differential Equations)	20–0

JUNIOR YEAR

First	2·04	Applied Mechanics	3–5
Term	2·351	Materials of Engineering	2–2
	8·07	Precision of Measure	1–1
	13·01	Naval Architecture	3–5
	13·11	Theory of Warship Design	4–10
	13·21	Warship Design	5–0
	M36	Advanced Calculus	3–6
			21–29
Second	2·06	Applied Mechanics	3–5
Term	2·371	Testing Materials Lab	2–1
	13·02	Naval Architecture	3–5
	13·12	Theory of Warship Design	4–10
	13·22	Warship Design	5–0
	M37	Advanced Calculus	3–6
			20–27

REQUIRED DURING SUMMER

Work arranged by Postgraduate School

SENIOR YEAR

First	2·271	Hydromechanics	3–6
Term	13·13	Theory of Warship Design	3–6
	13·23	Warship Design	5–0
	13·58	Marine Engineering	3–4
	Ec15	Principles of Economics	3–5
	M731	Mechanics	3–6
		General Study	2–2
			22–29
Second	2·72	Machine Design	3–6
Term	13·14	Theory of Warship Design	3–8
	13·24	Warship Design	5–0
	13·37	Merchant Shipbuilding	2–2
	13·48	Model Making	2–0
	13·64	Marine Engine Design	3–0
	19·20	Metallurgy	2–1
	M732	Mechanics	3–6
		Memoirs	0–3
			23–26

REQUIRED DURING SUMMER

Work arranged by Postgraduate School

GRADUATE YEAR

First	1·451	Structures	3–6
Term	13·15	Theory of Warship Design	3–6
	13·25	Warship Design	6–0
	15·61	Law of Contracts	3–6
	16·811	Aeronautics	3–1
	19·50	Metallography	4–1
	L11	Elementary German	3–5
			25–25
Second	1·452	Structures	3–6
Term	1·46	Structural Design	2–0
	13·16	Theory of Warship Design	3–6
	13·26	Warship Design	6–0
	L12	Elementary German	3–5
		Thesis	13
			47

Elementary French L51 and L52 may be substituted for German L11 and L12.

BUSINESS AND ENGINEERING ADMINISTRATION

Designed to prepare the technical graduate for ultimate executive responsibilities of an important nature, the course leading to the Master's degree in Business and Engineering Administration has for its objective an awareness of the social implications of industry, an understanding of the interrelations of business and economics, and a facility in dealing 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 Course in Business and Engineering Administration. With this preparation the candidate may reasonably expect to complete the requirements for the Master's degree in one year. Without it, graduates from other courses at the Massachusetts Institute of Technology or from non-business courses in other accredited technical schools will undertake a two-year program. The first year of residence is devoted to the satisfying of prerequisites, and any remaining time during that year is assigned to additional subjects chosen from undergraduate electives. The second year is given wholly to graduate work, in accordance with the general requirements for the Master's degree as described on page 83.

Prerequisites to Graduate Study

In addition to satisfying undergraduate requirements* for the Master's degree common to all courses, candidates should have taken a substantial number of engineering units similar to those prescribed in the optional groups listed in the undergraduate Course in Business and Engineering Administration. Candidates should also present evidence that they have had the equivalent of the following undergraduate subjects:

15·41	Finance	Ec11, Ec12	Economic Principles
15·50	Accounting	Ec32	Statistics
15·61	Law of Contracts	Ec40	Money and Banking
15·70	Production	Ec61	Labor Relations
15·81	Marketing	E35	Reports
15·92	Industrial Problems		

and the equivalent of *any three* additional subjects to be selected from "B" subjects (other than those in the preceding group) as listed below.

The second or graduate year program comprises a selection largely of advanced "A" subjects from the following list, and the undertaking of a Master's thesis.

* M22 Differential Equations is not prerequisite for graduate work in this Department.

GRADUATE SUBJECTS IN BUSINESS AND ENGINEERING ADMINISTRATION

"A" Subjects. Primarily for Graduates

First	15·25	Indust. Traffic Manage.	3–6
Term	15·55	Prob. in Account. Policy	3–6
	15·75	Manufacturing Analysis	3–6
	15·85	Industrial Marketing	3–6
	15·95	Special Problems in Management	Time arr.
	Ec17	Economic Theory	3–6
	Ec19	Math. Approach to Economics	3–6
	Ec37T	Statistical Meth. for Qual. Control	3–6
	Ec47	Investment Finance	3–6
	Ec57	Public Utilities	3–6
	Ec59	International Econ. Relations	3–6
	Ec67	Labor Relations Seminar	3–6
	Ec91	Economics Seminar	3–6
Second	15·46	Fin. Admin. of Industry	3–6
Term	15·56	Anal. of Bus. Statements	3–6
	15·58	Problems in Accounting Control	3–6
	15·86	Market. of Consumer Goods	3–6
	15·88	Advertising	2–6
	15·94	Contemporary Problems Seminar	3–6
	15·95	Special Problems in Management	Time arr.
	15·96	Administrative Theory and Practice	3–6
	Ec28	Business Cycles	3–6
	Ec48	Investment Analysis	3–6
	Ec68	Personal Probs. & Labor Rel.	3–6
	Ec78	Govt. Control of Industry	3–6
	Ec92	Economics Seminar	3–6

"B" Subjects. Open to Graduates and Undergraduates

First	15·51	Industrial Accounting	5–4
Term	15·61	Law of Contracts	3–6
	15·71	Production	3–6
	15·83	Marketing Research	3–6
	Ec15	Principles of Economics	3–5
	Ec45	Monetary & Bank. Prob.	2–4
	Ec55	Economics of Transportation	2–4
	Ec61	Labor Relations	2–4
	Ec83	Urban Sociology	3–3
	Ec87	Methods of Soc. Investigation	2–3
Second	2·872	Prep. for Manufacturing	3–3
Term	15·42	Financial Problems	3–6
	15·51	Industrial Accounting	5–4
	15·62	The Law of the Market	3–6
	15·64	Law of Business Org.	3–6
	15·72	Technique of Executive Control	3–6
	15·82	Sales Management	3–6
	15·92	Industrial Problems	2–6
	Ec14	Current Economic Prob.	3–3
	Ec54	Corporations	3–3
	Ec62	Labor Problems	2–4
	Ec82	Principles of Sociology	3–3
	Ec84	Soc. Factors in City Plan.	3–4
	Ec88	Psychology in Bus. & Industry	2–4
	M54	Mathematical Laboratory	3–6

AERONAUTICAL ENGINEERING

Emphasis is laid upon individual study and research rather than upon formal classroom exercises. Each student must follow a consistent program of work directed toward some particular part of the aeronautical field such as aerodynamics, structures or power plants. Since most phases of the graduate work in Aeronautical Engineering rest heavily upon mathematics and mechanics, especial aptitude in these subjects is very desirable.

Meteorological Division

The Institute maintains a laboratory for synoptic meteorology with radio receiving and transmitting equipment for the collection and exchange of weather data. A teletype receiver is available for speedy collection of airways weather reports. Two radio operators are permanently employed for this purpose. There is also available equipment for the reproduction of weather maps used in the training of students and for exchange with selected American and foreign meteorological institutions.

The Meteorological Instrument Laboratory includes considerable equipment for the measurement and recording of local weather data, complete instrumentation for pilot balloon soundings and an assortment of meteorographs for airplane soundings. In addition there is available a set of about forty sounding balloon meteorographs for stratosphere investigations and a microscope for evaluation of sounding balloon records. A limited number of radio meteorographs of several different types are also available for instruction purposes and for high altitude investigations. A calibration chamber suitable for pressure-temperature calibrations at temperatures as low as −76° C has been constructed and also a humidity calibration chamber.

In coöperation with the United States Air Corps the U. S. Weather Bureau maintains an aerological station at the East Boston Airport. Daily flights are made to an altitude of 20,000 feet. Students are given an opportunity to participate in the aerological work at the airport.

Close coöperation is maintained with the Blue Hill Observatory of Harvard University, the Mount Washington Observatory, and the Woods Hole Oceanographic Institution.

The Daniel Guggenheim Aeronautical Laboratory

All of the aeronautical equipment, except for the engine laboratory and the smallest of the three wind tunnels, is located in the Daniel Guggenheim Aeronautical Laboratory. This is a four-story building of ample proportions, housing not only laboratory and research facilities but also classrooms, conference rooms, and offices for the staff.

The principal aeronautical equipment consists of three wind tunnels, 4, 5, and 7½ feet in throat diameter respectively, each equipped with balances and the necessary auxiliary equipment for making tests of airplane models or any other objects which are to be submitted to a current of air moving at known speed. The large tunnel is capable of handling an airplane model 40 inches in span. The maximum wind speed attainable is 90 miles per hour in the 7½-foot tunnel, 100 m. p. h. in the 5-foot tunnel, and 60 m. p. h. in the 4-foot tunnel.

The laboratories of the Department of Mechanical Engineering are used for the investigation of mechanical and structural problems. A considerable amount of special equipment for the preparation and testing of structural shapes is available.

The facilities of the Internal Combustion Laboratory (see page 90) are available to students in Aeronautical Engineering for study and research in the field of aeronautical power plants.

Undergraduate Preparation

The preparation required for graduate work in Aeronautical Engineering is equivalent to that possessed by a graduate of the Massachusetts Institute of Technology in the undergraduate Course in Aeronautical Engineering. With this preparation the candidate may reasonably expect to complete the requirements for the Master's degree in Aeronautical Engineering in one year. Graduates from other engineering Courses at the Massachusetts Institute of Technology or from non-aeronautical courses in other accredited technical schools, may register as graduate students but will usually find it necessary to devote a considerable portion of their first year of residence to making up their deficiencies in undergraduate aeronautical subjects, with a second year of strictly graduate work.

Students entering either the graduate or undergraduate courses without previous training in Aeronautical Engineering are strongly advised to register in the summer session previous to their first term of residence, as by this means it is usually possible to reduce materially the total period of study required. It is particularly important that this summer program include subjects 16·01, 16·02, 16·10 *and* 16·20 *unless already covered.*

In addition to the general requirements, graduate students who desire to obtain the Master's degree in Aeronautical Engineering must offer the equivalent of the undergraduate subjects which are listed below under Schedule I, if the degree with specification of field is undertaken, or under Schedule II, if the degree without specification is undertaken, or must take these subjects during their first year of residence. Exceptions may be made in individual cases.

Aeronautical Engineering Continued

Schedule I

NOT COUNTED AS "B" SUBJECTS

2·701	Machine Drawing (S)
2·351	Materials of Engineering (S)
2·42	Heat Engineering (S)
16·10	Aerodynamics of Airplane Design (S)
16·20	Structures
16·71	Airplane Shopwork (S)
16·72	Aircraft Production Methods (S)
	Intermediate French (S) or Spanish
	Intermediate German (S)

COUNTED AS "B" SUBJECTS

16·01	Introduction to Aeronautical Mechanics (S)
16·02	Introduction to Aeronautical Mechanics (S)
16·11	Aerodynamics of Airplane Design
16·17	Airplane Design Practice
16·21	Structures
16·62	Aeronautical Laboratory
16·75	Construction Details of Aircraft

Schedule II

NOT COUNTED AS "B" SUBJECTS

2·351	Materials of Engineering (S)
2·42	Heat Engineering (S)
16·10	Aerodynamics of Airplane Design (S)
16·20	Structures
	Intermediate French or German (S) (Unless offered for Entrance)

COUNTED AS "B" SUBJECTS

16·11	Aerodynamics of Airplane Design
16·21	Structures
16·62	Aeronautical Laboratory

(Subjects marked (S) are usually offered during the Summer Session as well as during the regular academic year.)

GRADUATE SUBJECTS IN AERONAUTICAL ENGINEERING

"A" SUBJECTS. PRIMARILY FOR GRADUATES

First	†2·132	Dyn. of Aircraft Engines	2–2
Term	2·801	Auto. Eng. Prob., Adv.	Time arr.
	16·03	Hydrodyn. & App. to Aero.	3–6
	16·07	Adv. Topics in Aeromechan.	3–6
	16·31	Airship Theory	2–3
	16·41	Instrumentation	3–9
	16·43	Instrumentation Laboratory	3–6
	16·45	Sp. Prob. in Aeronautical and Meteor Inst.	Time arr.
	16·53	Advanced Airplane Engine Design	5–3
	16·60	Adv. Aeronautical Prob.	Time arr.
	16·911	Synoptic Meteorology	3–6
	16·921	Meteorological Lab.	15–0
	*16·931	Dynamic Meteorology	5–10
	*16·941	Meteorological Seminar	2–2
	16·961	Phys. Oceanography	2–4
Second	2·802	Auto. Eng. Prob., Adv.	Time arr.
Term	16·04	Hydrodyn. & App. to Aero.	3–6
	16·08	Adv. Topics in Aeromechan.	3–6
	16·18	Airplane Des. Prac., Adv.	6–3
	16·25	Aircraft Structures, Adv.	3–6
	16·36	Airship Structures	2–4
	16·42	Aeronautical Instruments	3–9
	16·46	Vibration Measurements	5–6
	16·52	Aircraft Propeller Design	4–4
	16·54	Advanced Airplane Engine Design	5–3
	16·60	Adv. Aeronautical Prob.	Time arr.
	16·68	Aeronautical Seminar	2–2
	16·912	Synoptic Meteorology	3–6
	16·922	Meteorological Lab.	12–0
	16·932	Dynamic Meteorology	5–10
	16·942	Meteorological Seminar	2–2
	16·962	Phys. Oceanography	2–4
		Thesis	20–40 hours per week

"B" SUBJECTS. OPEN TO GRADUATES AND UNDERGRADUATES

First	2·791	Automotive Engines	4–4
Term	16·01	Int. to Aero. Mechanics	6–6
	16·11	Aerodyn. of Airplane Des.	6–4
	16·17	Airplane Design Prac.	8–0
	16·21	Structures	3–5
	16·62	Aeronautical Lab.	4–3
	16·81	Aeronautics	3–1
	16·901	Introduct. Meteorology	2–2
Second	2·792	Automotive Engines	4–4
Term	16·02	Int. to Aero. Mechanics	6–4
	16·14	Airplane Design Prob.	6–6
	16·22	Aircraft Structures	3–5
	16·44	Meteorological Instruments	5–5
	16·63	Aero. Lab. & Res. Methods	4–2
	16·75	Const. Details of Aircraft	7–2
	16·81	Aeronautics	3–1

Students may also elect subjects, given in other departments, but bearing a useful relation to their program of aeronautical studies. Those specializing in aircraft design will, in general, be advised to take advanced work in materials and elasticity; those choosing aerodynamics as their field may advantageously take courses in advanced physics, while those chiefly interested in engines should supplement their aeronautical studies by work in physical chemistry and in dynamics. The selection of such subjects is subject to approval of registration officer.

† Required preparation not covered in Course XVI.
* For Naval Officers only.

ECONOMICS AND SOCIAL SCIENCE

The Department of Economics and Social Science offers subjects to graduates who are studying for advanced degrees in other departments. The subjects included in the program of study for the master's degree in Business and Engineering Administration are mentioned on a preceding page. Advanced students may also submit Economics as their minor requirement for the doctorate. Provided they have had the necessary elementary groundwork, suitable programs may be arranged from the subjects listed below. The fairly broad range of selection enables the student to choose a group of subjects related to his major interest. Those interested in the economic aspects of particular industries will be given opportunity to devote special attention to such industries. It is suggested that all candidates for the doctorate include "Economic Theory" among the subjects submitted.

For a description and explanation of the five-year program leading to the degree of Bachelor of Science in the professional course and to the degree of Master

Economics and Social Science Continued

of Science in Economics and Engineering or Natural Science, see below.

"A" Subjects. Primarily for Graduates

First	Ec17	Economic Theory	3–6
Term	Ec19	Math. Approach to Economics	3–6
	Ec37T	Statistical Methods for Quality Control	3–6
	Ec47	Investment Finance	3–6
	Ec57	Public Utilities	3–6
	Ec59	Internat. Economic Relations	3–6
	Ec67	Labor Relations Seminar	3–6
	Ec91	Economics Seminar	3–6
Second	Ec28	Business Cycles	3–6
Term	Ec48	Investment Analysis	3–6
	Ec68	Personnel Problems & Labor Relations	3–6
	Ec78	Govt. Control of Industry	3–6
	Ec92	Economics Seminar	3–6

"B" Subjects. Open to Graduates and Undergraduates

First	Ec15	Principles of Economics	3–5
Term	Ec45	Monetary and Bank. Prob.	2–4
	Ec55	Economics of Transportation	2–4
	Ec61	Labor Relations	2–4
	Ec83	Urban Sociology	3–3
	Ec87	Methods of Soc. Investigation	2–3
Second	Ec14	Current Economic Prob.	3–3
Term	Ec54	Corporations	3–3
	Ec62	Labor Problems	2–4
	Ec82	Principles of Sociology	3–3
	Ec84	Social & Econ. Factors in City Plan.	3–4
	Ec88	Psychology in Bus. & Industry	2–4

GRADUATE SUBJECTS IN ECONOMICS AND SOCIAL SCIENCE

The Five-Year Curriculum in Economics and Engineering or Economics and Natural Science

A Five Year Course leading to the degree of Master of Science in Economics and Engineering or Economics and Natural Science together with the degree of Bachelor of Science in the professional Course in which undergraduate work was taken. Students pursuing this special program are expected to make their choice at the beginning of the third year. About two-thirds of the time will be devoted to advanced work in Economics and other social sciences, and the remainder of the graduate work will be carried on in the field of Science or Engineering, according to the individual's undergraduate course. The subject for the Master's thesis preferably shall be chosen in the field of joint interest for the social sciences and for the professional (Natural Science or Engineering) course pursued, that is, such subjects shall preferably involve the economic or social aspects of a scientific or engineering problem. (The Bachelor's thesis is not required in this five year program.) The usual requirements as to "A" and "B" subjects apply to this curriculum.

This Course is open to graduates of the Institute who may be admitted to the Graduate School and who meet the requirements of the Master's degree based on a program of advanced work, including thesis, in the field of Economics equivalent to that required in the five years' course. It is not open to students in the Course in Architecture or in Business and Engineering Administration, nor to graduates of other colleges who come to the Institute to specialize in Economics unless in addition to the advanced work in Economics they complete in residence a program of work in one of the departments of engineering or science approved by the Committee on the Graduate School.

Third Year

Twelve units of studies in Economics or other social sciences are taken by postponing an equivalent amount of work in the professional Course. These may be chosen from the following list:

First	15·52	Accounting	4–2
Term		*or*	
	15·11	Int. to Bus. Manage.	3–3
		and	
Second	Ec40	Money and Banking	3–3
Term		*or*	
	15·12	Int. to Bus. Manage.	3–3

Fourth Year

Senior or Undergraduate Thesis omitted in five year program. Eighteen units of studies in Economics or other social sciences are taken by postponing an equivalent amount of work in the professional Course. These may be chosen from the following list:

First	Ec17	Economic Theory	3–6
Term	Ec61	Labor Relations	2–4
Second	Ec14	Current Economic Prob.	3–3
Term	Ec32	Statistics	3–3
	Ec54	Corporations	3–3
	Ec72	American Government	3–6

Fifth Year

Forty units are given to a thesis; twenty-nine units to technical subjects which have been postponed in earlier years or to graduate subjects; and twenty-seven units to graduate subjects in Economics and Social Science from the following list:

First	Ec19	Math. Approach to Economics	3–6
Term	Ec37T	Statistical Meth. for Quality Control	3–6
	Ec45	Monetary & Banking Prob.	2–4
	Ec47	Investment Finance	3–6
	Ec57	Public Utilities	3–6
	Ec59	Internat. Economic Relations	3–6
	Ec67	Labor Relations Seminar	3–6
	Ec87	Meth. of Social Investigation	2–3
Second	Ec28	Business Cycles	3–6
Term	Ec48	Investment Analysis	3–6
	Ec68	Personnel Probs. & Labor Relations	3–6
	Ec82	Prin. of Sociology	3–3
	Ec88	Psychology in Bus. & Industry	2–4

DEPARTMENT OF MATHEMATICS

The Department of Mathematics offers courses leading to the degrees of Master of Science, Doctor of Philosophy and Doctor of Science.

The course of each student will be arranged in consultation with the Department from subjects mentioned below. A student who is interested in applied mathematics may also be allowed to select subjects offered in other departments. A candidate for the degree of Master of Science will be expected to offer the equivalents of M23, M24 Algebra and Geometry; M831, M832, M841, M842 Analysis; M441, M442 Geometry. Equivalent work may be substituted for any of these subjects.

To obtain the degree of Master of Science the student must elect in each term at least three subjects of advanced mathematics or allied subjects, and fill the remaining time with other electives and thesis.

For the degree of Doctor of Philosophy the student must fill the requirements stated above for Master of Science with the exception of a master thesis and spend at least an additional year in research.

"A" Subjects. Primarily for Graduates

First	M36	Calculus, Adv.	3–6
Term	M381	Theory of Functions	3–6
	M451	Fourier Series & Integrals	3–9
	‡M471	Seminar in Analytic Number Theory	3–9
	M551	Funct. of a Real Variable	3–9
	M571	Differential Equations	3–9
	M581	Continuous Groups	3–9
	M641	Differential Geometry, Adv.	3–9
	M651	Analytical Mechanics	3–9
	M661	Algebra of Quant. Theory	3–9
	‡M671	Potential Theory	3–9
	‡M681	Calculus of Variations	3–9
	‡M691	Characteristic Value Prob.	3–9
	M791	Th. & App. Elasticity	3–9
	M90	Mathematical Reading	Time arr.
Second	M37	Calculus, Adv.	3–6
Term	M382	Theory of Functions	3–6
	M452	Fourier Series & Integrals	3–9
	‡M472	Seminar in Analytic Number Theory	3–9
	M552	Funct. of a Real Variable	3–9
	M572	Differential Equations	3–9
	M582	Continuous Groups	3–9
	M642	Differential Geometry, Adv.	3–9
	M652	Analytical Mechanics	3–9
	M662	Algebra of Quant. Theory	3–9
	‡M672	Potential Theory	3–9
	‡M682	Calculus of Variations	3–9
	‡M692	Characteristic Value Prob.	3–9
	M76	Theory of Probability	3–9
	M792	Th. & App. Elasticity	3–9
	M90	Mathematical Reading	Time arr.

Summer Session

M563	Funct. of a Complex Variable	3–6

‡ Not offered in 1938–39.

"B" Subjects. Open to Graduates and Undergraduates

First	M331	Math. Th. of Statistics	3–6
Term	M441	Projective Geometry	3–6
	M731	Mechanics	3–6
	M77	Vector Analysis	3–6
	M831	Analysis	3–6
	M841	Analysis	3–6
Second	M332	Math. Th. of Statistics	3–6
Term	M442	Elem. Differential Geometry	3–6
	M54	Mathematical Lab.	3–6
	M62	Modern Algebra	3–6
	M732	Mechanics	3–6
	M77	Vector Analysis	3–6
	M832	Analysis	3–6
	M842	Analysis	3–6

METALLURGY

Graduate work leading to the degrees of Master of Science and Doctor of Science in the field of Metallurgy may be pursued along a number of lines. The major divisions are Process Metallurgy dealing for the most part with the production of metals from their ores, and Physical Metallurgy which is chiefly concerned with the study of the physical properties of metals and their alloys. A subdivision of the major fields into Ferrous Metallurgy, covering the many phases of the manufacture, properties and uses of iron, steel and the alloy steels and Non-Ferrous Metallurgy dealing with copper, lead, zinc, gold, silver and metals other than iron, is also possible.

Facilities are provided for the roasting and special treatment of ores, the extraction of the metals by wet methods or by furnace smelting, including the electrometallurgical processes and the study of high temperature equilibria. In addition to various types of smelting furnaces the laboratories are equipped with gas and electric furnaces for the making of alloys in small quantities. A coreless induction furnace with a melting capacity of one hundred and fifty pounds makes possible the production of steel and other alloys on a semi-commercial scale. Equipment is available for detailed metallographic investigation, for heat treatment study and research, as well as for x-ray examination. The latter field is provided for by a lead room in which radiographic studies may be made and by facilities for research in the atomic arrangement in metals. Facilities are available for advanced research in the field of magnetism. Through coöperation with the Department of Mechanical Engineering, physical testing of all sorts is possible.

Opportunity is given for study and research in more specialized subjects as heat and corrosion resisting alloys, the light alloys, and nitriding. Facilities are also available for the study of many of the fundamental physical properties of metallic systems such as electrical and thermal conductivities, magnetic properties and similar topics.

Metallurgy Continued

GRADUATE SUBJECTS IN METALLURGY

"A" Subjects. Primarily for Graduates

First	19·05	Fire Assaying, Adv	Time arr.
Term	19·13	Non-Fer. Metal., Adv	Time arr.
	19·23	Met. Iron & Steel, Adv	Time arr.
	19·25	Metal. Plant Design	13–0
	19·61	Phys. Metallurgy, Adv	Time arr.
	19·71	Physics of Metals, Adv	Time arr.
	‡19·73	Ferromagnetism	2–4
	19·75	Atomic Arrangements in Alloys	2–4
	19·87	Electrochemistry, Adv	3–6
	19·93	Fund. Ceramic Proc	7–4
	19·95	Sp. Problems in Ceramics	Time arr.
Second	19·06	Fire Assaying, Adv	Time arr.
Term	19·16	Metallurgy Gen., Adv	Time arr.
	19·18	Metallurgical Calc., Adv	2–6
	19·24	Met. Iron & Steel, Adv	Time arr.
	19 26	Metal. Plant Design	13–0
	19·62	Phys. Metallurgy, Adv	Time arr.
	19·71	Physics of Metals, Adv	Time arr.
	19·72	Th. of Metal Hardening	2–4
	19·94	Phys. Prop. of Ceramic Prod	5–4
	19·96	Sp. Problems in Ceramics	Time arr.

"B" Subjects. Open to Graduates and Undergraduates

Summer	19·22	Metallurgical Plant Visits	3–1
First	19·07	Metallurgy of Copper & Lead	5–4
Term	19·071	Metallurgy of Copper & Lead	4–3
	19·09	Met. Copper, Lead, Zinc	4–4
	19·19	Metallurgy of Iron & Steel	4–3
	19·27	Metallurgical Plants	3–3
	19·31T	Metallurgical Thermodynamics	3–6
	19·54T	App. of Metallography	3–2
	19·63	Cor. & Heat Resisting Alloys	2–4
	19·70	X-Ray Metallography	3–3
	19·83	Electrochemistry Lab	9–3
	19·85	Electric Furnaces	3–2
	19·91	Optical Ceramics	6–2
Second	19·12T	Met. Gen. Zinc & Minor Metals	4–4
Term	19·27	Metallurgical Plants	3–3
	19·32T	Principles of Steel Making	2–4
	19·54T	App. of Metallography	3–2
	19·64	Light Alloys	2–4
	19·69	Physics of Metals	2–4
	19·70	X-Ray Metallography	3–3
	19·82	App. Electrochemistry	3–6

‡ Not offered in 1938–39.

Electrochemical Engineering

The field of Electrochemical Engineering offers many opportunities for graduate work leading to the degrees of Master of Science or Doctor of Science in Electrochemical Engineering. Two general lines of advanced study are possible, the first dealing with the general applications of electricity to the production of important inorganic and organic chemicals and the second having to do with various branches of electrometallurgy and electrothermics. In the group of electrometallurgical processes are included problems of the production of metals from fused salts and high temperature reactions involving electric furnaces. High frequency induction, arc and vacuum type furnaces with adequate A.C. and D.C. supply are available for the study of electrometallurgical and other electrothermic processes.

Laboratories and equipment are available for both fundamental and applied electrolytic research.

Note.—In accordance with the changes noted on page 69 graduate degrees under the arrangements treated on this page will not be awarded after 1940. Students who wish after that time to pursue graduate work in one of the fields of Electrochemistry should consider the graduate programs offered by the Departments of Chemical Engineering and Metallurgy.

Undergraduate subjects, which may be taken at the Institute or elsewhere, but may not be counted for an advanced degree:

2·50	Heat Measurements
6·11, 6·12	Electrical Engineering Principles
6·77	Electrical Engineering Laboratory

"A" Subjects. Primarily for Graduates

First	19·87	Electrochemistry, Adv	3–6
Term		Research	
Second		Research	
Term			

"B" Subjects. Open to Graduates and Undergraduates

First	8·82	Electrochemistry	3–6
Term	19·09	Met., Copper, Lead, Zinc	4–4
	19·83	Electrochemistry Lab	9–3
	19·85	Electric Furnaces	3–2
Second	19·70	X-Ray Metallography	3–3
Term	19·82	App. Electrochemistry	3–6

Ceramics

The field of Ceramics covering as it does pottery, structural clay products, refractories, abrasives, glass and enamels, is a very broad one, but a sound training in the fundamentals of the subject gives a basis for later specialization. The laboratories are well equipped with testing apparatus as well as with machines and kilns for carrying out the regular plant processes.

"A" Subjects. Primarily for Graduates

First	19·93	Fund. Ceramic Processes	7–4
Term	19·95	Sp. Problems in Ceramics	Time arr.
		Research	
Second	19·94	Phys. Prop. of Ceramic Prod	5–4
Term	19·96	Sp. Problems in Ceramics	Time arr.
		Research	

A number of Group A subjects listed in other Courses may be taken for credit in the field of Ceramics. Such for example are:

First	2·53	Heat Measurement II	Time arr.
Term	10·70	Prin. of Combustion	4–6
Second	8·28	X-Ray Diffraction	2–4
Term	8·29	Quantum Theory of the Solid State	3–6
	10·74	Furnace Design	3–6

"B" Subjects. Open to Graduates and Undergraduates

First	3·03	Economics of Mining	2–4
Term	19·91	Optical Ceramics	6–2
Second	3·04	Principles of Mining	2–4
Term			

DESCRIPTION OF SUBJECTS

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. An elementary course in the theory and practice of plane and topographical surveying. Breed and Hosmer's *Principles and Practice of Surveying, Vol. I.*

1·01. SURVEYING AND TOPOGRAPHICAL DRAWING. A course in surveying consisting of fieldwork, computations and the making of scale drawings, profiles, contour maps, and conventional signs for topography, followed by a study of their application to the solution of engineering problems. Breed and Hosmer's *Principles and Practice of Surveying, Vol. I.*

1·02. SURVEYING. A course in elementary surveying. Breed and Hosmer's *Principles and Practice of Surveying, Vol. I.*

1·041. SURVEYING. At Camp Technology. The fieldwork consists of plane and topographic surveying, in which the transit, tape, level and plane table are used, the astronomical determination of the meridian, the adjustment of instruments and many important problems in surveying. Plans and maps are made from notes taken in the field. (Not accepted in place of 1·05 in Course I.) Breed and Hosmer's *Principles and Practice of Surveying, Vol. I.* This subject satisfies the requirements in surveying for Courses IV-B, IV-C, VI, VI-A, IX-B.

1·042. SURVEYING. At Camp Technology. Lectures, fieldwork and drafting. The theory and practice of plane and topographic surveying is supplemented by many problems. Field training is given in the use of surveying instruments. Designed for students in Course XVII. Breed and Hosmer's *Principles and Practice of Surveying, Vol. I.* This subject satisfies the requirements in surveying for Courses IV-B, IV-C, VI, VI-A, IX-B.

1·05. SURVEYING. At Camp Technology. An extended subject covering plane, topographic and elementary geodetic surveying. The fieldwork consists of making plane and topographic surveys in which the tape, transit, level, stadia method and plane table are used. Astronomical determination of azimuth, time and latitude. Triangulation. In the drafting room, plans and maps are made from original field notes. In the class room, discussions on the methods of conducting surveys, and a limited number of problems are given. Breed and Hosmer's *Principles and Practice of Surveying, Vols. I and II;* Hosmer's *Practical Astronomy.* This subject satisfies the requirements in Surveying for Courses IV-B, IV-C, VI, VI-A, IX-B.

1·07. GEODETIC SURVEYING (B). At Camp Technology. Four weeks of field and office work. The fieldwork includes measuring a base line with Invar tapes; triangulation with repeating and with direction instruments; precise leveling; astronomical observations. (Elective for a limited number of students in Course I who have satisfactorily completed the third year. Given if a sufficient number of students apply.)

1·10. SURVEYING. At Summer Mining Camp, Dover, New Jersey. Lectures, fieldwork and drafting. The fieldwork consists of plane, topographic, magnetic dip-needle, magnetometer and mine surveying. Plans and maps, both surface and under ground, are made from the notes taken in the field. Discussions of surveying methods are supplemented by numerous problems. Breed and Hosmer's *Principles and Practice of Surveying, Vol. I.*

1·12. ASTRONOMY AND SPHERICAL TRIGONOMETRY. Supplements 1·00 and 1·01, and is therefore treated from the standpoint of the engineer. Spherical trigonometry covers the principles of the subject sufficiently to serve as a preparation for the work in astronomy. The class work in the latter includes the theory of spherical and practical astronomy. The fieldwork is given at Camp Technology and includes the determination of latitude, longitude, time and azimuth with the engineer's transit. Hosmer's *Practical Astronomy.*

1·13. GEODESY. The methods of conducting a geodetic survey are discussed in detail, including the mathematical treatment of base line measurements, triangulation and precise leveling. Hosmer's *Geodesy.*

1·135. INTRODUCTION TO VIBRATION THEORY (B). Basic theory of free and forced vibrations with and without solid and fluid friction. To meet the needs of practical engineering, special emphasis is placed upon the analysis of various vibration measuring devices, accelerographs, frequency meters, etc. The proper interpretation of the results obtained from such devices is studied in detail and attention is given to the principles of design of instruments and recording systems. Practical problems of mechanical vibration and of vibration prevention are discussed. Some laboratory experiments are included to illustrate the principles involved.

1·136. VIBRATION PROBLEMS (A). Covers the available methods of solving the more complex problems in vibrations—step-by-step integration, the differential analyzer, model study, electrical network solution, Rayleigh and Rayleigh-Ritz methods, Lagrange's equations, and the general solution of n^{th} order vibration equations. Non-harmonic vibrations are included. Analysis of complex mechanical systems under transient and periodic forces and displacements. Particular attention is given to practical problems illustrating the application of the various methods and principles. Laboratory exercises with stroboscope and shaking machines demonstrate validity of theoretical analysis.

1·138. SEISMOLOGICAL LABORATORY (B). Subject will be arranged to meet needs of individual students.

Civil and Sanitary Engineering Continued

1·141, 1·142. Advanced Geodesy (A). Methods of developing the higher formulas for computing geodetic positions; theories of potential and the earth's figure; theories of astronomical, magnetic and gravity observations; and application of least squares to the adjustment of geodetic surveys.

1·15. Navigation. Includes a study of the use of the compass, log, sextant and charts, and the dead reckoning and astronomical methods used in locating the position of a ship at sea.

1·16. Aerial Surveying (B). A study of the various methods of constructing maps from photographs for engineering purposes, and the methods of making topographic maps from vertical and from oblique photographs. A study is also made of the different methods of control of aerial surveys. The work covered is confined to the methods of producing the maps from the photographs, and does not take up the technical work of photography or of piloting.

1·18. Map Reading and Topographical Drawing. A study of the different conventional signs employed in making topographic maps. Each student is required to make a number of plates of conventional signs, and to solve problems relating to contour maps. (Not open to first year students.)

1·20. Railway and Highway Fieldwork. A complete location survey for a section of a railway or highway; together with a systematic drill in laying out curves by different methods, setting slope stakes for earthwork and staking out masonry structures. A limited amount of class work and drafting is given to supplement the fieldwork. Allen's *Railroad Curves and Earthwork;* Allen's *Field and Office Tables.*

1·21. Railway and Highway Curves. A thorough study of the mathematics of curves with applications to location and property lines of railways, highways and waterways. Simple, compound, reversed, spiral and vertical (parabolic) curves are treated. Allen's *Railroad Curves and Earthwork;* Allen's *Field and Office Tables.*

1·22. Quantity Surveying. Methods of computing quantities for civil engineering work. It includes earthwork volumes, haul and mass diagram; concrete volumes and detailed estimates of quantities of ingredients; preparation of bills of material for reinforcing steel, timber structures, etc. Stress is laid on the ability to read plans and on neatness, accuracy and the use of methods accepted in professional practice.

1·25. Engineering Construction (B). Deals primarily with the construction of civil engineering works, such as railways, highways, water power, water supply and similar projects. The subjects covered are estimates and reports, contracts and specifications, methods of economic comparison, financing of engineering projects, engineering organization and duties, acquisition of land, and construction methods including clearing of the site, earth and rock handling, and construction of structures of concrete, steel and timber. Principles are illustrated by studies of typical projects. Particular attention is given to methods of control of concrete mixtures.

1·26. Railway Signaling (B). Interlocking and block signals; and remote, centralized and automatic train control. Critical attention is given to the development of modern signaling practices with reference to the economics of train operation. The subject is illustrated by inspections of railway signal installations.

1·271, 1·272. Transportation Engineering (B). Transportation by railway and highway with some attention to air and water transportation. Subjects treated include railway maintenance of way including turnouts and yards, highway location and pavement design and research, railway rolling stock and motor vehicles, economics of location illustrated by typical projects, traffic and transportation surveys, highway traffic control, underlying principles of railway and highway operation, waterways, air transport, public relations and regulation including I. C. C. accounting, coördination of the different forms of transportation.

1·273. Transportation Engineering (B). An abridgment of 1·271 and 1·272. (Given primarily for U. S. Army Engineer Officers.)

1·28. Railway Design (B). The design of railroad yards and terminals.

1·301, 1·302. Advanced Railway Transportation (A). A continuation of the undergraduate subjects in transportation engineering 1·271 and 1·272. It pertains to the design and operation of locomotive, freight and passenger terminals; use of motor transport; railway economics; public relations and control; and involves individual investigations and reports.

1·32. Design of Harbor Works (A). Includes the study of tides, currents, wave action, methods of shore protection, layout of channels and anchorage basins, size of ships; methods of making soundings, borings, pile driving, pile tests, wharf construction, dredging, land reclamation and other waterfront construction; design of wharves, bulkheads and similar structures; methods and equipment for cargo handling; study of preservative treatment of timber. Field trips will include inspection of Boston Port facilities and waterfront construction.

1·34. Municipal Engineering (B). An elementary subject especially arranged for students in City Planning. It deals with the phases of municipal engineering that must be considered by those responsible for the planning or replanning of towns and cities. Subjects covered include the location, design, construction and maintenance of city streets; a study of urban problems of traffic and transportation; and a brief consideration of municipal systems of drainage, water supply, sewage disposal and other public utilities.

1·35. Roads and Pavements. Principles governing the location, construction and maintenance of roads, and the construction and maintenance of pavements for city streets. Bruce's *Highway Design and Construction.*

1·371, 1·372. Advanced Highway Transportation (A). Study of research results and methods of design, construction, maintenance, operation and economics of highways.

1·38. Highway Design (B). A design for the improvement of an existing highway by substitution of improved alignment, grades and new pavement, and the preparation of an estimate of cost.

Civil and Sanitary Engineering Continued

1·39. Graphic Statics. Graphic methods of problems dealing with forces and reactions, curves of bending moment and shear and stresses in simple trussed structures. Hudson and Squire's *Elements of Graphic Statics.*

1·40. Theory of Structures. An introductory subject covering outer forces, reactions, moments and shears for fixed and moving loads, the use of influence lines, the design of steel and wooden beams and plate girders, and the analysis of continuous beams by the use of the Equation of Three Moments. Spofford's *Theory of Structures.*

1·401. Theory of Structures. An abridgment of 1·40 for students in Courses VII_3 and IX-B. Spofford's *Theory of Structures.*

1·402. Structures. To cover strength of materials, bending moment and shear, distribution of normal and shearing stress, strength of columns, influence lines for bending moment and shear in beams and girders; effect of moving loads; beam and girder design; deflection of beams; composite beams; elementary theory of reinforced concrete.

1·41, 1·42. Theory of Structures (B). An extended subject, in continuation of 1·40. It deals with the analysis and design of the more common structures of wood, steel and masonry by analytical and graphical methods. First term: roof and bridge trusses of various forms, including simple end-supported trusses, three-hinged arches, cantilevers, portals, viaduct towers and three-dimensional frameworks. Second term: masonry structures, including dams and arches, and the application of the methods of deflection, least work, slope deflection, etc., to the solution of various statically indeterminate structures. Spofford's *Theory of Structures.*

1·411. Structures (B). A continuation of 1·402, dealing particularly with the analysis of trussed structures, three-hinged arches, cantilevers, portals, towers, three-dimensional frames and stability of masonry walls.

1·421. Theory of Structures (B). A continuation of 1·41 for students in Course VII_3. The elementary theory of reinforced concrete, stability of masonry walls, deflection of trusses and the theory of least work. Spofford's *Theory of Structures.*

1·422. Structures. Masonry structures including piers, retaining walls and arches, the deflections of beams and trusses and other structural members, and the analysis of building frames by slope deflection, least work, moment distribution and other methods. (Not offered in 1938–39.)

1·44. Stationary Structures. For students in Mining Engineering, designed to give them a knowledge of the fundamentals of the theory and design of structures.

1·451, 1·452. Structures. Arranged for Naval Constructors. It is intended to give some familiarity with problems met by structural engineers and the usual methods employed by them in stress analysis for and design of structures. The subject matter includes the use of influence lines and the analysis of simple trusses, portals, rigid frames, trusses with redundant members, space framework, continuous beams, the computation of deflections and the analysis of statically indeterminate structures. Spofford's *Theory of Structures.*

1·46. Structural Design. Design calculations and drawings for a small steel truss bridge, intended to illustrate and amplify the work of 1·451, 1·452.

1·48. Foundations (B). A brief outline of the basic principles of Soil Mechanics, followed by the study of foundations for bridges, buildings and other structures. Pile foundations, deep foundations, and lateral pressure determinations are included. Jacoby and Davis' *Foundations of Bridges and Buildings.*

1·491. Soil Mechanics (A). A detailed study of those physical and mechanical properties of soil which govern its behavior as an engineering material. Principles of soil classification; studies of the laws of permeability, capillarity and seepage; the quicksand phenomenon; compressibility and consolidation; sheering strength of cohesionless and cohesive soils; elasticity and plasticity; and correlation of these factors with problems in earthwork engineering. *Mimeographed Notes.*

1·492. Soil Mechanics (A). Specific applications of modern soil research are considered on the basis of the physical studies of 1·491. Stability of slopes and retaining walls; earth and masonry dams, with special reference to stability, seepage, and piping effect; bearing capacity and settlement of foundations; piles and pile groups; frost action; and special types of foundations. *Mimeographed Notes.*

1·493. Soil Mechanics Laboratory (A). Technique of soil testing, including measurements of specific gravity, water content, density and limits of consistency; mechanical analyses; permeability, consolidation and shear tests; various special tests.

1·501. Bridge Design (B). Shows the relation of the theory of structures to engineering practice through the preparation of designs and drawings for a riveted plate girder railway bridge, a welded girder bridge and a wooden truss. Emphasis is laid on the development of careful, systematic and practical habits of computation.

1·502. Structural Design (B). An extension of 1·501 including the design of a riveted steel truss highway bridge, and a reinforced concrete bridge.

1·51. Advanced Structural Theory (A). A study of the basic theorems underlying the analysis of statically indeterminate structures, computation of deflections of trussed structures, method of slope-deflection, moment distribution procedure.

1·52. Structural Design (B). Application of the theory of structures to the design of a steel truss highway bridge.

1·531. Reinforced Concrete Design (B). Covers by lecture and problem work the design of reinforced concrete floor systems, columns and footings. Special attention is given to the consideration of costs and economical design.

1·532. Reinforced Concrete Design (B). A continuation of 1·531 consisting of the complete design of a typical cross-section for a building, including flat slab and ribbed floor systems, also simple and combined footings. Lectures and problems cover moments at beam and column connections.

1·541, 1·542. Reinforced Concrete Design, Advanced (A). First term: a more advanced treatment of the subject matter handled in 1·58, designed for graduate students from other colleges who have already had some training in this field. A complete design for an interior bay

Civil and Sanitary Engineering Continued

of a typical factory building, illustrating design of floors of various types, columns, footings, etc. Second term: a continuation of 1·541, dealing with more difficult types of concrete structures, such as the rigid frame bridge, domes, tanks and similar structures.

1·551, 1·552. Structural Design, Advanced (A). A study of problems met by the designing engineer, such as choice of type, economics, design, erection methods, with special reference to indeterminate structures, such as high buildings, arches, suspension bridges, and continuous trusses.

1·561, 1·562. Structural Theory, Advanced (A). A study of the basic theorems underlying the analysis of statically indeterminate structures, and the methods of applying these theorems in the analysis of statically indeterminate structures, computation of deflections by various methods, secondary stress analysis.

1·571, 1·572. Statically Indeterminate Structures (A). A detailed study of certain types of indeterminate structures such as continuous and suspension bridges, high building frames, arches, arched dams. Spofford's *Theory of Continuous Structures and Arches.*

1·58. Design of Reinforced Concrete Structures (B). The elementary principles of reinforced concrete with the consideration of methods and rules used in design of concrete structures.

1·59. Concrete Research (A). Gives opportunity for attacking special problems, such as the determination of important properties of concrete under various conditions. It also permits studies aimed toward improving the quality of concrete through determination of the effect of numerous variables upon the important properties. The variables include: character and gradation of aggregates, composition and fineness of cement, exposure conditions, size of mass, addition reagents, method of tamping, and proportions of materials. The important properties include: heat of hydration, volume change, durability, strength, elasticity, permeability, plastic flow, and workability.

1·60. Hydrographic Surveying. At Camp Technology. (a) Stream gaging: The student is instructed in the principles of measuring the flow of water in open channels, the work being carried out on one of the nearby streams. Each student is instructed in the use of various types of current meters and the test data of his gagings assembled and plotted. (b) Soundings: On Gardner's Lake the student is instructed in the method of making soundings, including instruction in the use of the sextant.

1·62. Hydraulics. The elementary principles of hydrostatics and hydrodynamics, including the laws governing static and dynamic pressure, and the flow of water through orifices, tubes, nozzles, weirs, pipe lines and open channels. Special attention is given to the laws of hydraulic friction and accompanying losses; to the practice of water measurement in pipes and open channels; and to such important occurrences as back water in channels, the hydraulic jump and water hammer. Includes a discussion of the fundamental theory underlying the design and operation of hydraulic turbines and centrifugal pumps. Russell's *Hydraulics, Fourth Edition.*

1·63. Hydraulics. Comprises the essentials of 1·62 but omits the hydraulic turbines and centrifugal pumps. The treatment of pipe-flow and open channels is also abbreviated. Russell's *Hydraulics, Fourth Edition.*

1·64. Hydraulics. Comprises the essentials of 1·62 but certain portions of the subject matter are abbreviated. Russell's *Hydraulics, Fourth Edition.*

1·66. Hydraulics, Advanced (A). An elaboration of subjects fundamentally treated in 1·62 and, in addition, studies in the advanced field of theory and practice. Special treatment of pipe flow (including air, water and oil), the alternate stages of flow in open channels, design of transitions, the hydraulic jump, laws of hydraulic similitude and model experimentation are among the subjects included. Russell's *Hydraulics;* Gibson's *Hydraulics, and professional papers.*

1·68. Theory of Models (A) Presents the principle of dimensional analysis and its application to many problems, also the theory of models as applied to conditions of dynamic similarity when terrestrial gravitation, universal gravitation, viscosity, capillarity and elasticity are the physical forces acting. Numerous model studies will be cited to illustrate the work covered.

1·691. River Hydraulic Laboratory (A). Instruction in the construction of models for river hydraulic experiments, in the method of making such experiments, and in the interpretation of the results thereof. Registration for the subject is limited in accordance with the number of models available in the laboratory.

1·692. River Engineering (A). A study of the hydraulic factors affecting river flow, the theory of bed load transportation, and means for improving rivers as regards floods and also for navigation.

1·70. Water Power Engineering (B). This subject and 1·71 treats of the problems involved in the location, design and construction of hydroelectric developments as a foundation for practice in this field, or for the advanced studies of the graduate year. The subjects include a thorough study of hydrology: precipitation, run-off, water losses and their relations; the analysis of stream flow data as a basis for estimates of water power, flood flow, storage and pondage problems, followed by the theory and practice of hydraulic turbines and general plant arrangement. Barrows' *Water Power Engineering.*

1·71. Water Power Engineering (B). Continuing from 1·70 the elements of design of the main features of a hydroelectric development—the dam, waterway and power house are studied. The work of both terms is also accompanied by drafting room exercises, consisting of computations, reports and problems of design. Barrows' *Water Power Engineering.*

1·72. Flood Control (B). Includes elements of importance in flood control, flood frequencies, flood damages, and the economics of flood control and water power development; reservoirs for flood control, their selection and planning, including a study of dams and waterways; channel improvements and levees. Supplemented by drafting room exercises with reports and problems of design. Barrows' *Water Power Engineering.*

1·731, 1·732. Water Power Engineering, Advanced (A). These subjects are supplemented by subjects 1·851, 1·852 and include the study and design of the

Civil and Sanitary Engineering Continued

various portions of some water power project at a site where actual data are available from surveys and reports. Other general problems of power development are also considered, with their basic theory and practice. A field trip of several days' duration to examine typical power and storage developments is included. Barrows' *Water Power Engineering*. Creager and Justin's *Hydroelectric Handbook* and Justin and Mervine's *Power Supply Economics*.

1·75. Hydraulic and Sanitary Engineering (B). The first eleven weeks are devoted to a comprehensive study of the principles of water supply engineering, which includes rainfall and run-off, consumption of water, surface and ground water supplies, dams and impounding reservoirs, supply and distribution works, principles of treatment of water and design of treatment works. Opportunities for group inspection of nearby treatment works are included and a limited number of students are permitted to receive several days' instruction in the operation of a modern water treatment plant in a nearby city. The last four weeks are devoted to a study of the principles of design of sanitary sewers and storm drains, including methods for estimating the quantity of sewerage and storm water run-off. Babbitt and Doland's *Water Supply Engineering*; Metcalf and Eddy's *Sewerage and Sewage Disposal, a Textbook*.

1·76. Sanitary Engineering (B). A continuation of 1·75 covering the principles of design and construction of sewage collecting systems and appurtenances, the principles of sewage treatment and the design and construction of treatment works. Opportunities are offered for group inspection of nearby sewage works and a limited number of students are permitted to receive several days' training in the operation of a modern sewage treatment plant in a nearby city. Metcalf and Eddy's *Sewerage and Sewage Disposal, a Textbook*.

1·78. Sanitary Engineering (B). A continuation of 1·75, covering in more detail the subject matter of 1·76 and in addition thereto the elements of disposal of industrial wastes and municipal refuse and garbage. Opportunities are offered for group inspection of nearby sewage works and for several days' training in the operation of a modern sewage treatment plant in a nearby city. Metcalf and Eddy's *Sewerage and Sewage Disposal, a Textbook*.

1·79. Sanitary Design (B). The design of a sanitary intercepting sewer for a small community followed by the design of a system of storm drains for a small area.

1·801. Hydraulic and Sanitary Design (B). An investigation for and report on a gravity water supply for a small community.

1·802. Sanitary Design (B). The same as 1·79 followed by the design of a sewage treatment plant for the community.

1·811. Sanitary Engineering, Advanced (A). A comprehensive study of the principles of modern water treatment engineering, including coagulation, sedimentation, filtration, sterilization, softening, corrosion, and removal of tastes and odors. Opportunities are offered for group inspection of nearby treatment works and for several days' training in the operation of a modern water treatment plant in a nearby city. *Notes prepared by Professor Camp and textbooks and professional papers by various authors.*

1·812. Sanitary Engineering, Advanced (A). A comprehensive study of the principles of modern sewage treatment engineering, including screening, removal of grit, 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. Opportunities are offered for group inspection of nearby sewage works and for several days' training in the operation of a modern sewage treatment plant in a nearby city. *Notes prepared by Professor Camp and textbooks and professional papers by various authors.*

1·851, 1·852. Water Power Design, Advanced (A). (For description see Advanced Water Power Engineering 1·731, 1·732.)

1·881. Sanitary Design, Advanced (A). The design of a modern water treatment plant to effect the proper treatment of a given water for domestic and industrial consumption. Conducted in parallel with 1·811.

1·882. Sanitary Design, Advanced (A). The design of a modern sewage treatment plant to effect the proper treatment of a given raw sewage. Conducted in parallel with 1·812.

1·90. Professional Practice in Civil Engineering (A). Supplements the technical subjects offered by the Civil Engineering Department. It covers the professional, financial, quasi-judicial, and ethical obligations of the engineer to clients, contractors, the public, and to other engineers. Engineering costs, fees, salaries, accounting methods, reports, contracts for engineering service and the preparation of contract documents for the various types of engineering projects, are considered at length. The subject is illustrated by numerous examples taken from practice.

The following subject is offered as a General Study. For description see Division of General Studies.

G22. Development of Transportation.

MECHANICAL ENGINEERING

SUBJECTS 2·00 TO 2·99

2·00, 2·01. APPLIED MECHANICS. *Statics:* Analysis of force systems in two and three dimensions, laws of equilibrium, distributed forces, centers of gravity, moments and products of inertia, application in determination of external forces and internal stresses in simple frames and machine parts. *Kinematics:* The laws of motion applied to rigid bodies and systems of bodies in various types of mechanisms. *Kinetics:* Momentum, energy, work and power. Dynamics of translation and rotation of rigid bodies in plane motion. Fuller and Johnston, *Applied Mechanics, Vol. I.*

2·011. APPLIED MECHANICS. Abridged from 2·00 and 2·01.

2·02. APPLIED MECHANICS. Applications of graphical and analytical methods in the solution of problems in kinematics and dynamics which are of especial importance to the mechanical engineer, including cams, gearing, linkwork and other mechanisms; string polygons and stress diagrams for simple trusses and frames; graphical differentiation and integration. *Elements of Mechanism,* Schwamb, Merrill and James.

2·031. STRUCTURAL MECHANICS, ELEMENTARY. Arranged for students in Courses IV and IV-B. Includes a study of the fundamental principles of statics, using both analytical and graphical solutions for the determination of the stresses in simple frames and trusses. Formulae are derived for use in figuring the centers of gravity and moments of inertia of plane areas.

2·032, 2·033. STRUCTURAL MECHANICS. An elementary subject in strength of materials arranged for students in Courses IV and IV-B. Deals with the physical properties of materials, simple problems in tension, compression and shear, the common theory of beams, stresses in columns, etc. Also includes a few exercises in the testing materials laboratory.

2·04. APPLIED MECHANICS. *Strength of Materials.* The physical properties of materials; simple stresses, thin cylinders and spheres under fluid pressure, riveted connections; the common theory of bending, including shearing forces and bending moments, the distribution of normal and shearing stresses, the equation of the elastic curve and the determination of slopes and deflections in beams; eccentric loading; stresses due to combinations of axial and transverse loads; theories for determining the strength of columns; the theory of torsion of circular bars; particular emphasis being placed on the application of these theories in the solution of engineering problems. *Applied Mechanics, Vol. II,* Fuller and Johnston.

2·041. APPLIED MECHANICS. A combination of 2·02 and 2·04 especially arranged for students in II-A.

2·042. APPLIED MECHANICS. Similar to 2·04, arranged for students taking the short preparatory courses.

2·05. APPLIED MECHANICS. A study of statics, dynamics and strength of materials. (For U. S. Army Officers only.)

2·06. APPLIED MECHANICS. Theory of continuous beams; elementary theory of elasticity applied to cases involving plane stress, with applications to members subjected to combined bending and torsion, helical springs, thick cylinders and plates; theories for determining stresses in non-homogeneous beams and columns, particularly as applied to reinforced concrete; analytical and graphical solutions of some more advanced problems in dynamics. *Applied Mechanics, Vols. I and II,* Fuller and Johnston.

2·07. APPLIED MECHANICS. The study of more advanced problems in engineering mechanics including stresses due to inertia in moving parts of machinery and graphical solutions applied in the field of statics and strength of materials.

2·08. APPLIED MECHANICS. Similar to 2·081 but especially arranged for students in II-A.

2·081. APPLIED MECHANICS (B). A study of the forces in machinery due to work applied and inertia of the moving parts. Graphical and analytical methods of determining accelerations in plane motion, with applications to crank and connecting rod mechanisms, speed regulation by means of fly-wheels, etc. Harmonic motion and other types of motion produced by cams of various forms are included. A portion of the course is devoted to the theory of free and forced vibrations in elastic bodies, with and without damping. A study of dynamometers for the measurement of power is also included.

2·082. APPLIED MECHANICS (B). A study of advanced engineering problems in mechanics, including stresses in moving parts of machinery, dynamic balance, critical speeds, friction losses, applications of the theory of least work, stresses in transmission lines and tramways, and various other problems in the field of mechanical engineering.

2·10. ORDNANCE ENGINEERING (B). Lectures and calculations on gun design, including stresses and strains in built-up and wire-wrapped guns; the design of recoil and counter-recoil mechanisms. The calculation of stresses in gun carriages, foundations, gear trains, roller bearings, and foundation bolts used in different types of mounts, forms an important part of the subject.

2·11. INDUSTRIAL PLANT ENGINEERING (B). Covers (a) soils and foundations, types of superstructures with some computation of steel and concrete frames; (b) heating and ventilation, air conditioning, and mechanical equipment of buildings; (c) fire protection methods.

2·121. APPLIED PHOTOELASTICITY (B). Instruction and practice in the use of commercial photoelastic apparatus with applications in the analysis of common engineering problems, together with lectures on modern photoelastic theory, materials, and methods.

2·125. RESEARCH IN PHOTOELASTICITY (A). Opportunity is afforded graduate students to apply photoelasticity to the solution of special problems, or to take part in current development of photoelastic theory and technique.

2·131. DYNAMICS OF ENGINES (A). Lectures and drawing-room exercises on the inertia forces and the

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stresses in the running parts of high-speed gasoline engines. Application is made chiefly to the types of engines used in automobiles.

2·132. Dynamics of Aircraft Engines (A). An advanced subject given to students having considerable knowledge of engine balancing and practical experience with aircraft engines. (For U. S. Naval Officers only.)

2·151, 2·152. Dynamics. A study of the inertia effects of rigid bodies and systems of bodies in motion other than simple translation or rotation about fixed axes. Begins with general cases of plane motion of extended bodies, and afterwards covers motion in three dimensions, relative motions, and motions about axes whose directions are changing. It deals particularly with the centripetal and gyroscopic couples associated with stabilizing and control devices of interest in torpedo design. (For U. S. Naval Officers only.)

2·201, 2·202. Advanced Mechanics and Theory of Elasticity (A). The fundamentals of the mathematical theory of elasticity in three dimensions developed for application in practical problems in strength of materials and dynamics; including St. Venant's theories of flexure and torsion, stresses in plates, rotating cylinders and shafts, compound cylinders, temperature effects, stresses in curved bars and unsymmetrical bars under flexure, stability of thin rods, plates and cylinders under pressure, vibration, etc.

2·203. Theory of Elasticity. The fundamentals of the mathematical theory of elasticity developed with particular reference to the solution of problems in the field of ordnance engineering. (For U. S. Army Officers only.)

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

2·222. Advanced Plasticity Problems (A). Continuation of 2·221 with practical applications. Bending and buckling of bars 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. The rolling, drawing, and extrusion of metals. Plastic flow problems in the field of synthetic plastics. Special problems are chosen in consultation with the instructor.

2·223. Plasticity Research (A). Experimental and theoretical investigations are carried through in the general field of the plasticity of engineering materials.

2·251. Fluid Mechanics. Physical properties of fluids, hydrostatics, stream line flow, circulation, dynamics of perfect fluids, compressibility and viscosity, laws of similitude, dynamics of real fluids, laminar and turbulent flow, friction, losses, flow measurements, principles of hydraulic machinery.

2·252. Fluid Mechanics. Continuation of 2·251. Physical fundamentals governing heat transfer in convection based on fluid mechanics and similitude with engineering applications. Application of laws of viscous flow to lubrication mechanics. Application of theory of compressible fluids to engineering acoustics. Sound intensity, propagation and absorption. Flow of fluids at sonic velocity.

2·253. Fluid Mechanics. The content of 2·251 and 2·252 compressed into one term. (For II-A only.)

2·254. Fluid Mechanics. Lectures of 2·251.

2·255. Fluid Mechanics. Lectures of 2·252.

2·271. Hydromechanics (A). Mechanics of a continuum, kinematics and dynamics of ideal and viscous fluids, compressible and incompressible fluids, flow in pipe lines, boundary layer, applications to hydraulic machinery.

2·272. Applied Hydromechanics (A). Continuation of 2·271. Potential flow, conformal mapping, flow around a single blade, a series of blades, induced drag, hydraulic machinery, leakage, fluids at high speed, cavitation, experimental methods and results.

2·273. Advanced Hydromechanics Problems (A). Selected in consultation with the instructor. Theoretical or practical research, design of hydraulic machinery.

2·30. Engineering Metals. A study of the principles involved in the production of cast metal parts. Lectures cover pig iron, ferrous and non-ferrous alloying, centrifugal casting, die casting, casting design, and inspection methods. Laboratory work consists of demonstration practice and reports on hand and machine molding, core making and testing, sand testing, cupola operation, oil and gas furnace melting of ferrous and non-ferrous metals, permanent mold casting, and the testing of cast metals. *Metal Castings*, Campbell.

2·304. Foundry Engineering (A). Covers advanced subjects in the fields of casting design, casting defects, foundry processes, heat treatment, sand control and testing, refractories, foundry organization and layout, pyrometry, and strength and properties of cast metals.

2·31. Engineering Metals. A study of mechanical working, heat treatment and its effects on physical properties, with applications to engineering metals. Subjects given include wrought iron and steel making processes, steel properties and specifications, constitution of steel as affected by heat treatment, special alloys and treatments, wrought non-ferrous metals, physical properties including tensile and fatigue, and high temperature effects, metal working calculations, physical testing and examination of wrought metals. *Materials of Construction*, Mills.

2·32T. Engineering Metals. A study of the fundamentals of the welding processes as applied to manufacturing and construction, and their influence on metals. Processes include manual and automatic A.C. and D.C. arc welding; oxy-acetylene welding; spot, seam, butt, and flash resistance welding; gas cutting, flame machining, and hard surfacing. Emphasis is placed on the general problem of design for welding and on the effect of welding procedure on the properties of welded joints.

2·33T. Engineering Metals (B). Further development of work given in 2·30 and 2·32T covering advanced studies in these fields and allowing opportunity for indi-

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vidual investigations dealing with the casting and mechanical working of metals.

2·331T. Metal Processing. A subject covering problems in the casting, hot and cold working, and welding of metals. Arranged to suit the needs of Naval Constructors. (Open only to students in XIII-A.)

2·332. Advanced Welding Engineering (B). A Continuation of 2·32T intended for students who expect to be actively engaged in welding engineering. The subjects covered include metallography of welding, design and strength of welded joints, residual stress effects, welding codes and specifications. *Current Technical Literature.*

2·34. Properties of Metals under Stress (A). An advanced subject on the behavior of metals under tension and compression, with special reference to overstrain and recovery. Phases of the mechanics of plastic flow dealing with creep of metals at high temperature. Effect of combined stress both static and dynamic and consideration of various strength theories bearing on failure of metals. Stress concentration in brittle and ductile metals, working stresses. Laboratory work in tension, compression, hardness, photoelasticity, and combined stress.

2·35. Engineering Materials (B). A study of ductile materials under tension, compression, torsion, and fatigue. Effect of temperature on tensile and fatigue properties. Fatigue under complete and incomplete stress reversals; effect of speed and form. Gerber, Goodman, and Moore empirical laws of fatigue; stress concentration. Basis of choice of working stresses for simple stress and simplified cases of combined stress. Laboratory exercises on points covered by lecture work such as stress concentration, damage effects in fatigue.

2·351. Materials of Engineering. A study of the production and engineering properties of metals, their alloys and the more important non-metallic materials; introduction to tensile and fatigue tests and their relationship to composition; physical metallurgy including alloy diagrams and the effect of hot and cold work and heat treatment. Consideration is given to the suitability and specifications of these materials in design. *Materials of Construction.* Mills.

2·361. Advanced Strength of Materials (A). The subject will embrace more advanced work on the behavior of materials under stress. Experts from outside interests assist the staff members in presenting certain special features. Laboratory exercises are held bearing on the subject matter presented in the lectures. Seminars on related subjects take place at frequent intervals. Two all-day conferences are held, at which representatives from industry present special subjects not covered in the lectures. During the summer of 1937, the general strength properties of metals were treated. In 1938 the strength properties of timber and concrete were scheduled. (For detailed description see Summer Session Catalogue for current year.)

2·37. Testing Materials Laboratory (B). Covers various laboratory methods for determining the physical properties of engineering materials and the interpretation of results of such tests. In addition to the usual study of the behavior of materials under stress, consideration is given to the testing of fabrics, stress analysis by strain determination and by photo-elastic methods. Measuring instruments, X-ray examination, methods of calibration and special research problems are included in the lecture periods. *Materials Testing.* Cowdrey and Adams.

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. *Materials Testing.* Cowdrey and Adams.

2·372. Testing Materials Laboratory. Similar in general outline to 2·37 with additional requirements in research reading.

2·373. Testing Materials Laboratory. A combination of 2·37 and 2·38 especially adapted to the Course in Building Construction.

2·38. Testing Materials Laboratory (Concrete). A study of the materials used in concrete, both plain and reinforced; the selection of a proper aggregate from materials that may be available, their treatment for various purposes and methods of proportioning. Instruction is supplemented by excursions to concrete jobs, concrete products companies and central mixing plants. *Plain Concrete.* Bauer.

2·391, 2·392. Dynamic Strength of Metals (A). A laboratory subject with weekly seminar, devoted to the study and experimental investigation of the strength and life of metals under working conditions. The following subjects will be discussed: fatigue, including influences of surface condition and corrosion; impact; instrumentation for vibration and dynamic stress; inelastic properties and effect on dynamic strength; creep at normal temperatures; wear and corrosion.

2·40. Heat Engineering. The laws of thermodynamics. Heat equations. Physical properties of fluids, especially of air and steam. Laws of heat flow by radiation, conduction and convection. Flow through composite walls and concentric cylinders. Film concept. Surface coefficients. Mean temperature difference. The fundamental laws governing the flow of fluids with application to orifices and nozzles. *A Standard Textbook on Thermodynamics; The Temperature Entropy Diagram*, Berry; *Steam Tables*, Keenan and Keyes.

2·41. Heat Engineering. A brief study of the fundamental laws and conceptions of engineering thermodynamics; the physical properties of gases, saturated and superheated vapors and their use in thermodynamic problems including the use of steam tables and charts; the laws governing the flow of gases and vapors and their application to heat engineering; elementary steam turbine theory and practice. In discussing the application of the various principles a brief description will be given of the apparatus and machines involved. *Elementary Engineering Thermodynamics*, Taft; *Steam Tables*, Keenan and Keyes.

2·411. Heat Engineering. An abridgment of 2·41.

2·42. Heat Engineering. Discussion of turbine and reciprocating engine cycles. Study of losses in real engines. Hirn's analysis. Heat flow to and from cylinder walls. Method of minimizing heat losses. Multiple fluid, reheat and regenerative cycles. Hot air and internal combustion engine cycles. Humidity and air conditioning

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problems. Theory and calculation of cooling towers. *Textbooks same as for* 2·40.

2·421. Heat Engineering. A study of theoretical vapor cycles; the reciprocating steam engine; theoretical gas cycles and the internal combustion engine; air compressor theory and practice; steam boilers, accessories and combustion. A brief discussion of the principles of refrigeration, heat transmission and humidity problems. The descriptive work will be continued as in 2·41. *Elementary Engineering Thermodynamics*, Taft; *Steam Tables*, Keenan and Keyes.

2·43. Heat Engineering (B). Power absorbing processes. Air compressors, efficiency, displacement, etc. Heat pumps. Kelvin warming engine. Refrigeration processes. Comparison of ammonia, carbon dioxide, water and air compression refrigeration cycles. Refrigeration at different levels. Voorhees multiple effect compressor. Elementary discussions of absorption refrigeration systems. Heat flow problems in condensers, interchanges, etc.

2·44. Thermodynamics of Mixtures (B). A study of the fundamentals of thermodynamics of mixtures and applications to engineering problems.

2·45. Engineering Thermodynamics, Advanced (A). The first and second laws of thermodynamics, their application to fixed mass and steady flow processes and to the determination of the properties of fluids. An introduction to the thermodynamics of solutions and chemical reactions and a study of the equilibrium of a pure substance.

2·461. Advanced Refrigeration (A). Use of various equations of state, van der Waals, Dieterici, Keyes, reduced forms, etc., with special application to the liquefaction of air. Thermodynamics of mixtures of gases and vapors with applications to the absorption refrigerating systems and to the separation of gaseous mixtures.

2·462. Heat Transmission Advanced (A). The variations of surface coefficients, conductivities, etc., under varying conditions; laws of heat transmission as illustrated in steam condensers, feed water heaters, brine coolers, radiators, steam boilers, engine cylinders, cooling of castings, freezing of ice, etc. It includes the solution of problems involving fluctuating and transient temperature conditions.

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 available heat insulating materials.

2·501. Heat Measurements. Same as 2·50, omitting the lectures.

2·51. Heat Measurements (B). A lecture and laboratory subject dealing with the theory and practical application of temperature measurements and the methods of measuring coefficients of heat transfer such as the conductivity, conductance, transmittance, convection, radiation and surface coefficients.

2·52. Heat Measurements (B). Lectures and laboratory exercises in temperature measurements including thermo-couples, resistance thermometry, optical and radiation pyrometry. The effect of radiation on true temperature measurement is treated. The study of heat transfer includes the actual determination of the coefficients of thermal conductivity by usual methods at high and low temperatures for different types of materials. The total radiation loss from low temperature surfaces is also experimentally determined.

2·53. Heat Measurements (A). An advanced subject consisting of selected experiments followed by a laboratory investigation of problems connected with the industrial application of heat such as thermal conductivity, thermal expansion, specific heat, ceramics, etc.

2·55. Power Plant Engineering (B). The production and use of steam for the generation of power, including a study of fundamental types of steam boilers, fuel burning equipment, prime movers and their allied apparatus. (Not offered in 1938–39.)

2·551. Power Plant Engineering. A consolidation of 2·55 and 2·56 particularly adapted to students in the Coöperative Course (II-A).

2·56. Power Plant Engineering (B). A continuation of 2·55 with application to problems. Will also include the fundamentals of the Diesel and Hydraulic power plant. (Not offered in 1938–39.)

2·56T. Power Plant Engineering (B). A combination of 2·55 and 2·56 (for 1938–39 only.)

2·57. Power Plants Advanced (A). An advanced subject on 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. The various steam cycles and types of auxiliary drive will be studied to show their effect on station heat balance. Includes discussion of deaërators, evaporators, condensers, heater, etc., including turbine and machinery foundations and layouts. Lectures and problems will be supplemented by trips.

2·58. Heat Engineering in Industrial Plants (B). Deals with the use of steam in such industrial plants as shoe and rubber factories, paper mills, laundries, hospitals, etc. The general characteristics of such plants, the selection of the heat and power supply and the distribution of steam for power and heating are considered. Problems are presented and solved in connection with the various heat machines in the power plant. Questions in connection with the use and economy of steam for process and heating are thoroughly discussed. Students are required to solve problems from actual plant data. Trips to various industrial plants will supplement the classroom work.

2·59. Torpedoes. Deals with the utilization of energy in the power plant of a torpedo. Includes the thermodynamics of gas and vapor mixtures, the laws of combustion of gaseous mixtures, heat losses, and the laws of heat transmission. The principle of the flow of fluids is applied to the calculation of the time required to decrease the pressure in the air tank, to design gas turbine nozzles and to determine the power developed in the turbine. (For U. S. Naval Officers only.)

2·60, 2·601. Food Engineering. A brief survey of the elementary principles of mechanism, mechanics, heat engineering, heat transfer and refrigeration precedes a discussion of the methods, processes, materials and equip-

ment used in the preparation and handling of foodstuffs, including canning machinery, packaging machines, bottling equipment, conveying systems, temperature and humidity control, bakery installations, etc.

2·621. Refrigeration Engineering (B). Deals with the physical properties of low temperature insulants; heat transfer through typical walls of cold storage plants, refrigerator cars, and refrigerator ships; moisture and temperature conditions necessary for the preservation of the important foods; the microbiology of foodstuffs, the nature of their ripening and spoilage, the impurities in the atmosphere.

2·622. Refrigeration Engineering (B). A study of the operation of various types of compressors, evaporators, condensers, and automatic controls used in commercial and household refrigerating systems. The application of refrigeration in the manufacture of water ice, eutectic ice, and dry ice. Time required to freeze ice. Ice formation on pipe surfaces. Manufacture of ice-cream. Students present a paper on the application of refrigeration to an industry not covered in the lectures.

2·63. Storage and Transportation of Foodstuffs (A). A continuation of 2·621 with a study of the refrigeration load and necessary equipment. Trips to near-by plants will be made, where it is possible, to supplement classroom study.

2·64. Refrigeration Engineering (A). A study of thermal, physical, and toxic properties of the chief refrigerants. A discussion of the more complicated applications of refrigeration to industry and science. Students present a paper on the application to an industry not covered in the lectures.

2·65. Mechanical Equipment of Buildings, Heating and Ventilation. Principles and practice of heating and ventilation; discussion of the various other mechanical equipment of a building, such as elevators, dust collecting systems, etc. Fifteen hours are given over to trips.

2·651. Mechanical Equipment of Buildings. Abridgment of 2·65.

2·66. Heating, Ventilation and Air Conditioning (B). Study and calculation of load, direct and indirect heating systems, heating boilers and water heaters, ventilation and the fundamentals of air conditioning.

2·671. Air Conditioning, Advanced (A). A study of the psychrometric and comfort data with application to air conditioning problems. Typical air conditioning equipment and controls will be studied with their application to various types of problems.

2·672. Heating and Ventilation Design (A). The choice of type of heating and ventilating system for a particular building, layout of piping and duct system together with complete calculations and estimation of cost. An investigation and study of existing plants will be made with trips to these plants whenever possible to bring out the practical problems involved in design.

2·680. Engineering Laboratory. The use and calibration of instruments used in mechanical engineering; the practice of heat measurements including heat by combustion and heat transfer; experimental studies involving the 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 (B). The use and calibration of instruments used in mechanical engineering practice is followed by experimental studies of heat engineering problems and problems in fluid mechanics. The equipment used consists of steam engines, steam turbine driven pumps, steam pumps, steam specialties, stationary internal combustion engines, an air fan, a single stage air compressor, an impulse type water wheel and pipe lines for study of fluid flow. (1938–39 only.)

2·682. Engineering Laboratory (B). A continuation of 2·681 with equipment such as the following: an air washer for humidity control, a two-stage air compressor, the M. I. T. power and heating plant, heat exchangers, heat measurements, a hydraulic turbine. (1938–39 only.)

2·683. Engineering Laboratory. Similar to part of 2·680.

2·684. Engineering Laboratory. Continuation of 2·683.

2·685. Engineering Laboratory. A combination of 2·683 and 2·684.

2·686, 2·688. Engineering Laboratory. Similar to 2·680. The exercises assigned to the several Courses differ somewhat according to the several fields of interest.

2·687. Hydraulic Laboratory. Supplements classroom theory and includes exercises upon orifices, nozzles, weirs, pipes, hydraulic turbines, centrifugal pumps, and other hydraulic equipment.

2·69. Refrigeration and Air Conditioning Laboratory (B). Experiments on, and study of various types of refrigeration, heating and air conditioning equipment. The refrigeration equipment consists of compression and absorption types and includes small commercial and domestic units using ammonia, sulphur dioxide Freon and methylchloride refrigerants. A constant temperature room is used in testing the units.

2·691. Refrigeration Laboratory (B). Similar to 2·69, omitting air conditioning.

2·692. Refrigeration and Air Conditioning Laboratory (A). Experiments with various refrigeration systems including the application of heating and refrigeration to air conditioning apparatus. Research problems.

2·70. Machine Drawing. Practice in the production of working drawings, including layout, detail and assembly drawings. Instruction is also given in drafting room procedure. *Working Drawings of Machinery*, James, Mackenzie and Sloane.

2·701. Machine Drawing. Engineering drafting-room procedure and technique in the production of working drawings of machinery. *Working Drawings of Machinery*, James, Mackenzie and Sloane.

2·71. Theory and Application of Mechanisms. The first portion of the subject consists of a comprehensive study of the theory of mechanisms by means of graphical and analytical methods. Introductory lectures on vector determinations of velocities and accelerations are followed by a discussion of wrapping connectors, cams, linkwork, screws, gear trains, differential mechanisms and gearing,

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including the theory of conjugate action, methods of production and design of spur, bevel, and screw-gearing. The second portion is of a more advanced character, with special emphasis on such design features as selection of suitable materials, determination of forms and proportions of parts, ease of assembly and repair, friction and provision for wear, etc. Lectures and problems cover the design of machine fastenings, shafting under combined bending and torsion, clutches and brakes, bearings, etc. Certain automotive problems are used to demonstrate the principles discussed. The design and construction of such representative automatic production machines as automatic screw machines, wire working machines, automatic machine-tools, are also studied. (For U. S. Army Officers only.)

2·72. Machine Design. Discussion of the theories of common mechanisms, with their application in design. Includes wrapping connectors, screws, spur and bevel gears, worm gearing, shafts, bearings, etc. Materials, forms and proportions of parts, friction and efficiencies are included. (For U. S. Naval Officers only.)

2·731. Machine Design. Discussion and design of machine elements with special reference to the selection of materials, proportions of parts and the economies of manufacture and assembly. The subject includes frames, fastenings, flat plates, tanks, and applications to simple machines.

2·732. Machine Design (B). A continuation of 2·731, including shafting, bearings, theory of lubrication, shaft connectors, all forms of gears, flywheels, etc. The work culminates in the complete engineering design of a comprehensive machine.

2·733T. Machine Design. Similar to 2·732, particularly adapted to students in the Coöperative Course (II-A).

2·74. Machine Design. A discussion of the principles underlying the design of machine elements, including fastenings, shafting, bearings, belting, gearing, balance wheels, etc. Particular emphasis is laid on the proper choice of materials, methods of manufacture, and rational methods of design. Illustrative problems are assigned for solution in the drawing room.

2·751, 2·752. Machine Design, Advanced (A). A systematic application of the principles of applied mechanics to the design of machines of complicated character. The subjects of centrifugal effects, vibration, balancing, lubrication and combined stresses are treated at considerable length. Lectures and problems on brakes and advanced gear design are also included. *Library research.*

2·761, 2·762. Machine Design. Subjects especially arranged and adapted to the needs of specialists in torpedo design. (For U. S. Naval Officers only.)

2·77. Design of Production Machinery. A discussion of automatic machines used in production work, such as wire working machines, automatic lathes, automatic screw machines, etc.

2·791. Automotive Engines (B). A study of the fundamental principles of the internal combustion engine, together with an introduction to design, including the principles of similitude, vibration and balance, materials of construction, working stresses, etc. Lectures and assigned reading are supplemented by laboratory work arranged to emphasize the principles discussed in the classroom.

2·792. Automotive Engines (B). A continuation of 2·791. Essential processes such as carburetion, distribution, ignition, lubrication, are studied as applications of fundamental physics and chemistry to the particular problems of the internal combustion engine. Among the design problems covered are superchargers, induction systems and auxiliary equipment.

2·793. Automotive Engine Design (B). Based on subject 2·791, but may be taken simultaneously. Each student makes engineering computations for, and assembly drawings of, one particular type.

2·794. Automotive Engine Design (B). Continuation of 2·793. The student may go farther with the design started in the previous term or he may select a new type for computations and layout.

2·795. Automotive Vehicles (B). A study of the power plants, transmission systems, running gears, chassis, and bodies of automotive vehicles including developments in domestic and foreign fields.

2·796. Automotive Vehicles (B). Continued study of automotive vehicles including current and future developments. Continuation of 2·795.

2·797. Automotive Vehicle Design (B). The design of some vehicle or component part to supplement 2·795.

2·798. Automotive Vehicle Design (B). The design of some vehicle or component part to supplement 2·796 and a continuation of 2·797.

2·801, 2·802. Advanced Automotive Engine Problems (A). Individual work in research or design by properly qualified graduate students. Problems are selected in consultation with the Instructor, and the hours are arranged to suit the individual case.

2·803, 2·804. Automotive Engineering (A). Fundamentals of automotive engineering are the bases of this subject. Study is made of important parts; and procedure of design is outlined. The student is given free choice of the type of machine for his individual study.

2·82. Diesel Engine Design (B). Lectures and drawing-room exercises in the design of oil engines of stationary type. Engines are studied with special reference to the services in which they operate, and to shop methods of construction, as well as to the thermodynamics and mechanical principles of design. Review is made of engine balancing, particularly as applied to large multi-crank engines having pitching couples. A problem is assigned on the design of an engine for a definite service. Inspection trips are made to plants having engines of the type studied.

2·83. Steam Turbine Engineering (B). Thermodynamics, hydrodynamics, and mechanics applied to problems in steam turbine engineering.

2·851. Machine Tool Laboratory. A course in the use and application of machine tools. Includes laying out work, filing, scraping machine parts, drilling, reaming, counterboring and tapping, tool grinding, straight and taper turning, screw cutting, milling, cylindrical and surface grinding and chucking. Special attention is given to the

Mechanical Engineering Continued

cutting angles and adjustments of cutting tools and cutting speeds for each material worked. *Advanced Machine Work*, Smith.

2·852. Machine Tool Practice. A continuation of 2·851. Includes fundamentals of tool making, hardening and tempering, gear cutting, thread milling and generating, planing and shaping, turret lathe and automatic screw machine practice, grinding and lapping, broaching, precision measuring, time study and production manufacturing processes. *Advanced Machine Work*, Smith.

2·853. Machine Tool Laboratory. Laying-out work, grinding tools, chipping cast-iron, filing and fitting cast-iron and steel machine parts, alignment and babbitting of bearings, drilling, reaming, counterboring and tapping, grinding drills, soldering. General machine work, including centering straight and taper turning and fitting, screw cutting, chucking, finishing, drilling, tapping, cylindrical grinding, plain and index milling and gear cutting.

2·854. Machine Tool Laboratory. Covers brief parts of 2·851 and 2·852 including instruction in some of the other mechanical processes. *Advanced Machine Work*, Smith.

2·871. Manufacturing Engineering (B). Principles and practice in production design, selection of factory equipment, tool and gage design, and inspection methods. Lectures and drawing-room exercises on the manufacturing design of a commodity to be produced in quantity, including the principles of dimensioning detail drawings with tolerances and the preparation of other necessary specifications required to convey precise and complete information necessary for the selection of equipment, tool design, production, and inspection. Also study and drawing exercises in tool and fixture design as well as gages. *Principles of Interchangeable Manufacturing*, Buckingham; *Factory Equipment*, Roe and Lytle; *Tool Engineering*, Dowd and Curtis.

2·872. Preparation for Manufacturing (B). A study of many of the engineering problems which must be solved before a finished article can be manufactured in large quantities after the design of the article has been completed; such as engineering organization, estimating costs of production, the design of tools and equipment, factory extensions, and quality control. The practices of large corporations having the most highly organized engineering departments along these lines will be cited as illustrations and used as the foundation for discussion.

2·88. Metrology and Dimensional Engineering Standardization (A). A study of fundamental units of measure, measuring systems, and calibration of standards; the purpose of measurements in scientific and research work, engineering in general use; a study of conventional measuring instruments, their characteristics and methods of calibration; accuracy of measurements; analysis of measurements; shop measurements and analysis by means of measurement; dimensional engineering standardization; and inspection engineering. *American Engineering Standards, S. A. E. Handbook, Notes prepared for class and Library Research.*

2·091, 2·902. Principles of Fabric Structure (B). A discussion of the properties of fibers as they relate to the properties of yarns and fabrics; the properties of yarns as they relate to fabrics; and the construction and finishing of fabrics to produce certain desirable characteristics in these materials. Will also include material dealing with principles of woven fabric structure together with the formation of knitted, braided, twisted, and felted materials. Structures such as leno, lappet, and swivel, jacquard, pile, and looped fabrics of all sorts will be fully discussed. The details of fabric design and finishing are included with such discussions of mechanisms as are essential to a proper understanding of the details of fabric structure. Mathematical analysis of fabric structure is also included together with the limitations imposed upon the designer in this connection.

2·903. Elements of Textile Manufacturing (B). Deals with the details of the handling of fiber in general and the operations incident to its proper manufacture. The fundamental principles are discussed in detail. The work covers cotton, woolen, worsted, bast fibred materials, rayons, and silk.

2·904. Principles of Textile Manufacturing (B). A continuation of 2·903. Deals with the details of the operations and the fundamental principles involved.

2·905, 2·906. Textile Technical Analysis (A). Deals with the physical determinations of strength, stretch, moisture regain, twist and various mechanical properties of interest to the yarn and fabric technician. The formulation and proper presentation of the data, precision of measurements, graphical interpretation of data, the variable factors which influence textile testing results, and the outlining of present trends in the textile research in this country and abroad are included.

2·907, 2·908. Textile Microscopy (A). The application of optical and microscopical equipment to the technical analysis of textiles. Lectures and laboratory cover the types of equipment, their use and the technique of textile microanalysis for fiber, yarn and fabric. Opportunity is offered for intensive research on projects involving quantitative determinations; the development of technique; the application of photomicrography, polarized light, fluorescence, swelling technique, etc., to textile microscopy. Schwarz, *Textiles and the Microscope. Library References.*

2·911, 2·912. Textile Research Laboratory (A). Opportunity is offered for the student to operate standard textile testing equipment to study the variable factors influencing textile tests and to carry out one or more research problems in the field of physical or optical analysis.

2·92. Principles of Textile Analysis. Lectures, demonstrations and laboratory covering the usual physical and optical analyses of textile fibers, yarns and fabrics. Such subjects as structure, twist, strength, porosity, rigidity, tearing resistance, fastness to light, fastness to washing, fastness to crocking, microanalyses, photomicrography, graphical analysis of data, and report writing are discussed in detail. Schwarz, *Textiles and the Microscope;* Wellington Sears, *Fabric Handbook; Library References.*

2·951 to **2·954.** Manufacturing Practice. These numbers cover the manufacturing work taken by the coöperative students at the plants of the General Electric Company. All students do not necessarily follow the same detailed line of work, neither are they always assigned

Mechanical Engineering Continued

to the same department. In general, however, the work will be of an investigational and productional nature, rather than of a purely manufacturing calibre.

2·951. Manufacturing Practice. First term's work at General Electric Company.

2·952. Manufacturing Practice. Second term's work at General Electric Company.

2·953. Manufacturing Practice. Third term's work at General Electric Company.

2·954. Manufacturing Practice. Fourth term's work at General Electric Company.

2·96. Study and Research. Original investigation of a selected problem in consultation with the Supervising Engineer for works assignment at plants of the General Electric Company. A comprehensive report of the investigation is to be submitted at the end of the Summer Session to the Department of Mechanical Engineering staff member in charge of the Course.

MINING ENGINEERING

Subjects 3·00 to 3·99

3·01. Mining I. Prospecting and exploring including applications of boring; support of ground and timbering; shaft sinking; petroleum development and production; explosives, mining development, rock excavation and tunneling; mineral land titles; coal mine development; subsidence; metal and coal mine ventilation and coal mining; engineering thermodynamics; mine equipment embracing air compressing, machine drilling and coal cutting. Peele, *Mining Engineers Handbook.*

3·02. Mining II. A continuation of 3·01. Mine production with description of underground mining systems and selection of the proper method; construction and use of mine models, hydraulic flow and pumping in mining and petroleum and other special topics; mine equipment embracing mechanical loading, underground transport, aerial cableway, hoisting, drainage, ventilating, safety apparatus, lighting and surface plant; power shovel, dredge and hydraulic mining; sampling, selling and purchasing ores, fuels and other mineral products; inquiry into the principles of smelting contracts.

3·03. Economics of Mining (B). Mineral resources, metals, fuels and other minerals: the economic effects on the business of mining of the following factors; geographic situation, transportation facilities, overproduction and stocks, secondary metals, by-products, strategic minerals, substitutes, new discoveries, import and export tariffs, government regulations, taxes, monopoly, capital requirements and costs of production and marketing.

3·04. Mining, Principles of (B). The principles and practice of mine sampling and examination; the interpretation of data and the writing of reports; inquiry into the risk factor in mining investments and its effect on valuation; the principles controlling methods and extent of development; the character of mechanical equipment; standardization, administration, depreciation and depletion. Hoover, *Principles of Mining.*

3·061, 3·062. Mining Engineering, Advanced (A). For graduate students who have had some experience in mining practice and mining engineering, and who desire to do advanced work in some topic of the subject not specifically covered elsewhere. The student is expected to make his own choice of the topic and of the allotment of time. The latter may be devoted variously to lectures, conferences, assigned readings, library studies, drawings, computations and written reports.

3·08. Mining Practice. Given at the Summer Mining Camp at Dover, N. J. Six days in the summer will be spent in familiarizing the students with processes and operations in mining, crushing and concentrating with visits to a number of nearby metal and coal mines in New Jersey and Pennsylvania.

3·101, 3·102. Mine Valuation (A). Interpretation of mine sampling, estimates of ore reserves, design and estimates of cost of plant equipment, determination of operating costs and valuation of the ore deposit. Given by the case system and the time is devoted to lectures, conferences, assigned readings, computations, and written reports. Designed for graduate students who have a background of experience in mining practice.

3·12. Mining Economics, Advanced (A). The study and analysis of the reports of mining and petroleum companies with inquiry into the principles and practice of cost accounting, the methods of treating depletion, depreciation, and obsolescence, and the incidence of federal income taxes, duties, and tariffs.

3·13T. Mining III (B). Lectures covering the elements of prospecting by the various scientific means: including practical magnetic, electric, seismic and gravimetric methods; description and application of apparatus for surveying deep bore-holes. Field exercises provide opportunity for use of electrical and magnetic apparatus following typical field practice. Laboratory work offers a chance for further study of apparatus.

3·14. Mining IV (B). Conducted as a seminar in which the student is allowed the election of approved topics in metal, non-metal or coal mining, or ore dressing, and pursues his study under instructors in the particular field selected.

3·20. Ore Dressing I. A lecture course giving a fundamental background for the work with flotation and related operations which follow in the second term. Deals primarily with chemical and physical principles which are pertinent to an understanding of flotation and action of flotation reagents, such as pH measurement and control, flocculation and dispersion phenomena and adsorption and other surface effects.

3·21. Ore Dressing II (B). The mechanical concentration of the mine ore to separate the valuable minerals from the waste. The greater part of the time is devoted to wet gravity concentration and flotation, including

Mining Engineering Continued

crushing machinery, screens, classifiers, jigs, vanners, tables and flotation machines. Amalgamation, pneumatic, electrostatic and other minor processes are also discussed, as well as accessory apparatus, mill principles, milling economics and typical mill flow sheets. It is aimed to correlate the lectures with 3·22. Richards and Locke, *Textbook of Ore Dressing.*

3·22. Ore-Dressing Laboratory (B). Principles and actual operation of ore-dressing apparatus. Briquetting, polishing and quantitative microscopic studies of mill products. The class makes three mill runs, (1) on gold ore, using stamps, amalgamated plate, vanner, classifier and canvas table; (2) on lead ore using trommel, classifier, jigs and tables, and (3) a flotation mill run. Individual tests are made on crushing machines, sizing screens, hydraulic classifiers, magnets and flotation machines. One very important part of this work is the cleaning up, weighing, sampling and analyzing of all the products, the computation of results and the preparation of written reports which are discussed at the weekly seminars.

3·23. Ore Dressing. The lectures embody the principles of wet gravity concentration, flotation, amalgamation and magnetic separation. The most important crushing and concentrating machines of interest to the metallurgists are treated briefly. The laboratory work covers three seven-hour periods for three weeks, and three seminars of one hour; it is practically identical with that of 3·22 with the exception that lack of time prevents the student from performing individual tests. Richards and Locke, *Textbook of Ore Dressing.*

3·241, 3·242. Ore Dressing, Advanced (A). Somewhat variable in scope and time allotment. Devoted to lectures, conferences and assigned readings.

3·251, 3·252. Theory and Practice of Flotation (A). Library readings, conferences and laboratory work, going more deeply into the subject than is possible in undergraduate work, and dealing with special phases in flotation such as fundamental theory, study of reagents, differential flotation, application to oxidized ores and the economics of flotation.

3·26. Ore Dressing, Economics (A). Conferences and problems involving the various factors of equipment costs, operating cost, efficiency of operation and profit.

3·271, 3·272. Ore Dressing, Design (A). Design of flow-sheets and layout of mills; usually includes a special problem of mill design to cover a set of stated conditions.

3·81T, 3·82T. Petroleum I and II. Methods and legal forms for the acquisition of petroleum lands; the planning of surface improvements and of sub-surface development; methods of drilling oil and gas wells, drilling contracts and coöperation in drilling; methods of extracting oil and gas from natural reservoirs; methods of protecting wells from caving and from underground waters, and methods of transportation and storage. Safety, sanitation and housing of employees. Statistics and economics of the industry. Methods of preparing and using field, property, production and structural maps. Use of well logs and structural contour models.

3·85T, 3·86T. Petroleum III and IV (B). Special methods for increasing the flow of oil and gas to wells: the production and distribution of natural gas; the extraction of natural gasoline from natural gas; the utilization of petroleum products as affecting the oil and gas producer; elements of the valuation of oil and gas lands. Laboratory studies of problems in production, transportation and storage of crude petroleum and natural gas. Examination of cores and samples from producing formations for grain size, porosity, permeability and saturation. Testing of cements and muds used in oil wells. Treating of emulsions for the removal of water and sediments.

3·89. Oil Field Visits. A five-day trip to the oil and gas fields of Western Pennsylvania.

3·901, 3·902. Oil and Gas Land Valuation (A). Considers the factors entering into the valuation of oil and gas properties, given by the case system. Lectures, conferences, assigned readings, drawings, computations and written reports. For graduate students who have had some experience in petroleum production.

3·911, 3·912. Advanced Petroleum Engineering (A). For graduate students who desire to take advanced work in some branch of the subject not specifically covered by other subjects scheduled. The student is expected to make his own choice of the special division and the allotment of time. The latter will be devoted to lectures, recitations, conferences, assigned readings, library studies, drawings, computations and written reports.

3·921, 3·922. Oil and Gas Law (A). Laws and legal forms relating to the acquisition of petroleum rights to production, storage and transportation of petroleum, natural gas and their products.

ARCHITECTURE

SUBJECTS 4·00 TO 4·99

4·021, 4·022. FREEHAND DRAWING. Drawing from simple geometrical solids in pencil, graphite crayon, and wash, to give an understanding of form and its graphic expression after which these and similar simple forms are used in elementary exercises in composition. Six weeks are spent at the Boston Museum of Fine Arts in studying and analyzing the design of simple architectural and sculptural forms. Basic figure construction and anatomy are given, followed by quick sketching direct from the human figure.

4·031, 4·032. FREEHAND DRAWING. A continuation of 4·022. Drawing from the nude in line and graphite crayon.

4·041, 4·042. FREEHAND DRAWING. A continuation of 4·032. The student is encouraged to experiment in figure drawing in various media. Students showing sufficient mastery of the figure are permitted to work out simple figure compositions.

4·051, 4·052. FREEHAND DRAWING (B). A continuation of 4·042. Students work in different media and make both large and small drawings to give a better sense of scale and proportion. Forms other than the human figure are studied for use in composition work. Simple problems in figure composition are given, with special reference to an architectural application.

4·053, 4·054. FREEHAND DRAWING (A). A continuation of 4·052, the work and problems in figure composition being of a more advanced nature. Open only to graduate students who have passed 4·052, or who demonstrate fitness for advanced work.

4·06. GRAPHICS. The fundamental conceptions of orthographic projections and fundamental problems on lines, planes and solids with supplementary exercises in the application of the principles of descriptive geometry to problems of an architectural nature.

4·071, 4·072. MODELING. Aims primarily to develop the student's sense of a third dimension in his study of architectural composition. Sketch exercises in modeling wax upon a given program of an architectural character.

4·081, 4·082. COLOR, COMPOSITION, THEORY AND APPLICATION. Aims to familiarize the student with the theories of color, both scientific and aesthetic, and to give him practice in the use of color.

4·091, 4·092. COLOR, COMPOSITION, THEORY AND APPLICATION (B). A continuation of 4·081, 4·082, the problems being of a more architectural character.

4·11. SHADES AND SHADOWS. Fundamental knowledge necessary for casting the conventional shadows employed in architectural design. Drawing-room work in the nature of test exercises based on textbook preparation. Covers the application of descriptive geometry methods and also short methods of construction useful in practice. *Notes on Shades and Shadows*, H. W. Gardner.

4·12. PERSPECTIVE. General theories of perspective and the methods of revolved plan and perspective plan. Practical work involving variations, short cuts and office manipulations. *Principles of Architectural Perspective*, Lawrence.

4·312. ABSTRACT DESIGN. Exercises in the general principles of composition as applied to abstract lines and forms. Problems in composition of architectural subjects decorative in character.

4·421, 4·422. ARCHITECTURAL HISTORY. Lectures, illustrated by stereopticon, covering the periods of Egyptian, Assyrian, Persian, Greek, Roman, Byzantine, Gothic, Renaissance and Modern Architecture, supplemented by reference reading, theme writing, and group conferences.

4·43. ARCHITECTURAL HISTORY. Similar to 4·421 and 4·422 but shorter. It is conducted in substantially the same way and covers the same subject matter in less detail.

4·461, 4·462. EUROPEAN CIVILIZATION AND ART: CLASSICAL AND MEDIEVAL CULTURE. Constitutes a history of culture, mainly that of Europe. The main currents of science and philosophy are considered; but emphasis is upon literature, sculpture and painting. Lectures, readings, and reports.

4·471, 4·472. EUROPEAN CIVILIZATION AND ART: THE RENAISSANCE AND THE SEVENTEENTH CENTURY. A continuation of 4·462 and 4·471.

4·481, 4·482. EUROPEAN CIVILIZATION AND ART: THE EIGHTEENTH CENTURY AND MODERN CULTURE (B). A continuation of 4·472 and 4·481.

4·491, 4·492. EUROPEAN CIVILIZATION AND ART (A). Selected topics in the history of culture. Supervised study, with conferences, readings, and reports but without lecture hours, for graduate students.

4·50 to 4·52. OFFICE PRACTICE. These subjects cover the work taken in the offices of planning commissions by students in the Course in City Planning Practice. Each of the three periods of office practice is undertaken in a different office, the assignments being at the discretion of the instructor in charge of the Course. Problems in design or research are assigned which have a definite relation to the activities of the planning commission concerned, and the work is supervised at regular intervals by an instructor in the City Planning Course.

4·50. OFFICE PRACTICE. First term's work with the City Planning Board of Boston, Mass.

4·51, 4·52. OFFICE PRACTICE. Second and third term's work with the Division of Metropolitan Planning (Boston), the Massachusetts State Planning Board, or the New England Regional Planning Commission.

4·53. PROFESSIONAL RELATIONS (B). Designed to give an understanding of the professional character of the practice of architecture. In it are discussed the personal, ethical, business and legal relations of the architect with clients, builders, craftsmen, engineers, etc., with whom he has to work in the practice of his profession; the relations that should exist between the architect, his professional organizations and the community in which he lives. References are made to legal handbooks upon the laws governing architecture and building, and to the various

Architecture Continued

documents that are issued by the American Institute of Architects. The course includes a number of lectures by individual lecturers selected for their professional standing and accomplishment. *Handbook of the Professional Practice, American Institute of Architects.*

4·60. Planning and Housing Legislation (A). 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.

4·62. Site Planning and Construction. A subject primarily for students in City Planning, in which problems in landscape construction are studied with emphasis on their relation to site planning. It is arranged in two divisions; *Grading Problems:* Estimating cut and fill; problems relating to contour maps; methods of making grading plans; cross-sections; surface and sub-surface drainage; road curves and gradients. *Construction Details:* Location and construction of steps, ramps, retaining walls, embankments, culverts, catch basins, etc.

4·63. City Planning Administration (A). Organization and administration of planning projects in state, county, region, and city; getting citizen and official interest and sanction; securing appropriations for preparation and carrying out the plan; different problems found in each area and how to meet them; sources of coöperation and how to secure their interest; adaptation of material to newspaper use and public participation; the form of maps most useful for getting public understanding of the proposals and their intent; dramatization of planning.

4·641. History and Principles of City Planning. The historical background of the modern city planning movement is presented in a series of lectures on the planning of ancient, medieval, Renaissance, and modern towns. The subject deals with the evolution of the modern city and the relation of architecture to problems of city development and civic design, concluding with a discussion of fundamental principles of city and regional planning. *Outline of Town and City Planning*, Thomas Adams.

4·642T. Theory of Site Planning (B). Lectures and class exercises supplementing the corresponding work in design and closely related to it. *Design of Residential Areas*, Thomas Adams.

4·651, 4·652. Theory and Practice of City Planning (B). Advanced problems of city and regional planning are studied, together with modern methods of dealing with them. Collateral reading, written reports, and round table discussions are essential features of the subject.

4·661, 4·662. City Planning Research (A). Selected topics in the field of city and regional planning. Supervised study, with conferences, readings, and reports but without lecture hours, for graduate students.

4·672. City Planning Design (B). Application of the principles of site planning to the design of housing groups and neighborhood units. Individual instruction is given in the drafting room, and the system of preliminary sketches, developed problems, and sketch problems is continued.

4·681, 4·682. City Planning Design (B). The practical application of city planning theory to the design of towns, cities, and regions. Individual problems are supplemented by group projects worked out in collaboration, and preliminary and final reports are considered essential accompaniments to each developed study. Includes the preparation of the thesis required for the Bachelor's degree.

4·691, 4·692. City Planning Design, Advanced (A). A continuation of the undergraduate subject 4·682.

4·711, 4·712. Architectural Practice. Lectures explaining the scope of architectural practice, the methods and operations within the architect's office, the principles governing the preparation and use of working drawings, shop drawings, scale and full size details and specifications, together with a discussion of the principal building materials and their use. Exercises in the drafting room to give the student some experience in the preparation of working drawings, scale and full size details, ink tracing on cloth, and the layout and use of site contours. Field work covering the use of the stadia method for determining the contours of a specific site. Visits to shops and to buildings under construction, followed by written reports and class discussion.

4·721, 4·722. Architectural Design II. A continuation of 4·712. Problems in architectural composition as applied to buildings of simple requirements and varied character. Carried on by means of eight hour preliminary sketch exercises in the form of sketch problems. Some of these are further developed to a final result in a period of from four to five weeks.

4·731, 4·732. Architectural Design III. A continuation of 4·722. The sketch problem exercises are of twelve hours' duration and the problems more advanced in character.

4·741, 4·742. Architectural Design IV. A continuation of 4·732.

4·751, 4·752. Architectural Design V (B). A continuation of 4·742 in methods, the character of the problems being of an advanced nature. Includes the preparation of the thesis required for the degree of Bachelor in Architecture.

4·761, 4·762. Architectural Design VI (A). A continuation of 4·752.

4·78. Planning Principles. A study of the principles underlying all good planning such as the logical relation to one another of the different parts of a building, the arrangement of proper lighting and circulation, axial development and balance.

4·811. Construction. Methods of analysis and computation, required in elementary architectural construction, treating of the theory of construction, loads, reactions, the design of beams, columns and various details, a wooden roof truss, slow burning construction. *Mimeograph Notes.*

4·812. Construction. A continuation of 4·811 including simple steel framing, the plate girder, and the elements of design in reinforced concrete. *Mimeograph Notes.*

4·93. General Science. Lectures and classroom discussions on the principles, methods and applications of chemistry and the ways in which these have influenced the

Architecture Continued

progress of culture and our conduct, materials, and mode of life.

4·94. General Science. The work of the first part of the term will be devoted to Geology, followed by ten weeks of classroom discussions of the fundamental laws of physics and applications to problems of interest to architects. The treatment is largely qualitative, making only limited use of trigonometry and calculus.

The following subjects are offered as General Studies:

G24. Development of Community Planning.

G64. Fine Arts.

G65. Expressions of Graphic Art.

G67, G68. Design in Manufactured Products.

CHEMISTRY

Subjects 5·00 to 5·99

INORGANIC CHEMISTRY

UNDERGRADUATE SUBJECTS

5·00. Chemistry, Entrance. Lectures, recitations and laboratory given during the summer to cover the entrance recommendation in chemistry.

5·01, 5·02. Chemistry, General. The fundamental principles of chemical science and the descriptive chemistry of the more common elements and their important compounds. Blanchard, Phelan and Davis, *Synthetic Inorganic Chemistry; Smith's College Chemistry, 3d Revised Edition*, Smith.

5·04. Chemistry. Lectures, demonstrated by experiments, covering a review of inorganic chemistry with special attention to principles and the fundamentals in inorganic chemistry. *Mimeographed notes;* Smith-Kendall, *College Chemistry.* (For U. S. Army Officers only.)

5·061, 5·062. Inorganic Chemistry (B). Presents in a correlative manner the physical and chemical properties of the elements and compounds. The attempt is made to systematize as far as possible the facts of inorganic chemistry with the aid of a comparatively small number of generalizations. Time is devoted to the discussion of recent theoretical and experimental investigations in this field.

GRADUATE SUBJECTS

5·071, 5·072. Seminar in Inorganic Chemistry (A). Special topics in inorganic chemistry such as the chemistry of the less common elements, the more complex reactions of the commoner elements, and reactions in non-aqueous solvents. In the second term a series of lectures on selected subjects is given by a number of members of the instructing staff. (Alternate Years. Not offered in 1938–39.)

5·08. Inorganic Laboratory, Advanced (A). Intended to acquaint the student with typical research methods, including such procedures as the employment of high vacuum technique, the conduct of operations in inert atmospheres and in non-aqueous media, the isolation of compounds of the rarer elements, etc. In all cases reference to the original literature is required for experimental details.

ANALYTICAL CHEMISTRY

UNDERGRADUATE SUBJECTS

5·10. Qualitative Analysis. Preliminary experiments illustrate principles and give practice in writing equations and in manipulation. Analysis of simple substances and industrial products such as minerals, pigments, slags and alloys.

5·11. Qualitative Analysis. Abridgment of 5·10.

5·12. Quantitative Analysis. Volumetric and gravimetric analysis, illustrating the more important typical processes. Special attention is given to manipulation, stoichiometry and modern theories of solution.

5·13. Quantitative Analysis. Continuation of 5·12. A correlative study of the Analytical Chemistry for the identification and determination of the more common constituents. Analysis of silicates, minerals, ores and alloys including electrolytic and electrometric methods, and when possible, an original study of some special analytical problem. Gas Analysis.

5·131. Quantitative Analysis. Abridgment of 5·13.

5·141. Analytical Chemistry. Chemical applications of the microscope, including microchemical qualitative analysis and the identification of crystalline material by the polarizing microscope. Measurement of hydrogen ion concentration. Typical illustrations of the use of the polariscope, saccharimeter and refractometer. Tests with the viscosimeter, nitrometer, turbidimeter and precision centrifuge.

5·142. Analytical Chemistry. The chemistry of the more important rarer elements with special reference to methods of separation, identification, and quantitative determination. Discussions of other special topics in Analytical Chemistry such as laws governing co-precipitation, the theory of indicators and the principles underlying potentiometric titrations.

5·16. Analytical Chemistry. Special methods designed for laboratory conditions of the practice school in Chemical Engineering.

5·18. Qualitative Analysis, Advanced (A). A study of the reactions of the rarer elements and their detection. Noyes and Bray, *Qualitative Analysis for the Rare Elements.*

5·26. Food Analysis (B). Analytical methods as applied to typical food products. Detection of adulteration. Status of food materials under pure food laws. Woodman, *Food Analysis.*

5·35. Applied Chemistry. The theoretical principles underlying the causes of corrosion and preventive measures by means of protective coatings. Properties, testing and application of paints, oils, varnishes, lubricants, wood preservatives, alloys.

Chemistry Continued

ORGANIC CHEMISTRY

UNDERGRADUATE SUBJECTS

5·41. Organic Chemistry I. The fundamental principles of the chemistry of the carbon compounds, based on a study of important substances of the aliphatic, aromatic, and heterocyclic divisions.

5·412, 5·413. Organic Chemistry and Laboratory. The laws and principles of organic chemistry derived from the study of the important classes of compounds. Laboratory experiments include syntheses of representative substances, and the use of reactions for classification and identification. Numerous problems are employed, and much individual instruction is given. (For U. S. Army Officers only.)

5·414, 5·424, 5·416, 5·426. Organic Chemistry Laboratory. Includes organic preparations, typical reactions associated with each class of organic compounds, identification of organic compounds, and special experimental problems. The class is divided into sections whose laboratory assignments are selected from the above types of work, but varied to meet the special needs of the several participating courses.

5·417. Quantitative Organic Analysis. Determinations of carbon, hydrogen, nitrogen, halogens and sulfur by semi-micro methods of analysis; conferences and discussions.

5·418. Organic Chemistry Laboratory. Abridgment of 5·416.

5·42. Organic Chemistry I. Amplification and extension of 5·41.

5·428. Organic Chemistry Laboratory. Preparations, class reactions and identification of typical organic compounds.

5·43. Powder, Explosives and War Agents (B). Chemical preparation, testing, history and use.

GRADUATE SUBJECTS

5·51, 5·52. Organic Chemistry II (A). The important principles of the science are emphasized from a more mature point of view.

5·53, 5·54. Organic Chemistry III (A). Designed to produce a familiarity with the phenomena exhibited by organic compounds. The laws and principles of organic chemistry are inferred from the known behavior of the substances.

5·55. Identification of Organic Compounds (A). The study of systematic methods of organic qualitative analysis including treatment both of individual compounds and mixtures.

5·56. Chemistry of Heterocyclic Compounds (A). (Alternate years. Not offered in 1938–39.)

5·562. Carbohydrates (A). Lectures on the determination of configuration and structure in the sugar group, and discussion of the synthesis, derivatives and reactions of such substances, with brief reference to the biological applications of such knowledge.

5·563. Cellulose and Polysaccharides (A). Discussion of the structure and chemistry of this group of substances with a brief description of their industrial processing.

5·57. Chemistry of Dyes (A). Systematic lectures, illustrated by experiments, on the synthetic organic dyestuffs, and their intermediates. (Alternate years. Offered 1938–39.)

5·574. Free Radicals and Organo-Metallic Compounds (A). The history and current developments in these fields will be discussed. (Alternate years. Offered in 1938–39.)

5·58. Chemistry of Natural Products (A). Lectures dealing with the chemistry of the animal pigments, flavines, carotinoids and related products, sterols and bile acids, with special emphasis on the chemistry of vitamins and hormones. (Alternate years. Offered in 1938–39.)

5·581, 5·582. Advanced Organic Laboratory (A).

5·583. Organic Physical Chemistry (A). (Alternate years. Not offered 1938–39.)

5·584. Molecular Structure of Carbon Compounds (A). Deals with the classical and the newer methods for determining the molecular structure of organic compounds and with problems of stereochemistry. (Alternate years. Not offered 1938–39.)

5·585. Theories and Applications of Catalysis (A). (Alternate years. Not offered 1938–39.)

5·591, 5·592. Recent Advances in Organic Chemistry.

PHYSICAL CHEMISTRY

UNDERGRADUATE SUBJECTS

5·61. Physical Chemistry I. Pressure-volume relations of gases; properties of liquids; general properties of solutions; laws of thermodynamics; thermochemistry; chemical equilibrium. Millard, *Physical Chemistry for Colleges.*

5·611. Physical Chemistry Laboratory I. Laboratory coördinated with the topics of 5·61.

5·612. Physical Chemistry Laboratory I. Abridgment of 5·611.

5·62. Physical Chemistry II. Continuation of 5·61. Phase equilibrium, kinetics of chemical reactions; transference; conductance; free energy of chemical changes; electromotive force of cells.

5·621. Physical Chemistry Laboratory II. Laboratory coördinated with the topics of 5·62.

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

5·63. Introduction to Thermodynamics (B). Units; fundamental ideas; first law and applications; second law and applications; uses of the thermodynamic functions; ideal and real gases and gas mixtures; chemical equilibrium, univarient systems; ideal and real solutions; voltaic cells; free energy calculations. Noyes and Sherrill, *An Advanced Course in Instruction in Chemical Principles.*

5·64. Introduction to Radiation Chemistry (B). Electric and magnetic units; deflection of charged particles; gaseous ions; black body radiation; Planck's theory; photoelectric effect; Bohr atom; quantum numbers; periodic table; hydrogen-like spectra; X-ray spectra; optical spectra; elementary quantum mechanics. White, *Introduction to Atomic Spectra.*

5·66. Surface and Colloid Chemistry (B). Structure of surfaces; surfaces and interfacial tensions; adsorp-

Chemistry Continued

tion; 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.

5·683. Physical Chemistry, Elementary. For students specializing in Mechanical and Aeronautical Engineering.

5·684. Physical Chemistry, Elementary. For students specializing in Biology, Public Health, and Sanitary Engineering. Gillespie, *Physical Chemistry*.

GRADUATE SUBJECTS

5·71, 5·72. Physical Chemistry (A). For graduate students who have not had the equivalent of 5·61 and 5·62. Noyes and Sherrill, *An Advanced Course of Instruction in Chemical Principles*.

5·741. Advanced Radiation Chemistry (A). Introduction to atomic and molecular spectra and their application to thermodynamic calculations and to molecular structure.

5·742. Statistical Mechanics (A). Statistical Mechanics and the theory of intermolecular forces with applications to the equation of state problem.

5·76. Thermodynamics and Chemistry (A). The development of equations for the treatment of chemical reactions and of equilibria in chemical systems. Gibbs, *Thermodynamics*.

5·77. Thermodynamics and Chemistry (A). The phase relations for heterogeneous systems are treated, special attention being given to binary mixtures. Roozeboom, *Die Heterogenen Gleichgewichte*.

5·79. Theory of Solutions (A). The properties of solutions are related to those of the components, with special emphasis on solutions of strong electrolytes.

SPECIAL TOPICS IN CHEMISTRY

5·81. Chemical Literature I. A study of foreign language scientific literature.

5·82. Chemical Literature II. Methods of using the journals, books and indexes.

5·83. History of Chemistry (B).

5·842. Optical Methods (B). Laboratory practice in the use of the polarizing microscope for the identification of crystalline material. Equipment is available for both microchemical tests and such optical tests as refractive index, interference figures and optical character. (Not offered to students who have completed 5·141.)

5·844. Engineering Chemistry. A survey of Qualitative and Quantitative Analysis with particular reference to cement, concrete, alloys, paints, pigments, varnishes and other building materials. (For students specializing in Building Construction.)

RESEARCH

5·911, 5·912. Journal Meeting in Inorganic Chemistry (A).

5·921, 5·922. Journal Meeting in Organic Chemistry.

5·931, 5·932. Journal Meeting in Physical Chemistry.

5·941, 5·942. Research Conferences in Inorganic and Organic Chemistry.

5·943, 5·944, Research Conference in Physical Chemistry.

Thesis. Minor researches to test ability to do work of an original character. Written reports and conferences are required and a formal record must be presented for acceptance. The student may select a problem in inorganic, analytical, organic or physical chemistry. Minimum, 32 units.

5·98. Research (A). Research for any of the advanced degrees in inorganic, organic or physical chemistry.

ELECTRICAL ENGINEERING

SUBJECTS 6·00 TO 6·99

6·00T. PRINCIPLES OF ELECTRICAL ENGINEERING. An extension of the principles of electricity and magnetism to linear-circuit analysis; a treatment of transient- and steady-state behavior of simple circuits having suddenly impressed constant and sinusoidal voltages or currents; association of engineering ideas and applications with the treatment of principles, as far as is feasible. *Special Notes by the Department of Electrical Engineering.*

6·01. PRINCIPLES OF ELECTRICAL ENGINEERING. A treatment of steady-state and transient behavior of linear multimesh circuits having suddenly impressed sinusoidal voltages and currents; a consideration of the properties of simple non-linear circuit elements and analysis of simple circuits containing them; a study of magnetic circuits, including eddy-current and hysteresis losses; association of engineering ideas and applications with the treatment of principles, as far as is feasible. *Special Notes by the Department of Electrical Engineering.*

6·02. PRINCIPLES OF ELECTRICAL ENGINEERING. Harmonic currents and voltages, and power in linear circuits; electronic principles and their application to vacuum and gaseous tubes, analysis of circuits containing such tubes, rectifiers, amplifiers, oscillators, modulators; polyphase circuits and measurements, including harmonics and symmetrical phase components, theoretical consideration of energy-conversion devices. *Special Notes by the Department of Electrical Engineering.*

6·03. PRINCIPLES OF ELECTRICAL ENGINEERING. Transformers for power and communication circuits, rotating magnetic fields, synchronous and induction machines. *Special Notes by Department of Electrical Engineering.*

6·031. PRINCIPLES OF ELECTRICAL ENGINEERING. Transformers for power and communications circuits, rotating magnetic fields, synchronous motors and generators, synchronous converter, polyphase and single-phase induction machines, mercury-arc power rectifiers.

6·04. PRINCIPLES OF ELECTRICAL ENGINEERING (B). Parallel operation of alternators, synchronous converter, mercury-arc power rectifier, single-phase induction motor, special-purpose alternating current motors, a general survey of transmission-line problems, calculation of line constants, short line solutions, skin effect, corona, insulator stresses and insulation breakdown, hyperbolic-function solution of long line problems, graphical methods, circle diagrams, inductive interference, transients, system stability, solution of networks. *Special Notes by Department of Electrical Engineering* and Woodruff, *Principles of Electric Power Transmission and Distribution, 2d edition.*

6·09. INTRODUCTION TO ELECTRICAL ENGINEERING. Lectures and laboratory exercises designed to describe the field of activity of the Electrical Engineer, and the preparation in science, mathematics, economics, and engineering which the practice of the profession requires.

6·12. PRINCIPLES OF ELECTRICAL ENGINEERING. The more important aspects of thermionic and gaseous conduction, circuit elements, associated circuits, apparatus and related topics with the consideration of fundamental processes involved. Mercury-arc power rectifiers. Dawes, *Electrical Engineering, Vol. 2, Third Edition*, and McArthur, *Electronics and Electron Tubes.*

6·211. APPLICATIONS OF ELECTRICITY IN INDUSTRY (B). A treatment of electricity in industry, establishing a scientific basis for its modern applications. Sources of energy. Analysis of power production in United States. Choice of system. Elements of electrical energy costs. Distribution of energy within the plant. Principles of electric heating, including energy conversion to heat, heat transfer, heating and cooling of metals, resistance heating, arc furnaces, low-frequency and high-frequency induction furnaces.

6·212. APPLICATIONS OF ELECTRICITY IN INDUSTRY (B). Mechanical, thermionic and photo-electric applications. Duty cycles. Operating characteristics of motors. Controller design and application, including types, methods of acceleration and retardation, protective devices. Essentials of connecting motor to load. Principles of moving fluids and solids. Problems in the application of motors, electron tubes and photo-electric cells.

6·221, 6·222. ELECTRIC POWER GENERATION (B). The economics and the technique of electric power generation. The study of the generating station as a unitary instrument for the conversion of energy. Generation with an appropriate degree of reliability at minimum total cost. The effect of the characteristics of the load curve on cost of generation. Thermal efficiency and commercial economy of various heat cycles. The general layout of the generating station. The calculation of fault currents and the operation of protective devices. The division of load among generating units for minimum cost. The interrelation between steam and hydro generation. By-product generation. Joint operation of industrial and central-station plants. Energy storage systems.

6·241, 6·242. ELECTRIC RAILWAYS (B). The mechanics of traction, calculation of speed-power-distance-time curves, factors affecting train resistance, energy consumption and power demand as influenced by weight, speed and equipment design, power distribution circuit, division of loads between substations, determination of substation demands and spacings, and motor characteristics and control. The foregoing is studied relative to local and trunk-line transportation.

6·251. ELECTRIC MACHINERY DESIGN (B). Transformers and induction motors. Materials of construction, methods of construction, calculation of electrical characteristics, and the influence of various factors of design on manufacture and operation of machines.

6·252. ELECTRIC MACHINERY DESIGN (B). Design of synchronous and direct-current machines. A continuation of 6·251 but also complete within the term.

6·26. ELECTRIC INSULATION (B). The fundamental laws of electric insulation and their application in electrical engineering. An introductory, but comprehensive treatment aimed at a general orientation in the field. Vacuum,

Electrical Engineering Continued

gas, liquid and solid insulation discussed principally from the point of view of the behavior of electrons and ions, atoms and molecules in producing the dielectric properties of engineering insulating materials. Experimental demonstrations are associated with some of the lectures.

6·27. Principles of Illuminating Engineering. An introductory subject giving a broad survey of the whole field of illuminating engineering. Consists of classroom work, problems, and laboratory investigations dealing with light sources, photometric units and measurements, vision, and lighting design. Serves as a foundation for the advanced subjects, also as an elective in Course VI. Moon, *The Scientific Basis of Illuminating Engineering.*

6·271, 6·272. Principles of Illuminating Engineering (B). A detailed treatment of particular phases of the subject matter of 6·27. Calculation of illumination from point sources with symmetric and asymmetric distributions, calculation of illumination from surface sources, the unit sphere method, the contour integral method, applications to daylighting and built-in artificial lighting. The photochemical theory of vision, data on the visual thresholds and their application to lighting design. Design of lighting systems, reflectors, and glassware. Moon, *The Scientific Basis of Illuminating Engineering.*

6·281. Principles of Wire Communications (B). Electrical transmission characteristics, as a function of frequency, of long lines with distributed constants in the steady state, distortion and its correction, communications transformers, insertion loss, networks, loading, filters, balancing networks, repeaters and carrier-current systems.

6·282. Principles of Radio Communications (B). A broad treatment of radio communication and the underlying theory, including: analysis of signals; physiological and architectural acoustics; microphones, loudspeakers; vacuum-tube amplifiers, oscillators, modulators, and demodulators; transmitting and receiving systems; radio frequency transmission lines; antennas and radiation; wave propagation phenomena.

6·29. Storage Batteries. Theory, construction, care and application of storage batteries. Vinal, *Storage Batteries.*

6·30. Principles of Electrical Communications. An introductory survey of electrical communications systems leading to a consideration of the relation between the response characteristics of such systems and the problem of transmitting intelligence from one point to another. Emphasis is given to the analysis of the network elements of these systems, including transformers, corrective networks, filters and other coupling means.

6·31. Principles of Electrical Communications (B). Vacuum tubes and their associated circuits as elements of communication systems. These elements include vacuum tubes operating as rectifiers, amplifiers, oscillators, modulators and demodulators, and photoelectric cells.

6.32, 6·32T. Principles of Electrical Communications (B). The steady state behavior of lines, cables, and related lumped networks, including a study of distortion and line loading. The circuit and radiation characteristics of antenna systems and a brief consideration of propagation phenomena.

6·331, 6·332. Electrical Communications Laboratory. A study of experimental methods used in the solution of communications problems, correlating physical phenomena with their theoretical interpretation. Includes a study of vacuum tubes and vacuum tube circuits, artificial lines and other networks, and radio frequency and acoustical measurements.

6·333. Electrical Communications Laboratory. Embraces in general the subject matter of 6·331 and 6·332, but is not so extensive.

6·34. Electrical Communications Laboratory (B). For students who desire undergraduate laboratory work in communications. Special work in vacuum tube circuits, audio and radio-frequency measurements, and acoustics can be arranged to suit the needs of the individual student.

6·40. Elements of Electrical Engineering. Applications of the general principles of the electric and magnetic circuit to the generation, distribution and utilization of direct- and alternating-current power. Hudson, *Engineering Electricity.*

6·42. Elements of Electrical Engineering. Applications of the general principles of the electric and magnetic circuit to the generation, distribution and utilization of direct- and alternating-current power with special reference to ordnance service. Hudson, *Engineering Electricity.* (For U. S. Army Officers only.)

6·47. Applications of Electricity in Industry. Considerations governing the choice, application and economics of distribution and use of electrical energy in industry. Principles employed in electric drive, electronic and photoelectric devices, electric furnaces and ovens, and movement of fluids and solids. Class work supplemented by laboratory work illustrating and developing the principles presented in class.

6·48. Electrical Equipment of Buildings. Lectures on the design of electric wiring, lighting and elevator systems for buildings. Cook, *Electric Wiring.*

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

6·511. Electric Power Circuits (A). Methods of solving power-circuit problems. Calculation of short-circuit currents in networks. The theory of multi-circuit transformers. Treatment of unbalanced circuits by the method of symmetrical components, with applications. General circuit constants. The theory and construction of performance charts for transmission lines. A comprehensive graphical treatment of transmission systems in the steady state. Reference Books: Dahl, *Electric Circuits, Vol. I;* Lyon, *Applications of Symmetrical Components;* Wagner and Evans, *Symmetrical Components as Applied to the Analysis of Unbalanced Electrical Circuits.*

6·512. Electric Power Circuits (A). A comprehensive study of transients on long lines. The general theory of travelling waves, followed by a consideration in detail of reflections and refractions at junction points, cir-

Electrical Engineering Continued

cuit discontinuities and terminals, the effect of resistance, inductance and capacitance in series and in parallel with the line, the effect of choke coils, etc. Lightning and its effect on transmission lines. Review of laboratory and field test methods and apparatus. Principles and practice involved in lightning protection of lines. Reference Books: Ruedenberg, *Elektrische Schaltvorgänge;* Bewley, *Traveling Waves on Transmission Systems.*

6·513. Power System Stability (A). A comprehensive study by analytical, graphical, and network analyzer (a-c calculating board) methods of steady-state power-system problems, such as those associated with system expansion and interconnection, voltage regulation, steady-state stability, etc. The theory and construction of performance charts for synchronous machines and combinations of power-network elements. A general discussion of the problem of power-system stability and its place in power-system design and operation. An exposition of methods for the determination of static power limits. A portion of the time is devoted to the solution of steady-state power-flow and stability problems on the M.I.T. Network Analyzer. Dahl, *Electric-Circuits—Theory and Applications, Vol. II.*

6·514. Power System Stability (A). Stability of power systems during disturbances. The effect of short circuits, sudden switching, etc. Solution by simplified methods as well as by complete point-by-point methods of analysis. Regulators and excitation systems. A comprehensive discussion of their action, involving determination by analytical and graphical methods of performance during voltage build-up and build-down, of their effects on the synchronous machines during disturbances, etc. Discussion of methods for improvement of stability, Damper windings and their effects. Effect of different methods of grounding the neutral points of the system. A portion of the time is devoted to the solution of power-system transient-stability problems on the M. I. T. Network Analyzer. Dahl, *Electric Circuits—Theory and Application, Vol. II.*

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

6·521, 6·522. Advanced Alternating-Current Machinery (A). Devoted to the analysis of the more intricate electrical problems met in the operation of alternating-current machinery. The following are some of the problems discussed. The effect of unbalanced conditions on the operation of synchronous and induction machines. Eddy currents in laminations, solid rotors, and the conductors of direct-current and alternating-current machines. Electro-magnetic field problems. Harmonic analysis of the magnetic density existing in the air gap of synchronous and induction machines and its effect on the generated e.m.f., the torque, and on vibration. Transient conditions due to the sudden alteration of the electric circuits or to the sudden application of the shaft load of synchronous and induction machines, particularly the effect of sudden short circuit on the current and torque and the conditions arising during pulling into step and phase swinging.

Much of the instruction is given during informal conference hours. These are arranged to give each student an opportunity to plan his program so as to concentrate on the study of those problems in which he is particularly interested.

A portion of the time is allotted to work in the machine-transients laboratory upon advanced problems.

6·531, 6·532. Power System Economics (A). Determination of demand, energy and customer components of cost of electric power. Allocation of demand costs. Study of load curves, load, diversity, loss and demand factors, load duration and peak percentage curves. Analytical studies of prediction of peak demand and energy output. Theory of incremental heat rates and their application to load division. Incremental loading of generating stations including effect of losses in transmission circuits. Rate structures, Hopkinson and Wright demand rates, off-peak rates, power-factor and coal clauses. Increment costs. Cost of energy losses in a power system. Economics of power-factor costs, correction and conductor sizes. Problems in interconnection studies and methods of operation. Cost, economic functions and value of hydro power. Firm capacity. Rate bases, depreciation, financial and operating statistics and forms of organization, problems in public utility economics and management. Relation between load, capacity and service continuity. Economics of radial distribution, primary and secondary networks.

6·541, 6·542. Electric Power Generation (A). The economics and the technique of electric power generation. The study of the generating station as a unitary instrument for the conversion of energy. Generation with an appropriate degree of reliability at minimum total cost. The effect of the characteristics of the load curve on cost of generation. Thermal efficiency and commercial economy of various heat cycles. The general layout of the generating station. The calculation of fault currents and the operation of protective devices. The division of load among generating units for minimum cost. The interrelation between steam and hydro generation. By-product generation. Joint operation of industrial and central-station plants. Energy storage systems.

6·551, 6·552. Railroad Electric Traction (A). The electrical and mechanical principles and economic considerations relating to railway electrification. The mechanics of traction, calculation of speed-time curves, train resistance for conventional design, light-weight, and stream-lined equipment as a function of weight and speed, energy consumption and power demand, analysis of motor characteristics, design and control as applied for traction purposes, analysis of motive-power equipment, steam, diesel-electric and electric as applied to traction purposes, power-distribution circuits, factors affecting substation rating and spacing, equivalent circuits for power distribution for analytical purposes or network-analyzer representation, calculations of short-circuit and ground currents, power costs and transportation economics. The foregoing is studied as regards electrification in particular and transportation in general.

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6·561. Advanced Network Theory (A). Characteristics of four-terminal networks; synthesis of two-terminal reactances, their equivalents and inverses; conventional filter theory; impedance correction; series and parallel operation of filters for band separation. Laboratory work is given. Guillemin, *Communication Networks, Vol. II.*

6·562. Advanced Network Theory (A). Latest contributions to analysis and synthesis of networks. Generalization of conventional filter theory; transient behavior of selective systems; synthesis of two-terminal dissipative impedances and of four-terminal reactive networks; two- and four-terminal equivalents; corrective networks. Guillemin, *Communication Networks, Vol. II.*

6·571, 6·572. Principles of Illuminating Engineering (A). An advanced subject dealing with the latest researches in physiological optics and their applications to lighting, the vector field method of calculating illumination, and the design of lighting system equipment. Moon, *The Scientific Basis of Illuminating Engineering.*

6·58. Transients in Linear Systems (A). Formulation, from physical considerations, of differential equations of circuit and field problems in electrical, mechanical, thermal, and acoustical systems which permit of linear treatment; analogies; mathematical studies of transient disturbances in these systems, using the Laplace transformation method (a method which includes the Heaviside operational calculus). Requisite background in complex variable theory is supplied. Bush, *Operational Circuit Analysis.*

6·59. Communications Laboratory (A). A graduate laboratory subject in communications in which the student carries out work on a substantial problem or selected group of problems in consultation with a member of the staff who is particularly qualified in the field. The student is expected to show a mature independence of attack and investigatory ability. His work is guided by conferences, with opportunity for detailed criticism and discussion.

6·60. Mathematical Analysis by Mechanical Methods (A). A study of computation procedures and the mechanical methods developed for performing them. General principles are developed and illustrated by existing equipment. Emphasis is placed on the methods adapted to the treatment of important problems where ordinary processes are extremely laborious.

6·61. Super-High-Voltage Engineering (A). Theory, characteristics and applications of high-voltage insulating media with emphasis on compressed gas and high-vacuum insulation. Principles and techniques involved in the production, measurement and utilization of very high voltages. Analysis of direct-current electrostatic, alternating-current and impulse-voltage sources. High-voltage phenomena. Physical properties of high-energy X-rays, cathode rays, neutrons and radiations from radioactive materials and their production for medical use. Present trends in the development of high-voltage power for transmission. Analysis of vacuum electrostatic machinery and of other methods of generation and conversion for direct-current power systems.

6·62. Principles of Electrical Communications (A). Deals with thermionic gaseous conduction and photo-electric tubes and their associated external networks. Includes an advanced study of linear and non-linear amplifiers, amplitude and frequency modulators, regenerative and super-regenerative circuits and oscillators. The class work is supplemented with laboratory problems.

6·631. Engineering Electronics (A). The electrokinetic theory of gases including free paths, mobility, diffusion, ionization, recombination and space-charge effects. Potential distributions between electrodes immersed in a gas, and theory and characteristics of glow, spark and arc discharges. Application to rectifiers, grid-controlled arc tubes, circuit breakers and lightning arresters.

6·632. Engineering Electronics (A). Engineering application of electronic apparatus. Current, voltage, and energy considerations in circuit interruption involving arcs. Mercury-arc rectifiers and associated circuits. Electric welding arc. Inversion and other special applications.

6·64. Electric Insulation (A). An advanced treatment of electric insulation and its behavior. A subject (partly conducted as a seminar) emphasizing major fundamental problems and recent progress in the insulation field. Presentation and discussion of the latest contributions in the current scientific literature.

6·651, 6·652. Electric Power Distribution (A). The theoretical principles of electric power distribution. The distribution system in theory. Calculation of power-system short-circuit transients. Limitation of short-circuit currents, maintenance of voltage, and the control and transfer of power. Theory of electric power cables, dielectric properties, calculation and limitation of sheath currents. Low-voltage and medium-voltage distribution networks. Interlacing of primary cables, load division and transformer spacing. Theory of relays, methods of obtaining selectivity and their applications. Load characteristics, economic problems in electric distribution, allocation of demand costs, determination of cost of energy loss and rate structures.

6·661, 6·662. Principles of Electric Machine Development (A). Design of transformers, direct-current machines and alternating-current machines and predetermination of characteristics. Voltage wave-form of generators. Calculation of eddy-current loss in windings of transformers and a-c. machines, and methods of reducing the loss. Unbalanced magnetic pull. Choice of slot numbers. Methods of reducing noise and vibration. Flux plotting. Heat flow. Ventilation.

6·671, 6·672. Vibrations (A). The theory of vibration of mechanical systems including certain acoustical and hydraulic problems. The complex-notation method will be generally used. (Students from other courses will be given a short preliminary instruction in this method while the Electrical Engineering students are working on more purely electrical problems. Thereafter the two groups will be united.) Forced, transient, and self-induced vibration. Single and multiple degrees of freedom. Analogies between electrical and mechanical systems. Non-linear systems. Application to mechanical devices, machines, and structures. Vibration measurements and corrections. The use and limitations of models, mechanical and electrical. Noise in machines, its causes and control. The control of temperature oscillations. The tide and an analysis of tidal power possibilities. Stresses in

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busbars and busbar supports. Inertia effects in high-speed mechanisms. Some laboratory work is included. Den Hartog, *Mechanical Vibrations.*

6·68. Special Problems in Electrical Engineering (A). Provides an opportunity for individual study, under a staff member, of advanced subjects related to Electrical Engineering not otherwise included in the curriculum. The program is laid out to suit individual requirements by students and staff members interested.

6·69. Sound in Electrical Communications (A). A study of the principles and apparatus involved in the production, measurement, transmission and reproduction of sound by electrical means. Laboratory measurements of sound fields and performance of receivers and transmitters.

6·73. Electrical Measurements Laboratory, Advanced (A). Advanced work of the nature of that given in 6·75T, and 6·76, the choice of problems being suited to the individual student.

6·74. Electrical Engineering Laboratory, Advanced (A). Laid out in accordance with the needs of the individual student, special problems on direct and alternating-current machinery being selected.

6·75T. Electrical 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 measurement of linear circuit elements, and the transient and steady state behavior of circuits made up of such elements. *Instructions for Students in the Electrical Engineering Laboratories, 9th Edition, June* 1937.

6·76. Electrical Engineering Laboratory. Choice of work by the student, subject to counsel of his instructor, from a broad selection of topics having to do with the measurement of non-linear circuit elements, including electronic devices, and the behavior of circuits in which such devices are used.

6·77. Electrical Engineering Laboratory. Characteristics and fundamentals of direct-current machinery. Ricker and Tucker, *Electrical Engineering Laboratory Experiments, Third Edition;* Kloeffler, Brenneman, and Kerchner, *Direct-Current Machinery; Instructions for Students in Electrical Engineering Laboratory, Ninth Edition, June,* 1937.

6·78. Electrical Engineering Laboratory. Polyphase circuits, symmetrical phase components, transformer, synchronous generator, synchronous motor, three-phase induction motor. Ricker and Tucker, *Electrical Engineering Laboratory Experiments, Third Edition; Instructions for Students in Electrical Engineering Laboratory, Ninth Edition, June,* 1937.

6·781. Electrical Engineering Laboratory. Polyphase circuits, symmetrical phase components, power transformer, synchronous generator, synchronous motor, single-phase and three-phase induction motors, power rectifiers and power filters with special emphasis on interference problems. *Text books same as for* 6·78.

6·79. Electrical Engineering Laboratory. Characteristics of single-phase induction motors, synchronous converters and power rectifiers, special purpose alternating-current machinery, characteristics of power transmission lines. *Textbooks same as for* 6·78.

6·80. Electrical Engineering Laboratory (B). For Electrical Engineering students who desire work in addition to, or different from that included in any one of subjects 6·75T, 6·76, 6·77, 6·78 or 6·79, and for any other students requiring a special program. Arranged to suit the requirements of the individual student.

6·81. Electrical Measurements Laboratory. Choice of work from a broad selection of topics dealing with methods of measurement of the electrical and magnetic properties of metals. *Instructions for Students in the Electrical Engineering Laboratories, 9th Edition, June* 1937.

6·84. Electrical Engineering Laboratory. Divided into two parts: (*a*) Electrical Measurements: Characteristics of electronic devices and associated circuits; (*b*) Electrical Machinery: Characteristics and fundamentals of alternating-current machinery. *Instructions for Students in Electrical Engineering Laboratory, Ninth Edition, June,* 1937; Ricker and Tucker, *Electrical Engineering Laboratory Experiments, Third Edition.*

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, Third Edition; Instructions for Students in Electrical Engineering Laboratory, Ninth Edition, June,* 1937.

6·88. Electrical Engineering Laboratory. Fourteen laboratory exercises covering the determination of the characteristics of the ordinary types of electrical machinery, control apparatus and electronic devices. The laboratory is supplemented with conferences in which fundamental principles underlying the laboratory work are reviewed. Textbooks same as for 6·85, and MacArthur, *Electrons and Electron Tubes.*

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 to **6·904.** Manufacturing Practice. These subjects cover the manufacturing work taken by the coöperative students at the plants of the General Electric Company in Lynn, Schenectady, Pittsfield and Erie. The students are not all assigned to the same jobs; neither are they always assigned to the same departments. The following is the list of the various departments to which students are assigned and it also indicates the approximate order in which the manufacturing practice is given:

GENERAL ELECTRIC COMPANY

Manufacturing planning including the design and manufacture of special machines, as well as quantity production methods.

Standardizing Laboratory and Meter Testing.

Direct-current Motor Test.

Alternating-current Motor Test.

Illumination Department.

Transformer Test.

Turbine and Air Compressor Test.

Refrigeration, Air Conditioning and Heating Appliances.

Power Plant.

Research in various departments including the Lynn, Schenectady and Pittsfield Research Laboratories.

Electrical Engineering Continued

6·901. MANUFACTURING PRACTICE. First term's work at plants of General Electric Company.

6·902. MANUFACTURING PRACTICE. Second term's work at plants of General Electric Company.

6·903. MANUFACTURING PRACTICE. Third term's work at plants of General Electric Company.

6·904. MANUFACTURING PRACTICE. Fourth term's work at plants of General Electric Company.

6·911 to **6·914; 6·921** to **6·924.** PUBLIC UTILITY PRACTICE. The subjects in Public Utility Practice are given by the Boston Edison Company and the Boston Elevated Railway Company. The various departments to which the students are assigned are listed below in the approximate order in which the work is given at:

BOSTON EDISON COMPANY

Maintenance of Line Department.
Standardizing and Testing Departments.
Steam Division of Generating Department.
Electrical Division of Generating Department.
Sales Department.
Installation Department.
Supply Department.
Electrical Engineering Office.
Scientific Research and Study covering the many Public Utility Problems.

BOSTON ELEVATED RAILWAY

Department of Rolling Stock and Shops.
Maintenance Department.
Transportation Department.
Power Department.
Miscellaneous Work.

6·911. PUBLIC UTILITY PRACTICE (EDISON). First term's work at the plants of the Boston Edison Company.

6·912. PUBLIC UTILITY PRACTICE (EDISON). Second term's work at the plants of the Boston Edison Company.

6·913. PUBLIC UTILITY PRACTICE (EDISON). Third term's work at the plants of the Boston Edison Company.

6·914. PUBLIC UTILITY PRACTICE (EDISON). Fourth term's work at the plants of the Boston Edison Company.

6·921. PUBLIC UTILITY PRACTICE (ELEVATED). First term's work at the plants of the Boston Elevated Railway.

6·922. PUBLIC UTILITY PRACTICE (ELEVATED). Second term's work at the plants of the Boston Elevated Railway.

6·923. PUBLIC UTILITY PRACTICE (ELEVATED). Third term's work at the plants of the Boston Elevated Railway.

6·924. PUBLIC UTILITY PRACTICE (ELEVATED). Fourth term's work at the plants of the Boston Elevated Railway.

6·941 to **6·944.** COMMUNICATIONS PRACTICE. These subjects cover the Communications work taken by the co-operative students at the various plants and laboratories of the Bell Telephone System. The first assignment is usually spent in the plant of the Western Electric Company at Kearny, N. J., and with the installation department in or near New York City, the second with the New York Telephone Company, and the third in the Bell Telephone Laboratories in New York City. The fourth term of practice is spent with any one of these organizations, depending upon the individual interest of the students.

6·941. COMMUNICATIONS PRACTICE. First term's work at the plants of the Bell System.

6·942. COMMUNICATIONS PRACTICE. Second term's work at the plants of the Bell System.

6·943. COMMUNICATIONS PRACTICE. Third term's work at the plants of the Bell System.

6·944. COMMUNICATIONS PRACTICE. Fourth term's work at the plants of the Bell System.

BIOLOGY AND PUBLIC HEALTH

SUBJECTS 7·00 TO 7·99

7·01. GENERAL BIOLOGY. An introduction to the study of living things. Essentially a general discussion of the fundamental facts and principles common to all the biological sciences. Elementary and preparatory in character and in aim.

7·02. MODERN BIOLOGY. Covers general biology with special reference to recent advances in the field. A consideration of the fundamental properties of living things; a survey of animals and plants with special reference to their physiology, anatomy, and classification, followed by a study of the principles of embryology, heredity, and evolution.

7·03. THEORETICAL BIOLOGY (B). Advanced lectures and recitations in general biology designed to acquaint the student with the principal theories and hypotheses which have played an important part in the development of biological science, and particularly of those which underlie the more fruitful research work of the present day. The two major problems discussed are heredity and oecology. Sinnott and Dunn, *Principles of Genetics*.

7·06. BOTANY. Beginning with the lowest forms of plant life, the various groups of algae and fungi are systematically studied and later, higher cryptogams. Some attention is paid also to the structure and development of flowering plants. The fundamentals of plant physiology are stressed. One hour a week is given to lectures on limnology and to laboratory work on the microscopic examination of water. Mottier, *Textbook of Botany for College Students*.

7·08. PARASITOLOGY (B). Invertebrate zoology with special reference to the parasitic forms and their relation to disease in man and the domestic animals. Lectures with demonstrations. Chandler, *Introduction to Human Parasitology*, 1930.

7·09. PARASITOLOGY, ADVANCED (A). Advanced work involving intensive study of some of the more important parasites causing diseases of domestic animals and man. The student will be required to study fresh materials from original sources, the aim being to acquaint him with methods of isolation and investigation which he could apply in problems of this character which might arise in his professional career.

7·10. INVERTEBRATE ZOOLOGY. A systematic study of the invertebrate animals, considering their form, structure, distribution, and economic value. Hegner, *Invertebrate Zoölogy*.

7·131. ADVANCED HISTOLOGY (B). A seminar and laboratory course intended to give the student practice in the preparation and interpretation of special histological materials and in embryology.

7·132. ADVANCED HISTOLOGY (A). Continuation of 7·131 in the direction of cytological and similar special materials.

7·14. COMPARATIVE ANATOMY. Covers the fundamentals of comparative gross anatomy of vertebrates and the essential histology of the organs. The structures will be partly dissected out by students and partly demonstrated by the instructor. Classification and general zoology of the vertebrates are also considered.

7·17. BIOLOGY OF FOOD SUPPLIES. A consideration of the growth, structure, and physiology of important food animals and crop plants, in relation to their utilization by man. Special attention is given to those animals, particularly invertebrates, which injure or infest food supplies. Robbins and Ramaley, *Plants Useful to Man*.

7·18. TECHNICAL ASPECTS OF ENTOMOLOGY (A). Numerous insects and mites are known to be of the highest importance to public health and the food industries due to their abundance and destructiveness. The general problems of their recognition and control are considered. Attention is also given to the insects beneficial to man.

7·20. PHYSIOLOGY, ELEMENTS OF. Lectures, laboratory, and reports on the physical and chemical bases of physiological function. The nature of protoplasm, and the nature of energy conversions, metabolism, and special application of general principles in organ functions comprise the topics covered. Designed to show the general bearing of physiology upon all biological studies.

7·201. ADVANCED PHYSIOLOGY (A). The application of mathematics to the analysis of biological data and of biological variability. A study of the physical and chemical properties of protoplasm; colloidal phenomena, diffusion, osmosis, membrane potentials, permeability; tropisms, photoreception; radiation, pressure, and temperature effects; photosynthesis.

7·22. PERSONAL HYGIENE AND NUTRITION (B). Consideration of personal health and disease, their conditions and causes; exercise, work, play, oral hygiene, hygiene of clothing, of the feet, of the alimentary canal, mental hygiene, etc. Special attention is given to diet from the standpoint of the science of nutrition.

7·23. APPLIED NUTRITION (B). Practical work in applied nutrition with problem work, individual case studies, and a special consideration of the practical difficulties in securing a proper and healthful diet for children of various types and social conditions. The greater part of this work (through the coöperation of the Dispensary Staff) is carried out at the Food Clinic of the Boston Dispensary.

7·28. LIMNOLOGY. A study of the physical, chemical, and biological aspects of natural waters, and of the microorganisms important in the examination of water for drinking purposes. The organisms are especially considered in relation to each other and to their environment. Whipple, *Microscopy of Drinking Water;* Welch, *Limnology*.

7·29. BACTERIOLOGY. Deals with fundamental principles of bacteriology and the general relations of microorganisms to chemical changes such as fermentation, putrefaction, and disease. Particular emphasis is placed on the examination of water supplies and the protection of community water sources. Buchanan, *Bacteriology;* Prescott and Winslow, *Elements of Water Bacteriology*.

Biology and Public Health Continued

7·301, 7·302. Bacteriology (7·302, B). Fundamental work in the biology of the bacteria. The first term is devoted to general bacteriology with a thorough study of selected types. The second term is devoted to special study of the bacteriology of water, sewage, air, and foods. Zinsser and Bayne-Jones, *A Textbook of Bacteriology;* Prescott and Winslow, *Elements of Water Bacteriology*, 1931, *Standard Methods of Water and Sewage Analysis; Standard Methods of Milk Analysis;* Hammer, *Dairy Bacteriology.*

7·321, 7·322. Bacteriology, Advanced (A). Reports and discussions of bacterial metabolism and growth, certain diagnostic tests, and recent developments in bacteriology. In the second term, laboratory problems and demonstrations include bacterial dissociation, filterability, bacteriophage, and special problems.

7·33. Plant Diseases. A brief survey of the types of plant diseases of economic significance which are caused by bacteria and fungi. Owens, *Principles of Plant Pathology.*

7·34. Limnological Fieldwork. (At Camp Technology.) A study of the biological and chemical characteristics of stream and lake waters, including temperature determinations at various depths, and the use of field kits in the microscopic examination of the plankton and for the examination for color, turbidity, and dissolved oxygen and carbon dioxide, etc. Sanitary chemical, microscopic and bacteriological examinations of these waters are also made in the laboratory. Whipple, *Microscopy of Drinking Water;* American Public Health Association, *Standard Methods of Water Analysis.*

7·35. Planktonology (A). A consideration of those animals and plants which drift about in the water, unattached. The identification, life history, and distribution are particularly considered.

7·36. Microbiology. A broad survey of the theory and practice involved in fermentation processes, and the industrial and economic applications of microbiology in agriculture and the manufacture of biochemical preparations. Industrial alcohol, vinegar, acetone, butyl alcohol, glycerin, fermentation acids, and the applications in the leather and food industries are especially considered.

7·361. Industrial Microbiology. The same as Microbiology (7·36) but with extended laboratory work.

7·362. Industrial Microbiology (B). A continuation of the preceding with more detailed laboratory investigation on a semi-commercial scale.

7·371, 7·372. Industrial Microbiology (A). Seminar work and laboratory studies involving comprehensive reports and investigations of selected problems in the applications of microbiology to the fermentation and food conservation industries. Among the problems which may be considered are the development or improvement of culture and biochemical methods employed in the manufacture of industrial alcohol, acetone, glycerin, butyl alcohol, and organic acids, and the study of special relations of microörganisms in the food, textile, fiber, timber, and leather industries.

7·38. Germicides and Antiseptics (A). A study of the basic principles, both in theory and application, of chemical and physical disinfection, bacteriostasis and fungistasis in their relation to industry, medicine, and agriculture. Methods of evaluation, the germicidal efficiency of agents, and the preparation of germicidal compounds are considered. Lectures, discussions, and laboratory problems.

7·41. Chemistry of Water and Sewage. Chemical examination of potable waters and sewage with lectures on the sanitary significance of the results.

7·42. Chemistry of Foods. Analytical methods, fundamental basis of nutrition; extent, character and legal status of food adulteration. Woodman, *Food Analysis.*

7·50. Communicable Diseases (B). The fundamental biological facts of infection, resistance, and immunity. The biological characteristics of infectious diseases of special interest to the sanitarian are considered in detail. Park and Williams, *Pathogenic Microörganisms;* Zinsser and Bayne-Jones, *A Textbook of Bacteriology.*

7·52. Industrial Hygiene (B). The maintenance and the effectiveness of the worker with a consideration of factory sanitation, industrial fatigue, occupational accidents, industrial poisoning, dust control, ventilation, and health administration in industry. Each student is assigned work in the detection and estimation of toxic substances or in the investigation of some industrial health problem according to his individual needs.

7·53. Air Examination. Considers the relation of the composition and physics of air to health, comfort, and efficiency. The physiological bases for air conditioning are indicated. Laboratory work covers the use of instruments for air testing, and the determination of certain dangerous gases, mineral and organic dusts, and microbic organisms in air. Drinker and Hatch, *Industrial Dust.*

7·531. Air Examination (B). Similar to 7·53 but with additional outside reading.

7·541, 7·542. Public Health Administration (B). Lectures and discussions on the history, organization, and administration of health departments and private health agencies, local, state, and national, and on current public health problems, their valuation and the methods by which they are handled in health departments.

7·55. Public Health Bacteriological Methods. Similar to 7·551, with haematology and procedures not directly related to pathogenic bacteriology omitted.

7·551. Public Health Laboratory Methods (B). Methods in use in state and municipal bacteriological laboratories considered. Training given in pathogenic bacteriology, including diagnosis of diphtheria, examination of specimens for tuberculosis and typhoid, microscopical diagnosis of malaria, etc. Haematology is included.

7·552. Immunological Methods (B). Methods used in serological laboratories and production of biologicals are studied in detail. The Wassermann, Kahn, Hinton, Kline, and other tests for syphilis are included.

7·57. Municipal Sanitation (B). Lectures and problems dealing with principles of sanitation as applied to the community, and including water supply, sewage and sewage disposal, sanitation of swimming pools and disposal of refuse. Horwood, *Sanitation of Water Supplies.*

7·58. Vital Statistics (B). Lectures, recitations, and problems by which the student acquires a working knowledge of statistical methods, consideration of errors,

Biology and Public Health Continued

and the preparation, graphic representation, critical analysis, and interpretation of data.

7·59. Sanitation (B). Engineering aspects of public milk supplies, including sanitation of production, transportation, and mechanical equipment used in pasteurization and handling, and other machinery incidental to the handling of milk and milk products; the principles of public health surveys; water supplies and excreta disposal in unsewered communities; street cleaning; control of mosquitoes, flies, and other insects; rodent control and ratproofing in buildings; housing; inspection and control of shellfish areas; the sanitary aspects of food manufacturing, including plant sanitation, etc.; refuse disposal practice; smoke and noise prevention; relation of animal diseases to human welfare; general sanitary inspection methods and the principles of epidemiology. Prescott and Horwood, *Sedgwick's Principles of Sanitary Science and Public Health.*

7·601, 7·602. Health Education (A). A consideration of the procedures and methods used by health departments and school departments in health education. The health program of the school system is discussed in detail as to both organization and method. Practical field work is provided. Turner, *Principles of Health Education.*

7·603. Public Health Education (A). A study of the methods and materials used in the health education of the general public by health departments and private health agencies with practice in the preparation of such materials. The press, radio, cinema, lecture, exhibit, report, personal contact, and community campaign are considered. Bauer & Hull, *Health Education of the Public.*

7·604. School Health Administration (A). Deals with the organization of the health work expected of teachers, doctors, nurses, physical educators, nutritionists, and others, presenting the objectives, activities, costs, and measures of accomplishment for each phase of the work.

7·63. Public Health Field Work (A). Conferences and field work in connection with clinics, departments of health, health centers, and other organized agencies for improving the public welfare. As examples, students might be required to study and report on new installations for water supply, sewage or waste disposal or housing projects, or to make extensive personal surveys of health departments, to assist health officers in investigations of epidemics, or in other ways to participate in health measures as carried out in the metropolitan district.

7·64. Public Health Problems (A). Seminar work in which the student makes an investigation of the methods of study of special problems in laboratory technique or in public health administration, such as the control of communicable diseases, the organization and supervision of food inspection, or the application of the principles of sanitary science to other problems.

7·65. Health Hazards in Special Industries (A). The specialized study of the dangers in particular industries, such as the rubber, textile, steel, and fiber industries, and those involving the possibility of infection or of injury through abrasive particles, by poisonous gases or solvents, or other special dangers. Preventive or palliative measures in such cases are also considered.

7·66. Epidemiology (A). Conferences devoted to a detailed consideration of the natural history of epidemics, such as typhoid fever, diphtheria, and scarlet fever, and their causes in their relation to public water supplies, milk supplies, sewage systems, insects, and personal causative factors. The student by critical examination of the more celebrated and instructive examples is enabled to prepare himself for the interpretation of corresponding phenomena arising in actual practice. A thorough review of the literature on other infectious diseases, including measles, whooping cough, influenza, tuberculosis, poliomyelitis, cerebrospinal meningitis, is included.

7·67. Functional Pathology (A). Lectures and recitations, to correlate mechanics, physics, chemistry, biochemistry, and physiology with disease manifestations.

7·68. Pathology (A). The principles of general pathology, with laboratory studies on prepared slides and gross specimens.

7·701, 7·702. Technology and Chemistry of Food Supplies. Lectures, discussions, and reports on the chemical composition, production, consumption, statistics, and methods of treatment of food materials. The 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 will be discussed in detail. The fundamental principles involved in physical processes such as refrigeration, dehydration, and salting, and the microbiology and chemistry of the processes is studied. For 7·701, Buechel, *Commerce of Agriculture;* for 7·702, Clemen, *By-products of the Packing Industry.*

7·71. Food Technology. Lectures, laboratory work and reports concerning the manufacture, processing, transportation, packaging, and laboratory control of foods and food products. Included in the course will be selected phases of the dairy, packing-house, refrigeration, canning, bakery, fisheries, and beverage industries with particular emphasis on the technical problems involved. Opportunity for students to study special problems in their field of interest will be afforded.

7·711. Technology of Food Products (B). Lectures, reports and laboratory experiments in the methods of food preservation and manufacture. Semi-plant scale operations in dehydration. The production of fruit juices and concentrates, canning processes, and quick-freezing of various foods included. Cruess, *Commercial Fruit and Vegetable Products;* Tanner, *Bacteriology and Mycology of Foods.*

7·712. Technology of Food Products (B). A continuation of 7·711 with particular 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.

7·721, 7·722. Advanced Food Technology (A). Advanced technical problems in special food industries, involving the use of dehydration, sterilization, homogenization equipment, and special applications of physics, chemistry, and biology in food technology. Clayton, *Colloid Aspects of Food Chemistry and Food Technology.*

7·80. Biochemistry (B). Primarily a laboratory subject with experiments designed to illustrate basic principles of biochemical procedure, as applied in various

Biology and Public Health Continued

fields. The laboratory work does not lay emphasis upon clinical aspects of physiological chemistry. Lectures cover the nature of chemical processes in plants and animals with special attention to the metabolism of foodstuffs and the nature of protoplasms.

7·802. Quantitative Biochemistry (B). Covers quantitative techniques in diagnostic analysis of normal and abnormal constituents in blood, urine, and tissue.

7·81. Zymology (A). Lectures, recitations and reports, with laboratory work on quantitative study of enzyme reactions, their products, and the conditions governing activity.

7·82. Biochemistry, Advanced (A). Technique for biochemical analyses and bio-assays, based on the recent literature. Discussions, reports, and laboratory problems.

7·831, 7·832. Microbiological Chemistry Laboratory (A). A laboratory course which emphasizes the quantitative aspects of the metabolic activities of microorganisms. Special problems in the general biochemistry of the yeasts, molds, and bacteria are investigated and the student is acquainted with many of the analytical and research methods now in use in various laboratories. Isolation and identification of various metabolic products, metabolic balance sheets, and respiration studies are included.

7·84. Biophysics (B). Training in analysis of biological problems and the employment of techniques from physics and allied sciences in their solution. Problems will relate to microbial life, enzyme action, permeability of living cells, excitation of protoplasms, and similar projects in the field of Biophysics.

7·91. Biological Engineering I (A).

7·92. Biological Engineering II (A).

7·941, 7·942. Research Problems (A). Directed research by graduate students in a field of biological science, but not contributory to the thesis.

The following subjects are offered as General Studies. For description of subjects see Division of General Studies.

G28. Economic Geography.

G86. Principles of Sanitary Science and Public Health.

G88. Biological Reproduction.

PHYSICS

Subjects 8·00 to 8·99

GENERAL PHYSICS

8·00. Physics (Entrance). Covers the entrance requirement in Physics. No laboratory work is given.

8·01. Physics (Mechanics). Lectures, recitations, supervised problem and laboratory work devoted to a study of the fundamental laws of point and rigid body mechanics. Free use is made of elementary calculus.

8·012. Physics (College Transfer). Given during the first term for those college transfer students who already have been allowed partial credit for 8·01 and 8·02 on the basis of a substantial course in general physics taken prior to their transfer. The subject is not to be taken by any student under requirement to take or to repeat 8·01 and 8·02. It is designed to supplement the transfer student's training in amount necessary to cover the requirements of 8·01 and 8·02. Free use is made of the calculus.

8·02. Physics (Mechanics and Heat). Lectures, laboratory and recitations. The subject is 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). A study of the laws of electrostatics, followed by a discussion of steady flow in conductors, properties of conductors, electrical energy and power, magnets and magnetic fields, galvanometers and their uses, meters, capacitance and inductance, and gaseous conduction. The calculus is used freely, and many types of problems are discussed.

8·034. Physics (College Transfer). Given during the second term for those college transfer students who already have been allowed partial credit for 8·03 and 8·04 on the basis of a substantial course in general physics taken prior to their transfer. The subject is not to be taken by any student under requirement to take or to repeat 8·03 and 8·04. It is designed to supplement the student's training in amount necessary to cover the requirements of 8·03 and 8·04. Free use is made of the calculus.

8·04. Physics (Electricity and Optics). A continuation of 8·03, dealing with sinusoidal e.m.f.'s and currents, alternating current circuits, resonance, and electrical oscillations. Discussion of electrical oscillations and waves introduces the subject of optics, which includes the geometrical optics of lenses and optical systems, and the physical optics of interference and diffraction. The quantum theory is mentioned, and its relation to X-rays and to radiation is pointed out. The nature and origin of spectra, color and its measurement, and the principles of illumination are discussed. A limited amount of time is given to polarization and double refraction.

8·05. Vibrations and Sound (B). The first part of the course is a study of the dynamics of vibrating bodies; coupled oscillators, strings, membranes and plates. The second part is a study of the transmission and radiation of sound. The properties of loud speakers and microphones are treated, and the characteristics of speech and hearing are discussed.

8·051. Special Problems in Acoustics (A). An advanced problem in acoustics or vibrations with assigned reading and consultations.

8·07. Precision of Measurements. A discussion of

Physics Continued

the principles underlying the treatment of experimental data and the planning of investigations involving measurements. The subject is intended as an introduction to research or thesis work. Goodwin's *Precision of Measurements and Graphical Methods.*

8·09. Physical Measurements. Laboratory work in mechanics, properties of matter, and heat.

8·11, 8·12. Experimental Physics (B). Designed to train the student in methods of analyzing experimental problems to determine suitable methods of achieving a desired result, both in the design and use of experimental equipment. The case system is used and the entire field of experimental physics, both pure and applied, is drawn on. In the laboratory work the experiments are of a semi-research character, designed to develop initiative, resoucefulness, and familiarity with modern experimental technique.

8·13. Undergraduate Colloquium (B). Student reports on topics of current interest in physics.

OPTICS AND PHOTOGRAPHY

8·15. Photography. An elementary course in photography intended primarily as an elective for students not in Course VIII. It is concerned principally with such applications of photography as record photography, artistic photography, stereoscopic photography, color photography and motion pictures.

8·152. Advanced Photography. A laboratory course in photography open only to students who have credit for 8·15 or who take 8·15 simultaneously. The experiments are concerned chiefly with the determination of the various characteristics of photographic materials and are designed to give practice in photographic technique.

8·161. Optics. Fundamental principles of geometrical, physical and physiological optics. Includes 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, photo-electricity, the design and construction of optical instruments, stereoscopy, and a detailed description of the performance of well-known optical systems such as telescopes, microscopes, photographic objectives, and projection systems.

8·162. Optical Measurements. Laboratory exercises illustrating the principles, methods and manipulation of optical instruments.

8·171. Advanced Optics (B). Covers the same subject matter as 8·161 in a more advanced manner.

8·173. Color Measurements (B). Theory of methods of measuring and specifying color in both the objective and subjective sense and the application of such methods to industrial problems. The experiments are designed to illustrate the photometric and chromatic properties of the human eye and to give experience in the technique of spectrophotometry and colorimetry.

8·174. Motion Picture Photography (B). A lecture course of a semi-professional character intended primarily for students planning to enter the motion picture industry. The subject matter is included in the Journal of Transactions of the Society of Motion Picture Engineers.

8·181. Optics Seminar (A). A discussion of important problems in photography and optics, including a review of the current literature and the results of researches in these fields at the Institute.

8·191. Microscopy and Photomicrography. Experimental lectures, approximately one-half of which are devoted to the optics of the microscope and the technique of photomicrography. The second half of the subject is concerned with the application of the miscroscope to such fields as biology, chemistry, crystallography, metallography, ceramics, and textile engineering. The lectures during the latter half of the course are given by experts in the above-mentioned fields.

8·194. Advanced Physical Optics (A). Primarily for students intending to specialize in optics. Open only to graduates or to seniors who have previously demonstrated marked ability in this field.

ELECTRONICS

8·201. Electronics. The electron and its properties, electronic devices, thermionic and photoelectric emission, with introduction to the quantum theory and Fermi statistics.

8·202. Electronic Laboratory. A course in intermediate electrical and electronic measurements, to accompany 8·201.

8·21. Electronic Phenomena (A). An introduction to modern electron theory including an elementary treatment of Maxwell-Boltzmann and Fermi-Dirac statistics with applications of these theories to thermionic and photoelectric emission from metals and to gas discharge phenomena.

8·212. Experimental Electronics (A). The theory and use of modern experimental apparatus as applied to electronic investigations. This includes experiments with the Compton quadrant electrometer, the FP-54 vacuum tube "Electrometer," the cathode ray oscillograph and the thyratron, as well as experiments of a fundamental nature on thermionic emission, photoelectric effect, and gas discharge phenomena.

8·213. Advanced Electronics (A). A comprehensive introduction to the fundamental investigations of thermionic and photoelectric emission of electrons from metals and of the general problems associated with gas discharge phenomena. Both the theoretical and the experimental aspects of these problems are discussed in detail. (Alternate years. Not offered 1938–39.)

8·214. Advanced Electronics (A). Continuation of 8·213, dealing primarily with problems associated with gas discharge phenomena. (Alternate years. Not offered 1938–39.)

8·215. Special Problems in Electronics (A). An advanced problem in electronics, with assigned reading and consultation.

X-RAYS AND THE STRUCTURE OF MATTER

8·26. Molecular Structure (A). Electric and optical properties of molecules, gases and liquids. Theory of polar molecules, refraction, scattering of light and Kerr effect. (Alternate years. Offered 1938–39.)

Physics Continued

8·27. X-RAYS AND CRYSTAL PHYSICS (B). X-ray apparatus, production of X-rays, absorption, scattering, refraction, X-ray spectra. Theory and application of the diffraction of X-rays in matter to the determination of the structure of crystals, and the atomic and molecular arrangement in liquids and amorphous solids. A general review of the structure of matter as determined by X-ray diffraction analysis.

8·28. X-RAY DIFFRACTION (A). The theory of X-ray diffraction and its application to the study of the structure of matter. Elementary theory of X-ray diffraction in crystals, the Lorentz factor, temperature effect, integrated intensity, the Darwin theory of diffraction in mosaic and perfect crystals. Atomic scattering and F curves. The Fourier method of determining the elctron distribution in crystals and in the atom. The Scherrer particle-size equation. X-ray scattering in liquids and gases. (Alternate years. Not offered 1938–39.)

8·281. CRYSTAL CHEMISTRY (A). A correlation of the results of X-ray analysis of the structure of crystalline and noncrystalline matter. The structure of metals and intermetallic compounds, ionic and nonionic crystals, molecular structures including the organic materials, high polymers, and silicates will be discussed. The structures will be considered with reference to atomic size, kind of chemical bonding, structures of radicals or complexes involved. So far as possible the structures will be correlated with the physical properties of the material. (Alternate years. Offered 1938–39.)

8·29. QUANTUM THEORY OF THE SOLID STATE (A). Motion of electrons in a periodic potential field. Methods of calculation of the elastic properties of solids. Discussion of electric conductivity, of the magnetic and optical properties of solids, and of the structure of alloys. (Alternate years. Not offered 1938–39.)

8·30. SPECIAL PROBLEMS IN CRYSTAL PHYSICS (A). An advanced problem in X-ray diffraction or crystal physics, with assigned reading and consultation.

ATOMIC STRUCTURE AND SPECTROSCOPY

8·311. ATOMIC STRUCTURE. Modern theories of the structure of atoms, optical and X-ray spectra, atomic models with application to the structure of the periodic table, radioactivity and nuclear structure, and related topics.

8·312. ATOMIC STRUCTURE LABORATORY. Experiments on selected topics in modern physics.

8·32. LINE SPECTRA (A). Deals with the characteristics of atomic spectra and their description in terms of quantum numbers, their interpretation in terms of current theories of atomic structure, and their use in explaining the chemical properties of the elements.

8·341, 8·342. SPECTROSCOPY SEMINAR (A). Discussion and reports by students of special topics in spectroscopy.

8·343. SPECIAL PROBLEMS IN SPECTROSCOPY (A). Supervised experimental work in the Spectroscopy Laboratory, to be taken concurrently with the Spectroscopy Seminar by students who desire to carry out special investigations not under the head of thesis work.

8·344. PRACTICAL SPECTROSCOPY (B). A course on the design of spectroscopic apparatus and its application to special problems in astronomy, biology, chemistry, physics, medicine, metallurgy, and engineering. Special emphasis will be laid on methods of spectroscopic analysis, both qualitative and quantitative.

8·345. APPLIED SPECTROSCOPY (B). A laboratory course consisting of the use of spectroscopic equipment in problems connected with the fields covered by subject 8·344 and designed to be taken concurrently with 8·344.

8·346. QUANTITATIVE SPECTROSCOPIC ANALYSIS (B). A short course consisting of the last two weeks of 8·344, designed for those interested in the application of quantitative spectroscopic analysis to industrial problems.

8·35. EXCITATION OF SPECTRA (A). Lectures and laboratory on fundamental processes of excitation, including excitation by absorption, by electron impact and by radiationless transfer of energy; arc, spark and furnace spectra; complex excitation; mixed gas discharges; optical and electrical methods of critical potential measurements; line intensities under different conditions of excitation.

8·36a. RADIATION MEASUREMENTS and

8·36b. RADIATION MEASUREMENTS LABORATORY. Aims to familiarize the student with modern instruments and methods employed in the measurement and analysis of ultraviolet, visible and infra-red radiation, as photoelectric cells and thermopiles. The laboratory instruction includes comparison and calibration of detectors, analysis of radiation by various methods, and practice with radiometric instruments. Special emphasis is placed on line intensity measurements.

NUCLEAR PHYSICS

8·411. NUCLEAR PHYSICS (B). Treats the principal fields in the study of atomic nuclei, building each up from its beginnings to the status of present knowledge. The treatment is primarily factual, the experimental results being correlated with those given by current theories. Lectures are supplemented by a laboratory course in which the student deals directly with the latest types of apparatus. Includes the properties of stable nuclei; isotopes, nuclear moments, mass and charge; radioactive transformations; mathematical theory of statistics and fluctuations; properties of alpha rays, gamma rays, electrons and positrons.

8·412. NUCLEAR PHYSICS (B). Continuation of 8·411 considering the nuclear spectra of alpha, beta, gamma rays and nuclear energy levels; nuclear force fields and scattering of alpha rays, protons, neutrons and electrons; excitation and transmutation of nuclei; artificial radioactivity; cosmic rays; applications of nuclear techniques to chemistry, biology, geology and other fields.

8·42. SEMINAR IN NUCLEAR PHYSICS (A). Discussion and reports on special topics in nuclear structure and related subjects, mainly from the experimental point of view.

8·43. THEORY OF NUCLEAR STRUCTURES (A). A review of current theories of the structure of atomic nuclei. Calculation of nuclear binding energies and collision reactions. Nature of internuclear forces. Theory of radioactive decay. (Alternate years. Not offered 1938–39.)

8·441, 8·442. SPECIAL PROBLEMS IN NUCLEAR RESEARCH (A). Supervised experimental work on radio-

Physics Continued

activity, nuclear bombardment, and general nuclear research, for students who wish to carry out special investigations which do not come under the head of thesis work.

THEORETICAL PHYSICS

8·461. Introduction to Theoretical Physics I (B) Mechanics, vibrating particles, strings, and membranes, with study of ordinary and partial differential equations, Fourier series, and vector analysis.

8·462. Introduction to Theoretical Physics II (B). Elasticity and hydrodynamics, heat conduction, electromagnetic theory, potential theory, and the electromagnetic theory of light.

8·463. Introduction to Theoretical Physics III (A). Wave mechanics and quantum theory, classical and quantum statistics, structure of atoms and molecules, and the properties of matter.

8·471. Historical Development of Physics (B). A survey of the fundamental contributions to physics in the order in which they appeared, from Archimedes to Einstein. The original papers are studied as far as this is possible, and the students themselves give a number of the lectures.

8·481. Advanced Mechanics I (A). The mechanics of particles and rigid bodies treated by the generalized methods of Lagrange and Hamilton. (Alternate years. Not offered 1938–39.)

8·482. Advanced Mechanics II (A). A continuation of 8·481, including the transformation theory of dynamics, the elements of perturbation theory and the general theory of orbits, non-holonomic and dissipative systems and the theory of vibrations. (Alternate years. Not offered 1938–39.)

8·491. Methods of Theoretical Physics (A). An advanced subject coördinating and developing the methods used in the solving of problems in electrostatics, hydrodynamics, heat flow, diffusion, wave motion, wave mechanics, etc. The equations governing these phenomena are developed and the effects of boundary conditions on the solutions are studied. The uses of Green's functions, eigenfunctions, variational methods, and conformal transformations are discussed in detail. (Alternate years. Offered 1938–39.)

8·50. Heat and Thermodynamics. First and second laws of thermodynamics, with applications to properties of gases, change of state, and chemical equilibrium. Elementary kinetic theory, Maxwell distribution of velocities, and the Maxwell-Boltzmann formula.

8·512. Statistical Mechanics (A). The basic principles of statistical mechanics with applications to physical problems. (Alternate years. Offered 1938–39.)

8·521. Quantum Mechanics (A). An advanced course in modern atomic theory. The Dirac operator method is developed, and the theories of electron spin and of the interaction of radiation and matter are discussed. The theories are applied in the study of atomic and molecular spectra, collision processes and other topics. (Alternate years. Offered 1938–39.)

8·54. Electromagnetic Theory (B). Formulation of field equations. Generalization to material media with discussion of theories of dielectric constant, permeability and polarization. Energy of the electromagnetic field—Poynting theorem. Wave propagation in unbounded media. Boundary conditions and propagation in bounded media: reflection and refraction of electromagnetic waves, with particular emphasis on the theory of propagation along conductors. Field due to an oscillating dipole and application to calculation of radiation from systems having known current distribution; antenna theory. Quasi-stationary state theory and the transition from the Maxwell equations to circuit equations.

8·56. Electromagnetic Wave Theory (A). Radiation problems, mechanics of the electron, and introduction to restricted relativity. (Alternate years. Offered 1938–39.)

8·57. Cosmic Rays and High Energy Phenomena (A). Theory of geomagnetic latitude, longitude and azimuthal effects. Atmospheric energy absorption of primary cosmic ray particles. Shower production and bursts. Galactic rotation. (Alternate years. Not offered 1938–39.)

8·58. Theory of Relativity (A). Restricted and general relativity, cosmological considerations, attempts at a unification of electricity and gravitation, quantum theory and relativity. (Alternate years. Offered 1938–39.)

8·591, 8·592. Theoretical Seminar (A). Discussion and reports by students on special topics in theoretical physics.

8·60. Special Problems in Theoretical Physics (A). Reading, consultation, and original investigation on a problem in theoretical physics.

ELECTROCHEMISTRY

8·82. Electrochemistry (B). Electrical conduction in liquids, solids and gases, theories of the voltaic cell, polarization and electrolysis, the principles involved in the corrosion, electrodeposition, and refining of metals, and the energy relations underlying the mutual transformations of chemical and electrical energy. Butler's *The Fundamentals of Chemical Thermodynamics; Standard texts on Electrochemistry*, and *Scientific Journals*.

The following subject is offered as a General Study. For description see Division of General Studies.

G14. Descriptive Astronomy.

CHEMICAL ENGINEERING

SUBJECTS 10·00 TO 10·99

10·11. PROBLEMS OF THE CHEMICAL ENGINEER. Describes the field of activity of the chemical engineer and the preparation along both chemical and engineering lines which the practice of the profession requires.

10·15. THESIS REPORTS. Intended to give seniors training in the presentation of the results of technical investigations by oral and written reports. An attempt is made to reproduce the variety of situations which confront the practicing engineer in presenting oral reports to groups with varying degrees of engineering training and experience. Thesis reports consist of periodic oral and written reports on progress of thesis before fellow students and staff members in chemical engineering. Committee reports consist of oral reports on some technical problem before student groups from various branches of engineering. The Department of English coöperates in this work.

10·16. APPLIED CHEMISTRY. The purpose of this subject is to develop the technique of applying the principles of general and physical chemistry to practical problems. The topics include combustion reactions, the chemical synthesis and transformation of fuels, corrosion, lubricants, the mechanical characteristics of amorphous materials, including plastics, the mechanism of interaction of liquids and solids with gases and the effects of high pressure on the properties of materials.

10·17. INDUSTRIAL CHEMISTRY. Deals chiefly with the industrial aspects of fuels, combustion and furnaces through the solution of numerous problems. Lewis and Radasch, *Industrial Stoichiometry*.

10·18. INDUSTRIAL CHEMISTRY. The more important industrial chemical processes are studied from the point of view of both the chemical reactions forming the basis of the process, and the plant necessary to carry on these reactions. In this way the interrelationships of the different industries as to raw materials, sources of energy, and standard types of apparatus are developed and a general survey of the field obtained. Extensive problem work is included.

10·201. INDUSTRIAL CHEMISTRY. Similar to 10·18 except that problems are of a less advanced character.

10·203. INDUSTRIAL CHEMISTRY. Similar to 10·18 except that problems are of a less advanced character.

10·21. INDUSTRIAL CHEMISTRY (B). A continuation of 10·18. Devoted to those industries which deal with amorphous solids, including glass, ceramics, leather, paints, textiles, paper, rubber, etc.

10·25. INDUSTRIAL CHEMISTRY (A). Covers industrial stoichiometry and the industrial chemistry of the more important chemical industries. It includes a detailed discussion of the inter-relationships of the important industries and problem work on the various processes discussed. The course is designed for graduate students primarily interested in industrial chemistry and particularly for new students from other schools who have had inadequate training in industrial stoichiometry.

10·26. INDUSTRIAL CHEMICAL LABORATORY (B). A study of the evolution of a chemical process from the idea as originally formulated through the successive stages of laboratory development to the design and equipment of the necessary plant.

10·28. CHEMICAL ENGINEERING. A study of the thermal properties of matter and the energy relationships underlying mechanical and chemical processes, including a thorough discussion of the first law of thermodynamics as applied to both batch and flow processes, and such operations as combustion, compression and handling of fluids, thermal control of chemical reactions, and the like. The second law is developed and its more elementary applications discussed.

10·29. CHEMICAL ENGINEERING (B). Devoted primarily to the quantitative engineering applications of the second law. Includes 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. Because of its vital importance, attention is given to high pressure operations, particularly the influence of pressure on thermal effects and chemical equilibrium.

10·30. ENGINEERING EQUIPMENT. Intended to give 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 will be placed on the determination of the operating characteristics of such equipment under plant conditions.

10·31, 10·32. CHEMICAL ENGINEERING (B). These subjects cover the basic principles underlying the unit operations of chemical industry. Because most of the operations involve fundamental problems in flow of heat this topic is first discussed in detail. There follows an analysis of the operations of evaporation, distillation, drying, humidification, filtration, subdivision of solids, hydraulic classification and similar topics. Emphasis is laid on quantitative relationships and these are illustrated by the solution of numerous problems. Walker, Lewis, McAdams and Gilliland. *Principles of Chemical Engineering*.

10·33. ANALYTICAL TREATMENT OF CHEMICAL ENGINEERING PROCESSES (A). The analysis of the unit operations of chemical engineering almost always involves three major principles: the conservation of matter and energy, the laws of equilibrium, and those of reaction rate. In a large majority of cases the latter reduce to problems of diffusion, requiring certain mathematical techniques, the presentation of which is the fundamental purpose of this subject. It involves the training in setting up ordinary and partial differential equations corresponding to specific physical situations, and presents methods available for their solution, including various graphical constructions.

10·35, 10·36. INDUSTRIAL CHEMICAL ENGINEERING. These consecutive subjects cover the several basic unit operations of the chemical industry, from the viewpoint of engineering economics. The operations include the

Chemical Engineering Continued

dynamics of fluids and flow of heat, evaporation, humidification, drying, distillation, filtration, and the mechanical treatment and handling of solids. Particular attention is given to the suitability and choice of equipment for the plant from the economic standpoint.

10·38. Explosives Plant Engineering. Includes a survey of the fundamentals of physical chemistry and chemical engineering, followed by a more advanced application of these subjects to the industrial operations involved in the manufacture of ordnance material with particular reference to propellants and high explosives. (For U. S. Army and Naval Officers only.)

10·39. Theory of Interior Ballistics. A study of the theories underlying the ignition and combustion of propellants in the gun and that of the motion of the projectile along the bore. Followed with applications to the design of guns and ammunition. (For U. S. Army and Naval Officers only.)

ENGINEERING OPERATIONS

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

10·41. Distillation (A). A quantitative study of the basic principles of distillation, as applied to binary mixtures, both of complete and limited miscibility and to multicomponent systems. Problems include batch and continuous simple distillations, steam distillation, vacuum and pressure distillation, rectification, heat recovery and the like. Special attention is paid to graphical methods.

10·45. Distillation and Absorption (A). A quantitative study of distillation, including rectification of binary and complex mixtures. Also includes a study of diffusional processes, with particular attention given the design computations for gas absorption equipment. A combination and condensation of subjects 10·41 and 10·46.

10·46. Absorption and Extraction (A). The basic principles of equilibria, mechanism and rate of interaction are studied in detail. Quantitative applications include 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. Particular attention is paid to graphical methods.

Includes a study of the basic principles of adsorption phenomena followed by problems in decolorization of oils, sugar syrups and the like; solvent recovery by adsorption and the leaching of various solids.

10·50. Heat Transmission (A). A course applying the fundamentals of conduction, radiation and convection of heat to the problems and situations most frequently encountered in chemical industry. Emphasis is laid upon the general relationships between fluid dynamics and diffusional processes. The approach to the problem is empirical, but dimensionally sound. Graphical methods are used in large degree. Every effort is made to orient the student as to the trends of present development.

10·52. Chemical Engineering II (A). Offered for graduates of other schools whose training in chemical engineering has been along somewhat different lines from that given in 10·31 and 10·32. Emphasis is placed on basic theories in flow of fluids and flow of heat and application is made to problems of an advanced character. Attention is paid to recent developments in chemical engineering.

10·53. Chemical Engineering Design (A). Open only to students who have taken the fieldwork of Course X-A. The problems involve the design of a complete plant, from the viewpoint of both chemical engineering and economics.

10·54. Economic Balance in Chemical Industry (A). Lectures and conferences planned to develop original power in the solution of problems in chemical industry. The problems cover a wide range of topics, but in each case the various factors under the control of the designer are analyzed quantitatively, to determine the optimum design from the viewpoint of cost and economic return.

10·55. Economic Balance (A). A shorter subject of the same character as 10·54, primarily for students in X-A who have completed field station work.

APPLIED CHEMISTRY

10·62. Applied Chemical Thermodynamics (A). Energy relations of chemical processes. Equilibria and thermal effects in heterogeneous and homogeneous systems, and technique of utilization of data in interpretation and practical control of chemical reactions.

10·63T. Industrial Chemistry II (A). A study of the chemical industries which deal primarily with amorphous materials, including thermoplastics, textile fibres, cellulose products, leather and rubber. A brief survey of the general principles of colloidal chemistry is followed by analyses of important problems encountered in these industries.

10·65. Catalysis and High Pressure Processes (A). A study of the principles involved in the use of high pressures and catalysts in certain chemical reactions, such as the synthesis of ammonia, synthesis of mixtures of aliphatic compounds, alcohols and hydrocarbons from water gas, hydrogenation of coal and oils, cracking of mineral oils, etc., together with a discussion of industrial applications, equipment requirements, and opportunities for research.

10·661. Introduction to Colloid Chemistry (A). A discussion of the colloidal state of matter and of the characteristics and behavior of colloids; a description of natural colloids and of the different methods of producing matter in the colloidal state, and a consideration of the methods applied in the study of substances in the colloidal state.

10·662. Colloid Chemistry (A). A continuation and extension of 10·661, with special attention to recent developments in surface reactions, gel formation, and their technical significance.

10·671. Colloid Seminar (A). Detailed consideration of a limited number of specific colloidal phenomena, such as thixotropy, antithixotropic phenomena, wetting, dispersing, and emulsifying agents and special optical methods in colloid research. Problems are chosen because of their vital importance in the application of colloid chemistry to industry.

Chemical Engineering Continued

10·672. Colloid Seminar (A). A seminar subject paying particular attention to industries using typical colloids as raw materials.

10·673. Colloid Chemistry Laboratory (A). Designed to train a limited number of men in the use of special instruments such as stalagmometers, bubble pressure pipettes, and surface and interfacial tensiometers. Also includes the laboratory technique of dialysis, electrodialysis, cataphoresis, modern microscopic technique, and micro-dissection, as well as the theoretical background pertaining to these methods.

10·674. Colloid Chemistry Laboratory (A). Continuation of 10·673.

10·68. Corrosion (A). Designed to assist in the selection of equipment for use in chemical engineering processes. Major emphasis is placed on resistance to corrosion, and considerable time is devoted to theories of corrosion and methods of prevention.

FUEL ENGINEERING

10·70. Principles of Combustion (A). Open to graduate students who have majored in a non-chemical branch of engineering or science and who wish to specialize in the engineering rather than the chemical phase of fuel engineering. As emphasis will be placed on the application of fundamental principles in combustion reactions, the subject matter will include instruction in physical and organic chemistry of particular importance in fuel engineering. Numerous problems, illustrating the quantitative application of these principles in fuel processing and utilization, will be assigned.

10·71. Fuel Engineering (A). An advanced subject in fuel engineering for students with an adequate background of physical and organic chemistry and thermodynamics. The subject includes such material as the mechanism of the combustion reactions, and the application of combustion principles to problems of design or use of equipment for fuel processing and utilization.

10·74. Furnace Design (A). A study of principles and calculations of furnace design and construction dealing with rates of heat transfer and with flow of gases in furnaces. The quantitative design and layout of several furnaces, retorts or still-settings will be carried out.

10·76. Seminar in Radiant Heat Transmission (A). Will stress the theory and derivations incident to heat transfer in furnaces. Among the subjects considered will be the general law of total radiation in its differential form, its applications to radiation between finite solid surfaces with evaluation for special shapes of engineering importance, the law of spectral energy distribution of radiation, its application to radiation from luminous and non-luminous gases, powdered coal flame radiation, and optical pyrometry.

10·79. Automotive Fuels (A). A brief discussion of refinery technology, particularly cracking; the mechanism of combustion in Otto and Diesel cycle engines; the relation of "engine knock" to chemical structure of a fuel; thermodynamics of engine cycles, allowing for dissociation; the volatility of motor fuels; gum in gasoline; theory of bearing lubrication. Problems will be assigned throughout the term and a comprehensive report required on some motor fuel subject.

SCHOOL OF CHEMICAL ENGINEERING PRACTICE

10·81. School of Chemical Engineering Practice —Bangor Station (A). At this station emphasis is placed on the study of electrolysis, drying, humidification, evaporation, absorption and causticization. This work is carried out in the plants of the Eastern Manufacturing Company at South Brewer, Maine, manufacturers of writing papers and sulphite pulp and of the Penobscot Chemical Fibre Company at Oldtown, Maine, manufacturers of soda and sulphite pulp. Offered from July through December and from February through May.

10·82. School of Chemical Engineering Practice —Parlin Station (A). The work involves studies of distillation, heat transfer, fluid flow, handling of corrosive materials, plant layout, and industrial chemical operations such as those employing catalysis and high pressure. This program is carried on at the Cellulose Products plant of Hercules Powder Company in Parlin, New Jersey. Offered from July through December and from February through May.

10·83. School of Chemical Engineering Practice —Buffalo Station (A). The work deals primarily with flow of fluids, flow of heat and combustion, the work extending over a wide field. Quantitative studies are made and tests run on coke ovens, blast furnace stoves, gas producers and the like. Experimental work on flow of heat, flow of fluids, absorption and other unit studies of chemical engineering is carried out in connection with the recovery of light oil and ammonia from coke oven gas. The work is done at the Lackawanna Plant of the Bethlehem Steel Company. Offered from July through December and from February through May.

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

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

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

GENERAL

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

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

10·991, 10·992. Seminar in Chemical Engineering (A). Offered primarily for post graduate students on thesis or preparing for the oral examination for the Doctor of Science degree.

GEOLOGY

SUBJECTS 12·00 TO 12·99

12·01. MINERALOGY. Lectures and laboratory work on the fundamentals of crystallography and mineralogy. The introductory study of crystal models is followed by instruction in blowpipe analysis. These preliminaries are then applied to the study of minerals by intensive work in determinative mineralogy. A close acquaintance is made with about one hundred and ten of the commonest minerals. Warren, *Determinative Mineralogy;* Dana, *Manual of Mineralogy.*

12·03. THEORETICAL MINERALOGY (B). An introduction to our present knowledge of the structure of crystals, and the application of this knowledge to mineralogy. Lecture topics include: the fundamental laws of crystal chemistry, radius ratio, coördination number, polarizability, ionic structures, electron pair bond structures, metallic structures; the silicates and silica framework crystals; isomorphism; polymorphism, cluster vibrations, cluster rotations, disordered structures, superstructures, solid solution and segregate phase formation; crystal growth and habit, crystal imperfections and lineage structures; the plastic deformation of crystals, translation-gliding and twin-gliding; the structural aspects of certain physical properties such as cleavage; phase diagrams.

12·05. MINERALOGICAL SEMINAR (A). Seminar hours devoted to the 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. It is intended that each investigation will result in a publication.

12·15. PETROGRAPHY. Lectures on the occurrence and genesis of rocks of all types and laboratory work using the polarizing microscope in the study of thin sections of rocks. Supplemented by field excursions to instructive nearby localities. Harker, *Petrology for Students;* Tyrrell, *Principles of Petrology;* Grout, *Petrography and Petrology.*

12·16. CHEMICAL PETROLOGY SEMINAR (A). Discussion of the physical chemistry of rock systems and the literature of petrogenesis. The topics covered will be based on Alling, *Interpretative Petrology of the Igneous Rocks;* Bowen, *Evolution of the Igneous Rocks;* and Niggli, *Das Magma.*

12·17. PETROLOGICAL RESEARCH (A). Research connected with some phase of chemical or structural petrology. It is intended that each investigation will be suitable for publication.

12·18. STRUCTURAL PETROLOGY SEMINAR (A). Discussion of rock fabrics, with emphasis on the relations of fracture, plastic and viscous flow, and recrystallization. The topics covered will be based on Balk: *Structural Behavior of Igneous Rocks,* Fairbairn: *Structural Petrology,* and Sander: *Gefügekunde der Gersteine.*

12·211. OPTICAL CRYSTALLOGRAPHY. Study of the optical properties of crystals with special reference to the identification of crystalline substances with the aid of the polarizing microscope. Students primarily interested in mineralogy and petrography study, in the laboratory, the optical properties of mineral crystals; other students receive instruction on the properties of common inorganic crystals. Winchell, *Elements of Optical Mineralogy, Fourth Edition, Part I.* Larsen and Berman, *Microscopic Determination of the Nonopaque Minerals* (*U. S. Geological Survey Bull.* 848).

12·26. STRUCTURAL CRYSTALLOGRAPHY (A). A development is given of the determination of crystallographic information from X-ray diffraction data. The lectures include: simple aspects of X-ray diffraction theory useful in crystallographic investigations, the reciprocal lattice, diffraction from a rotating crystal, and the Weissenberg method. Particular attention is given to the crystallographic information obtainable by this important method: point group symmetry, space lattice type, simplest unit cell, full diffraction symmetry and space group. In the laboratory, the student applies this theory to the determination of the characteristics of an assigned crystal. In simple cases the positions of the atoms may also be located.

12·301T, 12·302. GENERAL GEOLOGY. A study of geological processes, including the nature and origin of rocks and minerals, the surficial processes and results of erosion and deposition, and the development and evolution of plants and animals as determined from the fossils in the rocks. The first term is devoted to physical geology—minerals, rocks, and the geologic work of streams, oceans, glaciers, and the wind. The second term is devoted to a brief study of structural geology, followed by historical geology. Lectures, laboratory demonstrations and work on specimens and maps, and during favorable weather, field trips to points of geologic interest in the vicinity.

12·31. GENERAL GEOLOGY. Continuation of 12·30. Includes historical geology, laboratory work in lithology, and the study of geologic structures and maps. Several geologic field trips are taken.

12·321. APPLIED ENGINEERING GEOLOGY. Geology adapted to the needs of engineers. Ries and Watson, *Elements of Engineering Geology.*

12·322. APPLIED ENGINEERING GEOLOGY. The relations of geology to engineering problems, with reviews of actual cases.

12·33. FIELD GEOLOGY (B). Designed to teach practical methods of geologic mapping in the field.

12·38. GEOMORPHOLOGY (B). A study of the fundamental principles of geomorphology. Constructional land forms—plains, plateaus, mountains and volcanoes—are first examined and classified. Then the student considers cycles of erosion, caused by diverse eroding agencies in each class of constructional land form; and the various types of destructional land forms which erosion produces. Thus the histories of valleys, of glacial and aeolian land forms, and of shore lines are developed, leading to the final intergradation of the destructional with constructional land forms. The method will not be that of lectures, but will consist of inductive class discussions, with laboratory work and reading in selected literature. Opportunity for voluntary field work will be offered.

Geology Continued

12·40. Economic Geology. Lectures on the occurrence and origin of ore deposits. Lindgren, *Mineral Deposits, Fourth Edition.*

12·41. Economic Geology Laboratory (B). The student is trained in the determination of ore minerals and their relationships in hand specimens and in polished sections. The laboratory results are correlated with the geological occurrence of the ores. Intended as a laboratory supplement to 12·40.

12·42. Applied Economic Geology (B). Considers the application of geology to: prospecting for new ore bodies, geophysical prospecting, alluvial prospecting, diamond drill core interpretation, mine sampling and ore estimation. The various methods of underground geological mapping are discussed. Alternate years. (Not offered 1938–39.)

12·431, 12·432. Economic Geology Laboratory, Advanced (A). Laboratory study of specimens or suites of specimens from mineral deposits; metallographic or petrographic work.

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

12·44. Economic Geology of Fuels (B). The origin and the geological occurrence and utilization of deposits of natural gas, petroleum and coal.

12·511, 12·512. Paleontology. Designed to give a knowledge of the past life of the earth through a comparison with living plants and animals. Shimer, *Introduction to the Study of Fossils, Second Edition.*

12·52. Paleontology, Advanced (A). Laboratory work and assigned reading upon the Invertebrata or upon some aspect of stratigraphic geology.

12·53. Index Fossils (A). The determination of the geologic age of rock formations in North America through a study of their included organic remains. Grabau and Shimer, *North American Index Fossils.*

12·54. Micropaleontology (A). A study of fossil microscopic plants and animals.

12·55. Organic Evolution, Advanced (A). Study of various phases in the evolution of plants and animals.

12·581. Sedimentation (B). A brief survey of the chief types of sediments and sedimentary rocks with pertinent discussions on the environmental conditions under which they are formed and deposited.

12·582. Sedimentation (A). Consideration of the important primary and secondary chemical and physical characteristics of sedimentary rocks, supplemented by microscopic work in the laboratory, and by occasional field trips.

12·60. Glacial Geology (B). A study of glaciers, their origin, motion, resulting topographic forms, and types of deposits.

12·62. Geological Climates Seminar (A). (Alternate years. Not offered 1938–39.)

12·63. Physical Geology Seminar (A).

12·64. Geology of North America (A). Beginning with the present physiography of the continent, the geological history of each province is studied. This includes the stratigraphy, orogeny and igneous intrusives and extrusives and the influence of these upon the present structure and topography of the continent. (Alternate years. Offered 1938–39.)

12·66. Research (B). For students desiring special library, laboratory or field work on geologic problems.

12·70. Structural Geology. Deals with the original or primary structural features of igneous and sedimentary rocks and with the nature and causes of secondary structural features, joints, fissures, faults, folds and rock cleavage, their manner of formation and significance.

12·71. Structural Geology, Advanced (A). The causes, nature and significance of structural features produced in rocks by earth movements.

12·75. Metamorphic Geology (A). Study of rock alterations, including weathering, hydrothermal and dynamic alteration from the standpoint of physical, chemical and mineralogical changes. (Alternate years. Not offered 1938–39.)

12·79. Applied Engineering Geology. Designed for advanced students in engineering who have not had systematic training in geology. Intensive study of essential fundamentals of geological materials and processes, followed by consideration of applications of geology to engineering, largely by the reviewing of actual cases.

12·80. Geology of Coal and Petroleum (B). The geological occurrences of petroleum and coal deposits and the methods of investigating petroleum and coal properties.

12·81. Geology of Petroleum, Advanced (A). The stratigraphy and structure of the oil fields of the world, with special reference to those of the United States, are considered. Application is made of data in known petroliferous provinces to illustrate methods of exploration in the development of new regions.

12·851, 12·852. Theoretical Geophysics, Advanced (A). Selected topics in terrestrial physics: age of rocks; thermal problems; seismology and elastic problems; problems in crustal mechanics; figure of the earth and gravitational problems. *The Earth*, Jeffreys.

12·86. Elements of Seismology (B). A general introductory survey of seismology. The nature of earthquakes and their effects, and the propagation of seismic waves and their bearing upon the structure of the earth are treated. Seismic instruments and the applications of seismology to prospecting and engineering are briefly considered. (Alternate years. Offered 1938–39.)

12·87. Introduction to Geophysical Prospecting (B). This orientation course is designed to acquaint the student with the geophysical prospecting methods as a geological tool. The principles, possibilities and limitations of the methods are discussed, and the nature of the problem of interpreting the observational data is explained and illustrated.

The following subjects are offered as General Studies. For description see Division of General Studies.

G9. Geology.

G10. Organic Evolution.

NAVAL ARCHITECTURE AND MARINE ENGINEERING

SUBJECTS 13·00 TO 13·99

13·01, 13·02. NAVAL ARCHITECTURE (B). General theory of naval architecture; geometry of the ship; principles of flotation including displacement, stability and trim; buoyancy and stability in the damaged condition, subdivision for safety at sea; theory of waves; longitudinal strength; tonnage and freeboard. Rolling, pitching, heaving and yawing; steering and maneuvering; the resistance and powering of ships, influence of form and coefficients on resistance, models and model tanks; propulsion and propellers; methods of conducting power and speed trials; launching, grounding and docking.

13·021. NAVAL ARCHITECTURE. The resistance and powering of ships, influence of form and coefficients on resistance; powering and propulsion, propeller design, influence of hull on action of propeller; steering and maneuvering; rolling and pitching; buoyancy and stability in damaged condition, subdivision for safety at sea.

13·11. THEORY OF WARSHIP DESIGN.*

13·12. THEORY OF WARSHIP DESIGN.*

13·13. THEORY OF WARSHIP DESIGN.*

13·14. THEORY OF WARSHIP DESIGN.*

13·15. THEORY OF WARSHIP DESIGN.*

13·16. THEORY OF WARSHIP DESIGN.*

13·21. WARSHIP DESIGN.*

13·22. WARSHIP DESIGN.*

13·23. WARSHIP DESIGN.*

13·24. WARSHIP DESIGN.*

13·25. WARSHIP DESIGN.*

13·26. WARSHIP DESIGN.*

13·27. WARSHIP DESIGN.**

13·28. WARSHIP DESIGN.**

13·34. SHIP CONSTRUCTION. The structural design of steel cargo ships and their equipment. Details of steel construction, such as shell plating, framing systems, decks, bulkheads, double bottom tanks, and methods of fabrication and erection. Both riveted and welded construction are considered. The course also deals with deck auxiliaries, life-boat equipment, cargo handling gear, arrangement of quarters, ventilation and hull piping systems, joiner work and fire proof and fire resisting construction of passenger ships.

13·37. MERCHANT SHIPBUILDING.* A brief course dealing with the design and construction of various types of merchant ships, especially those which might be used as naval auxiliaries in time of war. The rules of the classification societies for building and classing merchant vessels, and the governmental regulations applying to tonnage, freeboard, subdivision, stability, life-saving appliances, fire protection and inspection, are considered.

13·40. YACHT ARCHITECTURE. A combined lecture and drafting room subject dealing with sailing and auxiliary yachts. In the lectures attention is called to the historical and technical developments of wooden boats. Illustrated by lantern slides and moving pictures. In the drafting room the student prepares the design of a wooden sailing yacht by fairing lines, making calculations and showing the method of construction and type of rig. The student is also given an opportunity to make a model of his design.

13·41. SHIP DRAWING. In this subject the student prepares the lines and curves of form of a merchant ship for definite trade requirements.

13·43, 13·45. SHIP DESIGN. (13·45 B). In these subjects each student continues the design which he began in 13·41. The following work is carried out in the drafting room: cross curves and curves of statical stability; drawing of midship section in accordance with the rules of the American Bureau of Shipping or Lloyd's Register of Shipping; inboard profile and deck plating plan; calculations for powering; subdivision, longitudinal and local hull strength, and launching; estimate of weights; diagrammatic plans for hull piping; layout of shell plating on prepared half model.

13·47. SHIP DESIGN.† Drawing-room exercises for students in marine transportation. Each student works up a design of a merchant ship, which includes the lines, dimensions, coefficients, displacement, freeboard, power and propeller requirements, and stability under various conditions of loading. He also draws a type midship section showing the principal scantlings of his design.

13·48. MODEL MAKING. The construction of a half model from the student's design. Such assistance will be given as will enable the student to complete the work.

13·52. MARINE ENGINEERING. An introductory subject in marine engineering covering both steam and Diesel machinery; fuels, combustion, boilers, reciprocating engines, turbines, auxiliary machinery and steam power plant layouts. Diesel and oil engines, motorship auxiliaries; types of engines, fuel injection and combustion, valve gears, supercharging, oil engine fuels, and Diesel electric drive. Chapman, *The Marine Power Plant.*

13·54. MARINE ENGINEERING (B). Special topics in dynamics and stress analysis. The dynamics of the crank-connecting rod mechanism; stresses in connecting rods; the balance of rotating and reciprocating machines; elementary vibration theory; torsional vibration in internal combustion engines and marine reduction gears; vibration of ships; dynamics of governors and flywheels; mechanical similitude and other related topics.

13·55. MARINE ENGINEERING. Following a brief review of nozzle and blade design the important dimensions of several turbines are computed and their principal features compared with other modern turbines. The effects of superheat, increased pressure, vacuum; types of auxiliary drive and heat balance of the marine steam plant are studied. Critical speed, blade strength, design of reduction gears and pump laws are discussed.

13·56. MARINE ENGINEERING.† An advanced subject devoted mostly to the economic aspects of marine engineer-

*Open only to Naval Students in Course XIII-A.

**Open only to special students in Naval Construction.

†Open only to students in XIII-C who have had a year of practical experience with a steamship company, with nine months service at sea.

Naval Architecture and Marine Engineering Continued

ing; comparison of fuels, and the various types of steam and Diesel propelling machinery for different types of ships and trade routes; the economical operation of propelling machinery and auxiliaries at sea and in port; boilers, main engines, auxiliaries and auxiliary systems.

13·58. MARINE ENGINEERING.*

13·61. MARINE ENGINEERING DESIGN (B). The design of various machinery parts in the drafting room; analysis of an engine with respect to torque diagram, stresses in various parts, bearing pressures, etc.; design of riveted and welded joints; the choice and relative advantages of different materials. *Marine Engineer's Handbook*, Sterling.

13·62. MARINE ENGINEERING DESIGN (B). Calculations and preliminary design of main propelling units for a steamship; determination of sizes of auxiliaries; machinery layout; diagrammatic arrangements of principal piping systems; application of modern heat transfer formulas; propeller design, and other marine engineering problems.

13·64. MARINE ENGINEERING DESIGN.*

13·73. MECHANICAL VIBRATION (A). The development of those parts of general vibration theory required for the engineering applications treated in the second term. Complex variable and vector representation, Fourier Series, harmonic analysis by tabular and mechanical methods, systems of several degrees of freedom, formal solutions, solution based on small oscillations, solution based on assumed frequency, continuous mass and elasticity, irregular distribution of mass and elasticity, Rayleigh's and Dunkerley's methods, separation of normal modes and determination of natural frequency by successive approximations, non-linear systems, self-sustained oscillations.

13·74. MECHANICAL VIBRATION (A). Engineering applications of vibration theory and methods of analysis. Stability of rotating bodies, balancing machines, balancing under operating conditions, turbine vibration, torsional oscillation of geared turbines. Reciprocating engines, balance of multi-cylinder engines, torsional vibration of internal combustion engines, curves, harmonic analysis of turning effort, calculation of natural frequency, amplitude, phase and vector diagram for energy input, damping. Methods for control of vibration in machinery installations. Methods of avoiding resonance, vector cancellation methods, dampers. Vibration isolation, vibration measuring instruments.

13·75, 13·76. ADVANCED MARINE ENGINEERING (A). Feed water systems; types of auxiliary drive; condenser design; applications of heat transmission; heat balance of main and auxiliary machinery; economic problems of marine engineering; factors influencing the selection of machinery; determination of sizes of engine room auxiliaries and pipe lines; heat stresses in piping; reduction gears, shafting, and foundations; calculations and drawings of a machinery layout for a specified ship may be made.

13·78. PROPELLER THEORY AND EXPERIMENTAL RESEARCH (A). A discussion of modern ideas of propeller action based on airfoil theory; cavitation; interactions of hull and propellers; various available methods of design. (Not offered in 1938–39.)

13·81, 13·82. SHIP OPERATION (B).† The engineering and economic aspects of ship operation, a study of the various items making up the operating disbursements and incomes; calculations for operating expenses and profits on various trade routes, comparison of different types of fuels and machinery for different sizes of ships and various lengths of voyage; influence of size of ship and speed on operating expenses; turn-around and port expenses; cubic and deadweight 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. Numerous problems in both cargo and passenger ship operation are assigned to the student.

13·83. PORT FACILITIES. A study of ports and port layouts, the handling and storage of ships' cargoes; piers, transit sheds, warehouses, railroad facilities, pier equipment; the design of the ship with reference to cargo handling, influence of turn-around on ship operation, longshore labor problems; marine passenger terminals. Special consideration is given to harbor and inland water transportation and the influence of the trends and developments in marine transportation on ports and port facilities.

13·90. EXPERIMENTAL RESEARCH (A). Designed to meet the needs of the graduate student who wishes to carry out a minor investigation in a particular field. Subject and hours arranged to fit individual requirements.

*Open only to Naval Students in Course XIII-A.

†Open only to students in XIII-C who have had a year of practical experience with a steamship company, with nine months service at sea.

BUSINESS AND ENGINEERING ADMINISTRATION

SUBJECTS 15·00 TO 15·99

15·11, 15·12. INTRODUCTION TO BUSINESS MANAGEMENT (B). Introduces the student to the functions and methods of business. The principal topics are: corporate organization, finance, accounting, production, marketing, with emphasis on the interrelations between these functions. Considers business problems in the order that they would be encountered were a new business to be launched: survey for a new venture; promotion; organization; personnel; operation; control; expansion or liquidation. (Not open to Course XV; may be taken as an elective in other Courses.)

15·20. OCEAN SHIPPING ADMINISTRATION. Deals with the types of ocean services and traffic agencies and their organizations; rate and traffic agreements; ocean shipping documents; ocean rates and regulation; marine insurance; and admiralty law. Its purpose is to acquaint the student with the more important aspects of the administration of ocean shipping.

15·25. INDUSTRIAL TRAFFIC MANAGEMENT (A). A study of the organization and operation of an industrial traffic department. Deals with industrial aspects of freight classifications, rate structures, routes, carrier-shipper relations, common carrier liabilities, general and special services, national and state common carrier regulations and protective insurance. Considers the types of transportation agencies such as rail, water, air, motor truck, mail, parcel post and express. Seminar discussions are supplemented with classroom conferences conducted by traffic managers from representative industries.

15·41. FINANCE. Deals with the principles of financial organization and management. Following an introductory study of the modern business corporation, the student examines the instruments and agencies used in finance—corporate securities, investment banking and the exchanges. Among the topics considered are: promotion, valuation, the financial plan, the sale of securities and the administration of income. Problems of expansion and the procedure during failure and reorganization conclude the subject. Specific cases illustrate the principles and afford an opportunity for individual analysis. Throughout the subject emphasis is placed on the changing character of financial management, the growing demand for consideration of interests other than those of the control group, and the development of new relationships between business and government.

15·42. FINANCIAL PROBLEMS (B). Selected topics in the fields of corporate and personal finance. Case studies in internal financial administration of industry provide opportunity for applying to concrete situations the principles developed in 15·41. Problems in personal finance constitute the major part of the subject and include consideration of investment, insurance and taxation.

15·46. FINANCIAL ADMINISTRATION OF INDUSTRY (A). Deals chiefly with the practical problems of internal financial management. Based upon the principles developed in 15·41, the subject proceeds with an analysis of the specific problems confronting business managers in the manufacturing, mercantile and public utility fields. Although the case method is largely used other readings are also required. Oral and written reports form an important part of the work. Primary attention is given to current financial operations; and attendant consideration to financial problems relating to taxation, consumer purchasing power and the availability of investment funds.

15·50. ACCOUNTING. Familiarity with the uses and interpretation of financial reports is an essential business tool. Since analysis depends upon a knowledge of constituent elements and their derivation, the subject begins with a brief consideration of double-entry bookkeeping. The major part of the term is devoted to a consideration of the problems inherent in the typical financial statements. The form and content of balance sheets and of profit and loss statements are considered; the problems of surplus, depreciation and valuation are studied. The subject concludes with an introduction to methods of statement analysis. So far as is possible, reports and accounting policies of actual companies form the basis for discussion. Throughout the course emphasis is placed upon interpretation of results. (Not open to students below the third year.)

15·51. INDUSTRIAL ACCOUNTING (B). The application of accounting control to industry. Includes the principles of cost analysis as applied to problems of manufacturing, distribution and administration. Teaching material is drawn from a wide variety of business situations.

15·52. ACCOUNTING. This shorter subject has as its objective the introduction of the student to the elements of accounting. The preparation and structure of representative financial reports to stockholders and creditors are examined in order that the student may understand their use and significance.

15·55. PROBLEMS IN ACCOUNTING POLICY (A). A consideration of case problems involving accounting policy, approached from the administrative viewpoint. The application of analytical methods to financial data is stressed. Discussion covers the nature and determination of income, asset valuation, presentation of net worth, consolidated statements.

15·56. ANALYSIS OF BUSINESS STATEMENTS (A). Aims to develop analytical ability in the interpretation of business statements and reports. Examines varying forms of statements (including those prescribed by regulatory bodies), and information essential to adequate statement analysis. Emphasis is placed on the effect of economic conditions upon the industrial enterprise and the relation of these factors to the analytical procedure. The subject is presented through the medium of case discussions and written reports.

15·58. PROBLEMS IN ACCOUNTING CONTROL (A). Examines the scope of the accounting function with emphasis upon the duties and responsibilities of the controller. Explores the principles underlying records systems and the extent to which various actual systems meet desired requirements. Periodic reports, budgets, costs, cash control, internal check, inter-company and branch

Business and Engineering Administration Continued

control, machine accounting, taxes and other special problems, including the relation of the controller to stockholders and to public bodies, are considered.

15·61. The Law of Contracts (B). Covers the entire field of the law of contracts generally. Deals comprehensively with the rules applicable to the formation of contracts, their performance and discharge and also the rights of third parties in contracts. The rules applicable to special kinds of contracts such as agency, sales and negotiable instruments are treated incidentally but not comprehensively.

15·62. The Law of the Market (B). Deals with the rights and liabilities of buyers and sellers of goods and also the rules of law applicable to customary methods by which purchases and sales are financed. Covers fully the uniform law of sales and uniform law of negotiable instruments.

15·64. The Law of Business Organization (B). Deals with the legal problems arising out of the forms of organization through which commercial activities are carried on. The legal aspects of the formation, operation and termination of agencies, partnerships, corporations and unincorporated association are considered in detail.

15·70. Production. A basic treatment of the manufacturing process. Among the important topics covered are: factory organization and personnel; fabricating and assembling sequences; productive facilities, their selection, arrangement and coördination; product design; purchasing; internal and external transport of materials; inspection; stores; and salvage. Classroom work is supplemented by plant visits and reports.

15·71. Production (B). The application of the principles of scientific management in production. Topics covered include: process research; operation analysis; standardization of materials, facilities and methods; production control; the design and installation of wage incentive systems and their bearing upon labor; and the management of clerical activities. Classroom work is supplemented by plant visits.

15·72. Technique of Executive Control (B). A survey of the means by which the line executive deals with the working group. The student considers the nature of executive responsibilities and methods of control; devices for stimulating the desire of the employee to improve the quantity and quality of his work; ways of collaborating with other executives and functional specialists. Considerable time is given to a study of common executive difficulties with subordinates, associates and superiors.

15·73. Management Laboratory. Work Simplification and Time Study. Instruction in the technique of motion study, an essential tool of modern management extensively used for the simplification and standardization of manual work. Includes such topics as process charts, micro-motion and principles of motion economy, proper work-place layout, labor-saving tools and equipment, assembly jigs, etc. Moving picture films of industrial operations are used as case material; instruction is given in labor relations involved in the introduction of work simplification; problems of employee training are considered; and the bearing of motion economy upon morale is discussed. Instruction in the use of the stop watch for rate setting. Includes such topics as selected times, leveling factors, fatigue study, allowances, base-rate evaluation.

15·75. Manufacturing Analysis (A). Deals with the formation of analytical sequences for the appraisal of management methods in a manufacturing establishment. Evaluates such factors as process, facilities, operating methods, organization, control structures, incentives. Analyzes the specific activities of such functions as purchasing, storage, traffic, research, design, inspection, salvage and maintenance. The subject is conducted as a seminar.

15·81. Marketing. An elementary subject which deals with the broader social and economic aspects as well as the managerial problems involved in marketing operation. Includes such topics as product policy, selection of channels of distribution, brand policy, advertising and sales promotion, customer relationships and problems of price structure. Major emphasis is laid on the marketing of manufactured consumer goods, although some attention is given to the marketing of industrial goods and agricultural products. Instruction is based primarily on the problem method, supplemented by reading assignments and occasional lectures.

15·82. Sales Management (B). Familiarizes the student with the operation of sales departments of manufacturing and service organizations. Among the problems considered are: product planning, market research, pricing, credits, sales promotion and advertising, organization of the sales department, control of the sales force, and administrative control of sales operations, including budgets and selling costs. Class meetings are devoted largely to discussions of actual business situations. Frequent brief written reports are required.

15·83. Marketing Research (B). Deals with the basic principles and techniques used in marketing research. Through experience with actual problems the student is trained to analyze a problem in its components, to secure the facts necessary for its solution, to interpret the data, and to prepare a suitable written report. An important portion of the work consists in an original study which is conducted by the class. As part of this investigation each student is expected to make a substantial number of field interviews.

15·85. Industrial Marketing (A). An advanced subject which deals with the problems involved in marketing goods to manufacturers and other industrial users. It covers such topics as buying methods and motives, distribution channels, formulation of marketing policies, marketing research, sales organization and control, compensation of salesmen, advertising and sales promotion, engineering service, control of marketing costs, product planning, pricing and terms of sale, and credit and collection policies. Special emphasis is laid on the coördination of methods to evolve logical and consistent marketing programs. Instruction is for the most part given through group discussions of specific problems of concerns engaged in this type of marketing. Each student is required to prepare as a term report, a complete marketing program for an industrial product.

15·86. Marketing of Consumer Goods (A). An advanced subject dealing with the problems faced by manu-

Business and Engineering Administration Continued

facturers of consumer goods in marketing their products. Discusses contemporary marketing problems from the standpoints of fundamental economics and practical circumstances. Representative topics are: pricing methods as affected by current legislation; resale-price maintenance; relationships with distributors; adaptation of products and packages to consumer demand; governmental control of marketing and the consumer movement. Contemporary marketing literature and current business problems are used as source material for group discussions.

15·88. Advertising (A). Deals with the underlying principles and technique of advertising, with particular emphasis on the viewpoint of the business man who uses advertising as a tool. The subject covers the advertising of both industrial and consumer goods.

15·92. Industrial Problems (B). Coördinates the previous subjects which the student has taken. The work consists of a series of problems presented by coöperating executives to illustrate the application of underlying principles to specific business situations. Emphasis is laid upon the formulation of a well rounded administrative policy as distinguished from the previous functional approach. In this way is indicated the interdependence of Marketing, Finance, Accounting, Production, and Labor, and the interrelationships of the business as a whole with government and with the public.

15·94. Contemporary Problems Seminar (A). A symposium dealing with contemporary industrial and economic issues. Preparation includes assignments to current periodicals as well as text references. A one-hour period is devoted to general discussion of current assignment; a two-hour period is conducted as a seminar with oral reports and general discussions. Objectives are the development of facility in the appraisal of current trends; stimulation of interest in business relationships with government, labor and the public; experience in discovering key factors influencing contemporary events. Representative topics have included: trends in public relations; American foreign commercial policy; government control of security issues and exchanges; causes of the recession of 1937; the Robinson-Patman Act; undistributed profits tax; constitutional limitations and the supremacy of the judiciary in a federal democracy; the consumer movement; the housing problem in the United States. Guests (faculty members or industrialists) are invited to attend the two-hour sessions.

15·95. Special Problems in Management (A). For graduate students who desire to do advanced work or to carry out some special investigation of a management problem not specifically covered elsewhere and not qualifying as a thesis. Hours and credit to be arranged. May include readings, conferences, laboratory and field work, and reports.

15·96. Administrative Theory and Practice (A). A seminar for the consideration of the initial problems confronting the business administrator whose responsibilities call for the determination as well as the execution of policy, and incorporate supervision over the major functions of the business. A method of approach to administrative problems is formulated. The techniques of negotiation, mediation and group deliberation are outlined. The relationships of the business administrator to subordinates, investors, vendors and customers, associates, the community, the government and the public, are examined. Administrative procedure in old and established organizations *vs.* newly organized companies is compared. Underlying principles leading to continuity of administrative tenure are reviewed. Administrative methods in political and military areas are differentiated from those used in industrial fields.

Thesis. To complete the requirements for graduation, every student enrolled in the Department conducts an original investigation of a problem, preferably one of practical value to industry, in the field of management or engineering. The purpose of the thesis is threefold. It gives the student experience in applying the scientific method and specific research techniques to a typical business problem; it aids him in developing the ability to achieve constructive results on his own responsibility; it teaches him how to present his conclusions in convincing fashion.

Graduate Thesis (A). Original research in the field of business administration. The purpose of such work is to ascertain the student's ability to make a contribution to existing knowledge.

AERONAUTICAL ENGINEERING

SUBJECTS 16·00 TO 16·99

16·01, 16·02. INTRODUCTION TO AERONAUTICAL MECHANICS (B). Elementary dynamics of particles, fluids, and solid bodies, with applications to aeronautics.

16·03. HYDRODYNAMICS AND ITS APPLICATION TO AERONAUTICS (A). Selected advanced topics in continuation of 16·02, including the theory of flow potentials, the flow equations of Euler, the energy equations of Bernouilli and Kelvin, ideal two dimensional flow, theory of finite wings and wing combinations, instability of discontinuous layers, Karman streets and boundary layer.

16·04. HYDRODYNAMICS AND ITS APPLICATION TO AERONAUTICS (A). Continuation of 16·03 with practical application of its theory and methods.

16·07, 16·08. ADVANCED TOPICS IN AEROMECHANICS (A). A detailed study of several aeromechanic problems of practical importance which are too long and too difficult to be included in 16·03 and 16·04. Particular attention given to the mechanics of airplane spin and of wing and tail flutter, and of air flow at compression speeds to advanced phases of boundary layer phenomena as they affect burbling, also to the problem of sound reduction and vibration damping directed toward greater passenger comfort, and to similar problems as time allows.

16·10. AERODYNAMICS OF AIRPLANE DESIGN. Application of aerodynamic theory to airplane design and aircraft propellers. Warner, *Airplane Design, Vol. I;* Weick, *Aircraft Propeller Design.*

16·11. AERODYNAMICS OF AIRPLANE DESIGN (B). Performance problems and general theory of longitudinal, lateral and directional stability, controllability, and maneuverability of airplanes. In addition to the classroom work, each student receives flight demonstration of the airplane motions studied. (Students may omit this part of the subject.) Warner, *Airplane Design, Vol. I.*

16·14. AIRPLANE DESIGN PROBLEMS (B). Lectures, discussions and drafting-room exercises devoted largely to the choice of type of airplane to be used for a given service. Several problems are assigned, and each student makes a selection of type, executes a preliminary design, and estimates the airplane weight and performance. Warner and Johnson, *Aviation Handbook.*

16·17. AIRPLANE DESIGN PRACTICE (B). Actual practice in design. Each student carries through the "layout" and calculations for a simple airplane. Niles and Newell, *Airplane Structures.*

16·18. AIRPLANE DESIGN PRACTICE, ADVANCED (A). Students make a preliminary design of an airplane selected by the group. The development of the design is carried through the wind-tunnel test. The results are discussed, and the model is changed so as to give it satisfactory characteristics. In addition, special structural and detail design problems in connection with the design are carried through.

16·20. THEORY OF STRUCTURES. A subject covering outer forces, reactions, shears and bending moments, the use of influence lines, the three moment equation, torsion and bending on simple sections, the design of members subjected to flexure only, the analysis of trusses by algebraic and graphical methods and the design of simple columns. Niles and Newell, *Airplane Structures.*

16·21. THEORY OF STRUCTURES (B). Covers the analysis of fittings and allied details, the use of the generalized three moment equation, the fundamental concepts of various methods for determining deflection of beams and trusses and the fundamentals of the method of least work. Niles and Newell, *Airplane Structures.*

16·22. AIRCRAFT STRUCTURES (B). Covers applications of the methods of least work and deflections to the analysis of indeterminate structures, the elements of the analysis of space framework, the use of methods of analysis currently employed in the design of all-metal aircraft and a consideration of the assumptions used in the determination of design load factors and load distributions specified for use on commercial airplanes. Niles and Newell, *Airplane Structures.*

16·25. ADVANCED AIRCRAFT STRUCTURES (A). The exact content of this subject varies somewhat from year to year as new methods of analysis become available for examination. Particular attention is paid to the investigation and development of methods for the analysis of all-metal airplanes and considerable time is spent on applications of the theory of elasticity to problems involving stiffened sheet in compression, plates under normal load and similar problems. Niles and Newell, *Airplane Structures.*

16·31. AIRSHIP THEORY (A). A study of the aerodynamic and aerostatic forces which must be borne by an airship structure, including consideration of airship stability and control. A preliminary study is made of the properties of aerostatic gases and of the general theory of sustentation of lighter-than-air craft.

16·36. AIRSHIP STRUCTURES (A). Methods of stress analysis employed in the design of rigid airships, following a brief discussion of the general arrangement and design of the hull structure and of the external loading conditions.

16·41. INSTRUMENTATION (A). Instrument problems of mechanical engineering, aeronautics, and meteorology are studied from the standpoint of fundamental physical principles. A unified treatment applicable to a wide range of instruments is based on the general theory of one-dimensional systems with special emphasis on transient phases of the response to arbitrary forcing functions. In each case, tests from practice or the laboratory are compared with the theoretical results. Thermometers, pressure gages, engine indicators, vibration measuring instruments, magnetic compasses, and gyroscopic aircraft instruments are considered. Attention is given to the factors which control the practical errors of each instrument.

16·42. AERONAUTICAL INSTRUMENTS (A). A continuation of 16·41 directed particularly toward aeronautical instrument problems. Altimeters, rate of climb meters, airspeed meters, sonic altimeters, radio altimeters, radio

Aeronautical Engineering Continued

aids to flight, and blind landing systems are studied. Hydrodynamical theory, acoustical theory, and electromagnetic wave theory are introduced where necessary. Attention will be given to special test instruments and automatic control equipment if time is available.

16·43. Instrumentation Laboratory (A). To be taken simultaneously with 16·41. Principles developed in 16·41 are applied to various types of instruments with special emphasis upon dynamic performance in each case. Laboratory exercises are devoted to the following subjects: transient and steady state behavior of one-dimensional systems, pressure gages, engine indicators, magnetic compasses, gyroscopic instruments, barometric altimeters, rate of climb meters, thermographs, hygrometers, and anemometers. A selection of experiments is allowed to suit the needs of students interested in particular fields.

16·44. Meteorological Instruments (B). Methods and instruments used to obtain and evaluate meteorological data. Lectures on the fundamental principles involved are accompanied by laboratory and field exercises. The student carries out calibrations of typical barographs, thermographs, meteorographs, and radiometeorographs. Wind velocity measurements are made with the theodolite and sounding balloons. Actual observations made with these instruments are plotted on various meteorological charts in a form suitable for synoptic or dynamic studies.

16·45. Special Problems in Aeronautical and Meteorological Instruments (A). Problems of interest to properly qualified individual students are studied in consultation with the instructor.

16·46. Vibration Measurements (A). Methods and instruments used to obtain and interpret data on mechanical vibrations. Lectures and laboratory exercises are devoted to consideration of the possibilities and limitations of mechanical, optical and electrical instruments for measuring vibrations. Electromagnetic, piezo-electric, carbon resistance and capacitative pickup units are studied. Cathode ray and electro-magnetic oscillographs are used for making visual observations and photographic records from internal combustion engines and other sources of vibration. The analysis of complex vibratory motions into harmonic components by means of mechanical analyses is illustrated by laboratory exercises.

16·52. Aircraft Propeller Design (A). Theory and practice of propeller design including the study of propeller stresses. Classroom work is supplemented by actual design practice. Weick, *Aircraft Propeller Design.*

16·53. Advanced Airplane Engine Design (A). Advanced problems in the design of airplane engines, including drafting room layouts.

16·54. Advanced Airplane Engine Design (A). Continuation of 16·53, including the design of superchargers, reduction gears, etc.

16·60. Advanced Aeronautical Problems (A). Covers individual advanced work by properly qualified graduate students. Problems are selected in consultation with the instructor, and the hours are arranged to suit the individual case.

16·62. Aeronautical Laboratory (B). Lectures on the methods and equipment used in aeronautical research, and experience in the making of tests in the Institute wind tunnels.

16·63. Aeronautical Laboratory and Research Methods (B). A continuation of 16·62, with lectures on more advanced laboratory methods, and on free-flight testing, together with training in the application of these methods.

16·68. Aeronautical Seminar (A). Intended primarily for students conducting theses in aeronautics. Consists of a series of meetings with discussions of new publications and of current research work by both graduate students and members of the staff.

16·71. Airplane Shop Work. Shopwork and lectures on the handling of materials used in airplane construction, and on methods of fabrication including elementary work in airplane welding, and in fitting, design and fabrication, rib and spar making, wing covering, doping, et cetera, and an elementary study of the various airplane types, parts and designs. *The Airplane and Its Engine*, by Chatfield and Taylor.

16·72. Aircraft Production Methods. A selected group of factories, such as production machine shops, foundries, forges, mills, metal and wood working shops, are visited and their basic processes studied in detail. Each visit is carefully outlined in advance and a definite report is required. A week is spent in Hartford, Connecticut, where a study is made of the methods of engine, propeller and aircraft production in the factories of the United Aircraft Manufacturing Corporation.

16·75. Construction Details of Aircraft (B). Drafting board problems and lectures dealing with the detail design of the airplane structure, and power plant installation.

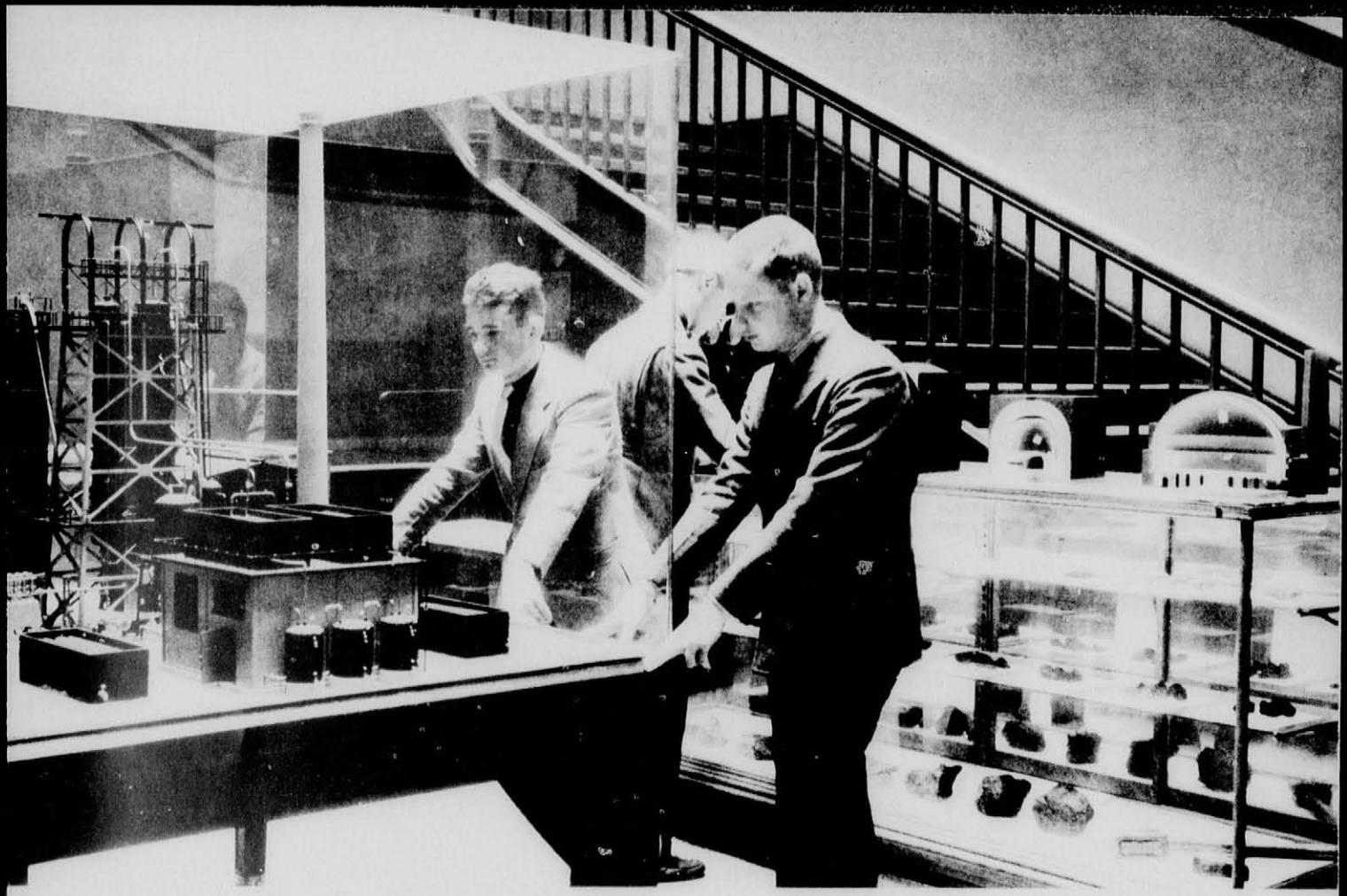
16·81. Aeronautics (B). Aircraft and the general principles of flight.

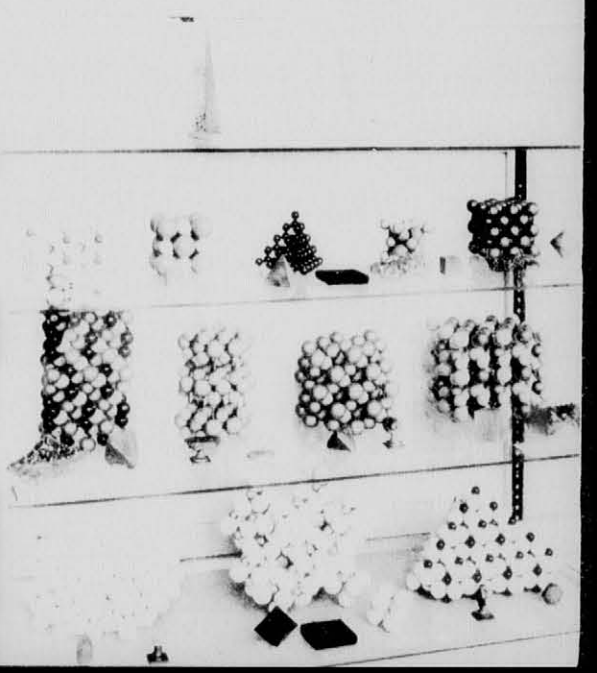
16·811. Aeronautics (B). Similar to 16·81 but particularly adapted to the needs of Naval Constructors.

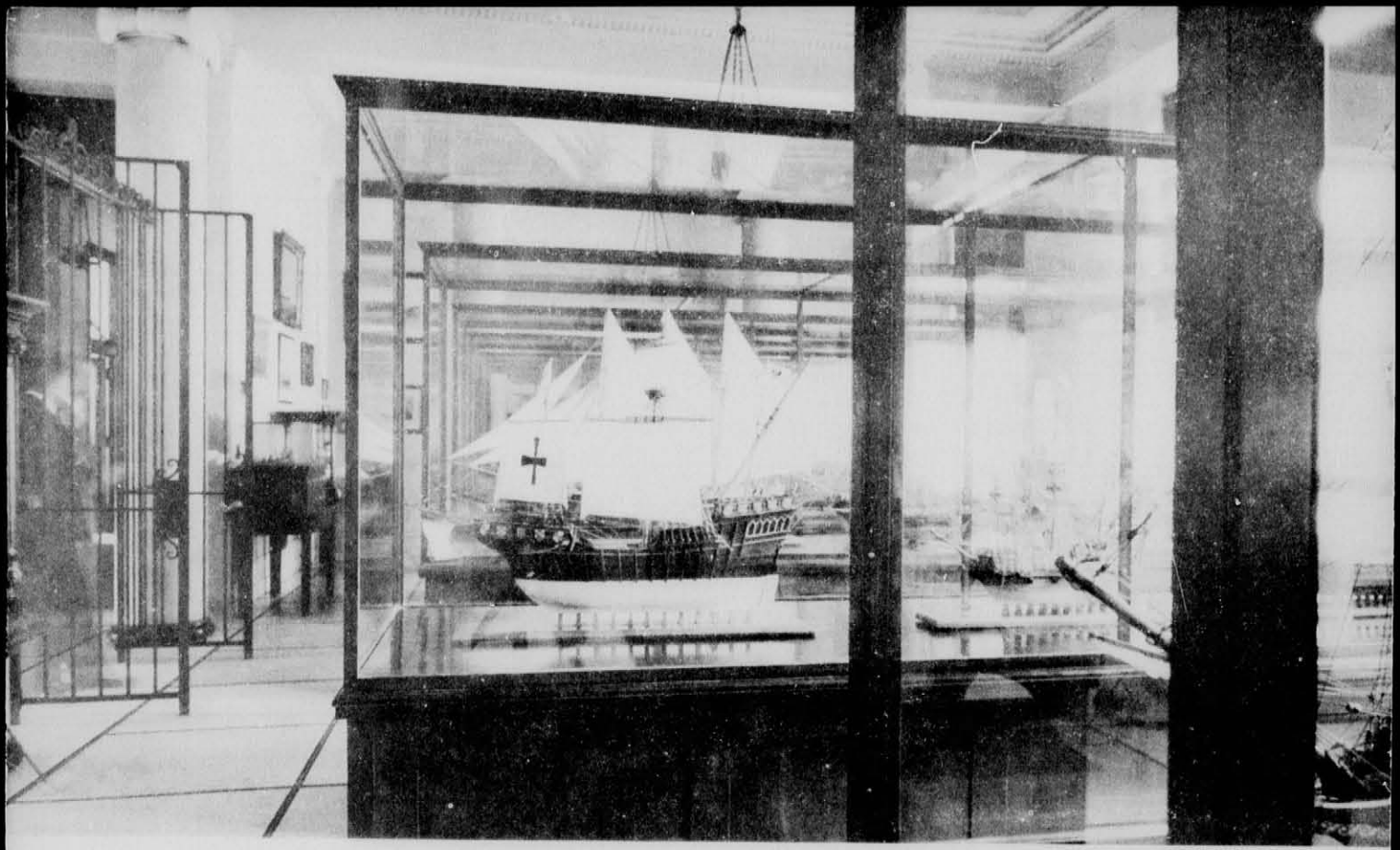
16·901. Introductory Meteorology (B). Intended to give a simplified almost non-mathematical treatment of the fundamental physical laws which hold in the atmosphere and their practical working out in the usually observed meteorological phenomena. A brief study of weather maps and polar front analysis is included together with a short discussion of the principles underlying weather forecasting. Humphreys, *Physics of the Air.*

16·911, 16·912. Synoptic Meteorology (A). A non-mathematical study of the phenomena of the weather map, starting with the modern conception of the structure of extra tropical cyclones, the polar front theory and the general circulation of the atmosphere. A detailed discussion of the forecasting of local weather phenomena, especially fog, showers and thunder storms.

16·921, 16·922. Meteorological Laboratory (A). Decoding and plotting of the daily weather reports broadcast from the Arlington radio station, analysis of weather maps and practice forecasting for selected areas.







Aeronautical Engineering Continued

16·931, 16·932. Dynamic Meteorology (A). The application of hydrodynamical and thermodynamical methods to the study of the atmosphere in rest and in motion.

16·941, 16·942. Meteorological Seminar (A). Weekly reviews and discussions, by staff members and students, of recent meteorological contributions published in current periodicals, and of original research.

16·961, 16·962. Physical Oceanography (A). A qualitative discussion of the general circulation of the North Atlantic and a theoretical analysis of the most important types of ocean currents.

BUILDING ENGINEERING AND CONSTRUCTION

Subjects 17·00 to 17·99

17·22T. Building Construction. A study of the construction of Third-Class Buildings, with particular reference to the residence. The fundamentals of the assembly of various materials commonly used in such construction are discussed together with their proper relationship and the sequence in which they are ordinarily combined in the field. Improved details of construction and the use of new materials are introduced. The work is carried on by class discussions and by supervised basic problem analysis in the drafting room. *Departmental Notes.*

17·31. Building Construction. A study of Second-Class Buildings. This type of construction involves the combination 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, are studied in the same manner as in 17·22T.

17·32. Building Construction. A study of the construction of First Class Buildings with special reference to those with reinforced concrete and structural steel frames. The relation of the frame to the exterior walls, the floor arches, the interior partitions, the mechanical equipment, the electrical services and the architectural balance are studied in the same way and in proper sequence, as in the previous courses in Building Construction.

17·40. Estimating and Job Management. This subject combines two of the important functions exercised by the builder. A knowledge of the basic units into which each estimate is divided, together with the break-down of such units into material and man-hour requirements affords the student a training in the fundamentals of estimating. This work is coupled with lectures and discussions on job planning and expediting, contract relations, labor relations, safety in construction, and the business aspects of contracting. (Not offered 1938–39.)

17·41. Building Construction. A study of the sequence, construction and management of steel framed structures below and above grade; structural steel erection; fireproof floor systems; enclosure walls of brick and stone; architectural terra cotta; partitions; marble and tile work; floor finishes. Sequence of the trades; job management with special emphasis upon safety in building. (Offered in 1938–39 only.)

17·41T. Construction Problems. A continuation of the study of Building Construction with particular emphasis upon job planning, operation and supervision. The various problems confronting the builder which are not specifically covered by the contract documents, but which are inherent in each project are considered. *Departmental Notes.* (Not offered 1938–39.)

17·42. Building Construction. A continuation of 17·41. (Offered in 1938–39 only.)

17·42T. Construction Problems. A continuation of 17·41T. (Not offered 1938–39.)

17·46. Building Construction. General subject in sequence of erection for buildings of wood, steel and concrete, with special emphasis on details of construction and properties of materials. Arranged for students who desire a general idea of building construction.

17·50. Job Management. A series of lectures on the management and control of an operation in the field. Includes a study of job organization; the time schedule; the progressive and orderly sequence in which the materials should flow to the job; the coördination of the several crafts, their regulation and management; the elimination of the hazard of fire and accident. Under this heading will also be included lectures on Professional Relations; Organized Labor; Business Experience, etc. (Offered in 1938–39 only.)

17·52T. Structural Problems. The first part of this subject is intended to establish a connection by graphical and analytical methods between the study of applied mechanics and structural theory. The student is enabled by graphical analysis actually to see stress distribution and is thereby afforded a more visual concept of stress analysis. This procedure is applied to forces, homogeneous and non-homogeneous beams of wood and steel and reinforced concrete, trusses and masonry piers and arches. The latter part of the subject is an application of these studies to structural design in timber, including the analysis of compound beams, trussed girders, floor frames of wood, roof trusses and details, timber and concrete-filled columns, and other details common to heavy timber construction. Wolfe, *Graphical Analysis;* Fuller and Johnston, *Applied Mechanics, Vol. II;* Voss and Barney, *Wood Construction.*

17·53. Structural Analysis. A study of the structural design of reinforced concrete, including the development of the theory of concrete design, a study of the specifications for stress, the design of fireproof slabs of several standard types, both solid and ribbed, the design of beam and girder construction, flat-slab construction, and reinforced concrete columns. *Design of Reinforced Concrete Structures,* Peabody. (Offered in 1938–39 only.)

Building Engineering and Construction Continued

17·53T. Structural Design—Reinforced Concrete. A study of the structural design of reinforced concrete building frames, including the development of the theory of design, consideration of specifications, the design of solid and ribbed slabs, beams and girder frames, flat slab systems, columns and footings. Special consideration is given to the economics of design. *Design of Reinforced Concrete Structures*, Peabody. (Not offered 1938–39.)

17·531. Structural Design—Reinforced Concrete. An abridgement of 17·53T with the same classroom exercises and preparation. A shorter time is devoted to problems than in 17·53T. *Design of Reinforced Concrete Structures*, Peabody. (Not offered 1938–39.)

17·54. Structural Analysis. A study of the structural design of the steel-framed commercial building, including shoring, needling and underpinning, derrick loads, standard code requirements, typical floor arch systems, beams and girders of rolled and built-up sections, study of riveted joints, review of plate-girders and trusses, columns and column loads, grillage footings, and caissons. *Steel Construction*, Voss and Varney. (Offered 1938–39 only.)

17·54T. Structural Design—Structural Steel. A study of the design of structural steel building frames, including the design of typical floor-arch systems, rolled and built-up beams and girders, a study of the design of details, truss analysis, columns, and foundation problems. Especial attention is given to general steel framing as related to architectural details, and to the application of structural design to shoring and underpinning. *Steel Construction*, Voss and Varney. (Not offered 1938–39.)

17·541. Structural Design—Structural Steel. An abridgement of 17·54T with the same classroom exercises and preparation. A shorter time is devoted to problems than in 17·54T. *Steel Construction*, Voss and Varney. (Not offered 1938–39.)

17·73T. Materials—Masonry. Begins with a study of the sources and composition of masonry materials together with their conversion into usable building form. Clays and clay products, cements and lime, concrete aggregates, composition and qualities of mortars, natural and cast stone, gypsum products and various masonry specialties are taken up from the standpoint of construction and engineering design.

Class discussions are augmented by reports on assigned collateral reading. *Departmental Notes.*

17·74T. Materials—Wood and Metals. Mechanical and physical properties of wood are studied 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 are among other phases taken up. The work in metals begins with alloy diagrams and their interpretation, followed by consideration of the most important non-ferrous alloys, and a more detailed discussion of the ferrous metals, their properties and heat treatment. Supplementing this work is the chemistry of corrosion and welding theory and practice. Class discussions are augmented by reports on assigned collateral reading. *Wood Handbook*, *Chemistry of Engineering Materials*, Leighou.

17·75. Materials. Lectures and laboratory work arranged for students in Courses IV and IV-B. The work covers the same field as 17·73T, with the exception that the supplementary reports are omitted. Laboratory exercises on the methods of making physical tests for the properties of the more common engineering materials, and a study of their behavior under stress are included.

17·76. Materials. This subject is a continuation of 17·75 and 17·76T, and covers the same field as 17·74T, with the exception that the supplementary reports and laboratory exercises are omitted.

METALLURGY

SUBJECTS 19·00 TO 19·99

19·01. INTRODUCTION TO METALLURGY. A brief orientation subject designed to acquaint the student with the fields of process metallurgy and physical metallurgy, and to emphasize the importance of metallurgy in industrial development.

19·03. FIRE ASSAYING. The sampling of ore and bullion, the assaying of ores for gold, silver and lead, and of bullions, solutions, matte and miscellaneous furnace products. The fire assay of copper, tin, mercury and platinum is briefly discussed. Typical ores, bullions and solutions are used for analysis; the important standard methods are covered. Stress is laid upon the accuracy of results and the neatness of work and of notes. Bugbee, *Fire Assaying.*

19·05, 19·06. FIRE ASSAYING, ADVANCED (A). The theory and practice of fire assaying, which includes practice with works methods for gold and silver; the fire assay for tin, mercury and members of the platinum group of metals; also a certain amount of research.

19·07. METALLURGY: COPPER AND LEAD (B). Deals mainly with the extraction of the metal from ores and concentrates by pyro- and hydro-metallurgical methods and the refining of the crude products. The principles of the subject are covered in thirty lectures. The remainder of the time is used in the library, laboratory and in conferences. The work in 19·11 is closely coördinated with this course. Hayward, *An Outline of Metallurgical Practice;* Hofman and Hayward, *Metallurgy of Copper;* Hofman, *Metallurgy of Lead.*

19·071. METALLURGY: COPPER AND LEAD (B). The lectures are given simultaneously with 19·07. The laboratory work is omitted but it is suggested that 19·11 be taken simultaneously. *Textbook same as for 19·07.*

19·09. METALLURGY: COPPER, LEAD, ZINC, ETC. (B). The lectures on copper and lead are given simultaneously with 19·07 and 19·071. In addition, there are fifteen lectures covering briefly zinc, aluminum and other metals. It is suggested that 19·11 be taken simultaneously. Hayward, *An Outline of Metallurgical Practice.*

19·11. METALLURGICAL AND ELECTROCHEMICAL LABORATORY. The roasting, sintering, smelting and leaching of copper and lead ores are carried out together with the refining and desilverizing of copper and lead. Practice in the use of various types of electric furnaces is obtained. The production of steel, ferro-alloys, calcium carbide, etc. by electrothermic methods and other pyrometallurgical and electrochemical processes are studied.

19·12T. METALLURGY: GENERAL, ZINC AND MINOR METALS (B). Covers in a general manner the properties of metals and alloys, treats in detail fuels and refractories, discusses the principles which govern pyro, hydro and electrometallurgical processes and considers typical metallurgical apparatus. In zinc and minor metals the work supplements that given in 19·09. Hofman, *General Metallurgy;* Hayward, *An Outline of Metallurgical Practice.*

19·13. NON-FERROUS METALLURGY, ADVANCED (A). For graduate students who have had fundamental courses in non-ferrous metallurgy and wish to continue the study of one or more of the metals. Latitude is allowed in the choice of subject and the time may be adjusted to suit the requirements of the work which may be a combination of library studies and conferences with laboratory work if desired. The work is confined to production and refining. Those desiring to study the properties of metals and alloys should register for 19·61, 19·62.

19·14. METALLURGY OF COMMON METALS. Designed for engineering students who do not expect to practice metallurgy as a profession. Considers iron and steel, copper, lead, zinc, aluminum, antomony, tin and nickel. The discussion covers sources, methods of extraction, physical properties of metals, principal uses, origin and effect of impurities, refining and industrial alloys. Elective in third or fourth year. Hayward, *An Outline of Metallurgical Practice.*

19·15. PRODUCTION METALLURGY. Introductory lectures deal with the general chemistry of metallurgical processes, fuels and refractory materials. Attention is paid throughout the remaining lectures to the world's resources of the various metals and ores with special reference to their production in the United States. In regard to non-ferrous metals, special emphasis is placed on properties and uses, but the basic principles involved in smelting, refining and alloying are described, together with brief descriptions of the various types of furnaces used. About half of the subject deals with iron and steel. The production of pig iron, cast iron, malleable cast iron and the various kinds of steel are gone into. The properties and uses of the various products are discussed. Alloy steels and alloy cast irons are dealt with, and heat treatment is taken up. Opportunity is given to visit a blast furnace, iron foundry, steel casting plant, and a plant with basic and acid open hearth furnaces, blooming mill and finishing mills. (For U. S. Army Officers only.)

19·16. GENERAL METALLURGY, ADVANCED (A). Fuels, refractories and the principles of roasting and smelting are studied with greater thoroughness than is possible in the undergraduate courses. A critical analysis is made of the manner in which these principles are carried out in present practice and suggested improvements are discussed.

19·18. METALLURGICAL CALCULATIONS, ADVANCED (A). The reactions involved in various metallurgical operations are studied, with special reference to their thermal values. Heat balances and furnace efficiencies are calculated and a critical study made of the results with a view to suggesting improvements in design or operation of apparatus.

19·19. METALLURGY: IRON AND STEEL (B). The production of wrought iron, pig iron, steel and alloy steels is considered in detail. Special attention is paid to the design and engineering operations incident to iron and steel manufacture and to the economic advantages of the various processes. Lectures are supplemented by plant visits which are covered by subsequent reports and seminars. Stoughton, *Metallurgy of Iron and Steel;* Camp and Francis, *Making, Shaping and Treating of Steel.*

Metallurgy Continued

19·20. METALLURGY: IRON AND STEEL. Arranged for U. S. Navy Officers who have had previous work in metallurgy at Annapolis. About half of the subject deals with alloy steels, taking up their manufacture briefly, devoting most time to properties, heat treatment, composition and uses. Alloy cast irons are also taken up. Other lectures deal with specification and inspection, and some work is given on corrosion. Opportunity is given for plant visits. (For U. S. Navy Officers only.)

19·211. METALLURGY: IRON AND STEEL. The class work is simultaneous with 19·19. Library work and plant visits are omitted. Stoughton, *Metallurgy of Iron and Steel.*

19·22. METALLURGICAL PLANT VISITS (B). Consists of one week spent in visiting metallurgical plants in New Jersey and Eastern Pennsylvania. The production of iron and steel, zinc, copper and lead is studied. Students will meet an instructor at a designated place about one week before the opening of the fall term. Required of men expecting to register for Metallurgy 19·07, 19·071, 19·19 or 19·21.

19·23, 19·24. METALLURGY: IRON AND STEEL, ADVANCED (A). Class work, conferences, plant visits and library work, aiming to supplement and to give a more detailed knowledge of the subject than is possible in the undergraduate courses.

19·25, 19·26. METALLURGICAL PLANT DESIGN (A). Aims to make the student conversant with some construction details of metallurgical plants. Involves the fundamental calculations for a given problem, the study of detail in working drawings, followed by the preparation of drawings of a plant as a whole and of some of the apparatus in detail, together with a final report.

19·27. METALLURGICAL PLANTS (B). Drafting room, library and conference work. Details of apparatus, plant arrangement and operations are studied and presented at occasional seminars.

19·31T. METALLURGICAL THERMODYNAMICS (B). A short course in thermodynamics emphasizing those portions which are especially useful in metallurgical operation. The free energies of substances at elevated temperatures and the activities of metals in solid and liquid alloys are used in interpreting a number of metallurgical phenomena and in determining the feasibility and limitations of a variety of metallurgical processes.

19·32T. PRINCIPLES OF STEEL MAKING (B). The reactions which are of importance in the manufacture of steel are studied from the viewpoint of physical chemistry. These include reduction of ore, reactions of liquid iron and steel with slags and gases and the chemical effects of alloys and deoxidizing agents. The influence of melting and refining methods upon the properties of the finished product is included.

19·50. METALLOGRAPHY. The general methods used in the study of metals and alloys, the construction and interpretation of equilibrium diagrams and the relations between the constitution of alloys and their physical properties are considered. The iron-carbon diagram is studied in detail with its application to the heat treatment and the use of steel and cast iron. Laboratory exercises include the microscopic examination of a series of typical non-ferrous and ferrous alloys. Williams and Homerberg, *Principles of Metallography.*

19·51T. METALLOGRAPHY I. An intensive study of the non-ferrous metals and alloys, the construction and interpretation of equilibrium diagrams and the relations between the constitution of alloys and their physical properties. Laboratory practice is included. Williams and Homerberg, *Principles of Metallography.*

19·52T. METALLOGRAPHY II. A continuation of 19·51T in which iron, steel, and the alloy steels are studied. Laboratory practice is included.

19·54T. APPLICATIONS OF METALLOGRAPHY (B). Lectures and laboratory conferences designed to familiarize the student with the applications of metallography to industrial problems. In the laboratory the microstructures of normal and defective commercial alloys are examined and discussed. The lectures are devoted to a critical résumé of the fundamentals of modern physical metallurgy which is essential to the proper interpretation of the microstructures.

19·57. PHYSICAL METALLURGY. The thermal and microscopic methods used in the study of metals and alloys together with the relations between the constitution of alloys and their mechanical properties are considered. Included are discussions of foundry practice, forging, welding, heat treatment, pyrometry and radiography. (For U. S. Army Officers only.)

19·58. ADVANCED PHYSICAL METALLURGY. A study of the fundamental properties of metals including the theories of metal hardening, the crystalline structure of metals, the relations between alloy diagrams and physical properties, normal and abnormal grain growth and similar topics. (For Army and Naval Officers only.)

19·59, 19·60. ADVANCED PHYSICAL METALLURGY. A study of the fundamental properties of metals and alloys with particular reference to materials used in torpedo construction. (For U. S. Naval Officers only.)

19·61, 19·62. PHYSICAL METALLURGY, ADVANCED (A). A series of conferences dealing with recent developments in physical metallurgy, accompanied by laboratory exercises in which brief research problems will be undertaken.

19·63. CORROSION AND HEAT RESISTING ALLOYS (B). A study of metals and alloys with respect to corrosion and heat resistance, including a discussion of inter-crystalline failure, corrosion protection, creep and selection of materials.

19·631. METALLOGRAPHY AND CORROSION. Designed primarily for students in Petroleum Production. Includes the metallography of 19·50 and the corrosion section of 19·63.

19·64. LIGHT ALLOYS (B). A detailed study of the structure, properties, heat treatment and uses of alloys of aluminum, magnesium and beryllium.

19·66T. HEAT TREATMENT. The effect of heat treatment on the physical properties of iron, steel and other metals. Considerable time is devoted to the determination of the proper heat treatment to bring out any particular property desired.

19·67. HEAT TREATMENT. Conferences and laboratory work dealing with the effect of heat treatment and hot

Metallurgy Continued

and cold work upon the physical properties of metals used in torpedo construction. (Open only to officers of the United States Navy taking Torpedo Engineering.)

19·69. Physics of Metals (B). A discussion of the modern theories of the metallic state resulting from a study of the physical properties of metals.

19·70. X-Ray Metallography (B). Lectures and laboratory work dealing with the use of X-rays in the study of metals. Includes radiographic examination of metal parts, as well as the X-ray diffraction study of the atomic and granular structures of metals, and their relations.

19·71. Physics of Metals, Advanced (A). A discussion of various problems of the crystalline metallic state and the dependence of physical properties upon structure. Experimental methods of obtaining information in this field are considered. Laboratory work in the form of short research problems is available.

19·72. Theory of Metal Hardening (A). A critical discussion of the modern theories of the hardening of metals.

19·73. Ferromagnetism (A). A study of the outstanding properties of ferromagnetism materials, their interpretation, and the application of ferromagnetism to the investigation of the physical structure of metals. (Not offered 1938–39.)

19·75. Atomic Arrangements in Alloys (A). Covers a few applications of statistical mechanics and thermodynamics to alloys. The discussions begin with a brief introduction to the fundamental concepts, and proceed to those applications which seem of most interest to the class. Special topics to be discussed include problems of order and disorder in alloys, ferromagnetism, phase changes and non-equilibrium states.

19·81. Elements of Electrochemistry. Fundamental principles of electrochemistry and their industrial applications for students who desire a general survey of this subject but who have had no previous preparation in physical chemistry. Thompson, *Theoretical and Applied Electrochemistry.*

19·82. Applied Electrochemistry (B). Consideration of the industrial applications of electrochemistry. Includes the theory and construction of different types of electric furnaces, electrometallurgical processes, accumulators and primary cells, and the electrolytic production of chemical compounds. The work also includes the design of one or more electrochemical plants for specific processes. Thompson, *Theoretical and Applied Electrochemistry.*

19·83. Electrochemical Laboratory (B). Carried on in conjunction with 8·82. Electrical conductance, single potentials, decomposition voltages, overvoltages, polarization, and electrolysis including practice in electroplating, also efficiency tests on technical processes involving electrolysis in aqueous solutions, e.g. the production of hypochlorite, chlorate, etc.

19·85. Electric Furnaces (B). Intended for fourth year and graduate students who desire to obtain some acquaintance with electric furnace operation, without having had any previous training in applied electrochemistry. Thompson, *Theoretical and Applied Electrochemistry and Neostyled Notes.*

19·87. Electrochemistry, Advanced (A). The application of thermodynamics to electrochemical problems, including electromotive force of reversible cells, electrolytic oxydation and reduction phenomena and high temperature equilibria in electric furnaces. Lewis and Randall's *Thermodynamics; Journal articles.*

19·901. Ceramics. An introduction to the more advanced ceramic subjects. The selection of ceramic materials, molding, drying and burning are taken up, as well as the physical properties of finished products. Commerical processes will be carried out in the laboratory on a small scale.

19·91. Optical Ceramics (B). Primarily a laboratory subject in which the methods of petrography are applied to the study of ceramic products and raw materials, such as clay, cement, glass, porcelain, refractories, etc.

19·92. The Nature of Glass. The subject is intended to bring out the latest ideas on the nature of the glassy state from various points of view. Six lectures will be given by nationally known authorities in this field. While there is no required preparation, it is desirable that the student have some knowledge of the previous literature on this subject. Six laboratory experiments will be offered illustrating the use of modern equipment for determining the various physical properties of glass which are indicative of its structure.

19·93. Fundamental Ceramic Processes (A). Covers the theory and practice of forming, drying and burning of clay articles, such as white wares, refractories, terra cotta, etc. The principles involved in the manufacture and use of glass, cements and abrasives will also be discussed. The principles of kiln and furnace design are discussed and practical examples will be analyzed.

19·94. Physical Properties of Ceramic Products (A). Includes the various methods of determining the properties of finished ceramic articles. The influence of manufacturing methods on these properties is taken up in order to bring out effective methods of control.

19·95, 19·96. Special Problems in Ceramics (A). For graduate students who desire to do advanced work in this field on some topic not specifically covered elsewhere. The student is expected to make his own choice of the topic and the allotment of time. The latter may be devoted to lectures, conferences, assigned readings, or laboratory work.

19·97. The Reactions in Ceramic Materials on Heating. This subject is offered for the purpose of bringing together our most modern information on the reactions in heating ceramic materials. It is well known that the greatest difficulties are encountered in that portion of the manufacturing process which entails firing of the ware. It is only by a complete understanding of the reactions which occur under these conditions that troubles can be eliminated and improvements made in a process. The subject will be discussed in six lectures from various points of view, and six laboratory experiments will be offered to illustrate the use of modern equipment in determining the firing characteristics of a given material.

DRAWING

SUBJECTS D1 TO D99

D11. ENGINEERING DRAWING AND DESCRIPTIVE GEOMETRY. Instruction in the correct use of drafting instruments and materials. Practice in lettering. The theory of projection drawing. Drawing in orthographic, isometric, oblique and perspective projection. A study of the fundamental concepts of descriptive geometry, including reference systems, representation of the point, line and plane: fundamental problems of position, of perpendicularity and of measurement. Especial emphasis is placed on the ability to visualize the problems, and the processes involved in their solution. A part of each exercise is devoted to a lecture. French, *Engineering Drawing*. Hood, *Geometry of Engineering Drawing*.

D12. ENGINEERING DRAWING AND DESCRIPTIVE GEOMETRY. A continuation of D11 including practice in dimensioning, the making of dimensioned freehand sketches of machine parts and the accurate detail and assembly drawings from the sketches. Tracing in ink and pencil on cloth or paper of the finished drawings. A study of the various surfaces and solids, their sections, developments and intersections. Finally, the application of descriptive geometry to certain problems arising in engineering practice. A part of each exercise is devoted to a lecture. French, *Engineering Drawing*. Hood, *Geometry of Engineering Drawing*.

D13. DESCRIPTIVE GEOMETRY. A course including only the descriptive geometry part of D11 and D12. This course is intended for transfer students who have been given credit in the Engineering Drawing of the first year. French, *Engineering Drawing*. Hood, *Geometry of Engineering Drawing*.

D21. PERSPECTIVE. Fundamental phenomena of appearance, the general theory of conical projection and its application to perspective, the method of revolved plan upon which all shorter methods are based, curves and apparent distortion. The study of direct division, direct measurement, relations between lines and points in the vanishing-point diagram, the cubic system, method of perspective plan, and shadows. *Principles of Architectural Perspective*, Lawrence.

ECONOMICS AND SOCIAL SCIENCE

SUBJECTS Ec1 TO Ec99

Ec11, Ec12. ECONOMIC PRINCIPLES. Elementary but comprehensive. Consists of an analysis and description of the existing economic structure of society, a brief study of economic theory and the application of that theory to some of the more important economic questions.

Ec14. CURRENT ECONOMIC PROBLEMS (B). Applies economic principles and statistical tests to the groups of economic problems that seem each year to be most timely. Among these have been the following: the problem of technological unemployment; high wage theory; gold standard; price fixing; international balances; control of speculation; tariff problem; financing by bonds vs. taxation; relative scope of government and business.

Ec15. PRINCIPLES OF ECONOMICS (B). A study of the fundamentals of production, business organization, supply and demand, the price level, wages and employment, interest and profits, and a brief consideration of leading economic institutions and problems. Restricted to mature students for whom it is especially designed.

Ec17. ECONOMIC THEORY (A). A brief historical review showing the interdependent growth of theory and fact, followed by the general theory of equilibrium under price competition and price monopoly from which will be determined, under the given conditions, wages, rents and interest. Findings will be revalued under conditions which more closely approach reality.

Ec19. MATHEMATICAL APPROACH TO ECONOMICS (A). Lectures and discussions in the use of mathematical methods in the field of economic theory. The topics included will vary from year to year.

Ec28. BUSINESS CYCLES (A). A study of the fluctuations in the different phases of business. In this is involved statistical interpretation, theories of the business cycle, studies of the intercausation of the different types of business changes, the interpretation and experimental tests of forecasting methods, the theory and practice of government control.

Ec32. STATISTICS. Includes frequency distributions, averages, measures of dispersion, higher moments, simple correlation, association, time series and index numbers, elements of sampling and precision. The methods are applied principally to business and economic data.

Ec34. ENGINEERING AND LABORATORY STATISTICS. Work in the practical handling of data. Designed for students and research workers who expect to deal extensively with test data. As far as possible, course material and problems will be drawn from current and recent investigations in the Institute's laboratories, nearby plants and from material presented by those attending the course. An attempt will be made, wherever possible, to show how the design of scientific and engineering experiments may be improved by considering in advance the problems of statistical precision and adequacy. One hour each week will be devoted to a seminar meeting with students of M332 at which discussions of recent developments in statistical methods will be presented by the instructors, students and outside speakers.

Ec37T. STATISTICAL METHODS FOR QUALITY CONTROL (A). The application of statistical technique to the control of the quality of goods produced by mass-produc-

Economics and Social Science Continued

tion methods. Includes application of the theory of sampling and correlation to industrial data, practical problems in sampling, inspection and testing, measurement of quality, industrial specifications, quality control charts, applications to products such as coal, steel, lamps, building materials.

Ec40. Money and Banking. Credit instruments, commercial banks, trust companies, savings banks, different kinds of loans, securities for loans, credit statements, the bank statement, the money market, group and branch banking, the federal reserve system, credit control, and foreign exchange.

Ec45. Monetary and Banking Problems (B). Presupposes a knowledge of the more elementary facts relating to banking in the United States. Topics to be discussed in conferences on recent and proposed changes in banking and monetary policy, including the insurance of deposits, limitations on scope of loans by banks, new types of banking institutions, devaluation of the dollar and inflation.

Ec47. Investment Finance (A). The topics discussed include forms of business organization, formal aspects of corporate securities, promotion and financing of new enterprises, financial aspects of business combination, accounting for income, administration of corporate income and of working capital, problems of business failure and of reorganization. The course is designed (1) to enable prospective investors to appraise the financial policies of business managements; and (2) to enable prospective business managers to understand the financial policies necessary to protect and to attract investment funds.

Ec48. Investment Analysis (A). Deals with the investment characteristics of enterprises of various kinds and with methods of analyzing the corporations whose securities are offered to investors. Measurement of the risk and yield of the securities of enterprises in new industries and of established enterprises in expanding, stationary and dwindling industries. Corporate reports and their interpretation. Investment ratios and criticism of such ratios. Investment canons and their limitations. Special attention is devoted to appraising enterprises whose securities may be under consideration for investment.

Ec54. Corporations (B). Intended to meet the needs of those students whose professional interest may be in scientific or engineering fields, but who desire some knowledge of corporate organization and finance and the social and political problems of business. Among the topics considered are: legal relationships within the corporation, financial organization and management, the evolution of corporate structures, intercorporate relationships, trade associations, combinations, and government regulation of industry.

Ec55. Economics of Transportation (B). The operation of economic principles and political factors in the transport industry, including a history of the industry in the United States, its rate problems, financial aspects and relation to the government. An attempt will be made to estimate the rôle which each separate agency plays in the transport system as a whole and to indicate the economic consequences of current developments.

Ec57. Public Utilities (A). Following a brief study of the general principles of organization and finance applicable to public utility corporations, attention is given to some important economic and management problems such as: the organization and structure of utility systems, holding companies and intercorporate control, economic elements in the production and delivery of service, financial problems of management, and the relation of government to the industry.

Ec59. International Economic Relations (A). A study of the financial position of the United States, United Kingdom and other important commercial countries based upon an analysis of international payments. Consideration is given to the mechanism of exchange, international banking institutions and money markets, the financing of foreign trade, international short term and long term investments. Attention is devoted to the influence of international factors upon American business conditions and to the economic effects of nationalism as manifested in tariffs, raw material and exchange controls and other types of trade restriction.

Ec61. Labor Relations (B). A study of the relations of employers and employees under present conditions of industry, how these are influenced by objective economic and legislative factors, and how they may be affected by company policies. Special attention is devoted to issues of collective bargaining.

Ec62. Labor Problems (B). With the background acquired in Ec61, this subject considers in greater detail problems of wages, hours of labor and unemployment. Special attention will be given to the economics of collective bargaining. Consideration also will be given to the economic problems raised by social security legislation in the United States. Throughout emphasis will be placed on the current aspects of labor problems.

Ec67. Labor Relations Seminar (A). Each student will investigate a particular topic in which he is interested and report to the class; the report will be followed by a general discussion. A wide latitude in the selection of subjects will be allowed: the problem may involve outside investigation or be largely library research; it may be in the general field of personnel relations, such as an investigation of written company labor policy, layoff policy, or wage policy; it may relate to organized labor, such as an investigation of trade agreements, the technique of collective bargaining; or the topic may be of a broader sociological or psychological nature, such as an investigation of the effects upon workers of unemployment, or an investigation of worker attitudes.

Ec68. Personnel Problems and Labor Relations (A). This subject will be a general survey of labor relations for the advanced student. The development of personnel programs and policies will be studied. Emphasis will be placed upon group relations, rather than upon individual adjustment problems. Recent developments will be particularly stressed. Cases will be used in addition to reading assignments. Outside speakers, personnel men and representatives of labor, will be invited to discuss with the class representative problems in the light of their experience.

Ec72. American Government. The governmental process in the United States viewed historically and functionally. The development of the American system will be studied in relation to the changes that have taken place

Economics and Social Science Continued

in political ideas both in this country and abroad. Attention will be given to the influence of the press, the radio and other factors affecting public opinion. Political phenomena will be correlated with economic changes and other social movements.

Ec78. Government Control of Industry (A). A study of the relationship of the state to economic activity. Attention will be centered on the United States, but comparison will be made with medieval gild control, the policies of mercantilism and with contemporary foreign systems. Topics include: instruments of control such as taxation and the administrative commission as developed in the United States, protection of consumers and wage earners, control of corporations, public utilities, security issues and exchanges, holding company regulation, trade associations, the anti-trust laws and the Federal Trade Commission.

Ec82. Principles of Sociology (B). After an introductory study of the social origins from the anthropological point of view, the effect of environment on human life and society will be dealt with. The social process will be discussed with reference to social institutions, folkways, mores, and laws. Some attention will be given to the concept of social progress, especially the social implications of the Industrial Revolution.

Ec83. Urban Sociology (B). Social origins; effect of environment on human life; social institutions; social change and social control; social characteristics of urban and rural communities; the relation of facilities for residence, commerce, government, education, and recreation; physical deterioration of the city as a by-product of social change; function of planning in the solution of social problems.

Ec84. Social and Economic Factors in City Planning (B). The social sciences in relation to the problems of city planning and housing. Subjects covered include: population growth and movement; rural-urban migrations and their relation to shifting industry; community costs for education and recreation; methods of assessment and taxation; fluctuation in land values; financing of public improvements.

Ec87. Methods of Social Investigation (B). A critical survey of methods for gathering and evaluating data in the social sciences. Topics discussed will include: principles of measurement in the social sciences, the administration of field work, the construction and use of the questionnaire, sampling methods, methods of tabulation, statistical tools for the interpretation of material gathered in field investigations. Material for discussion will be drawn from economics, sociology, and social psychology.

Ec88. Psychology in Business and Industry (B). Discussion of the application of psychological principles to such industrial and business problems as the following: methods of employment selection, selling and advertising techniques, the training of employees, the development and maintenance of morale, psychological aspects of employer-employee relations, psychological problems involved in wage-determination, the evaluation of wage-incentives, fatigue and related problems of efficiency. Psychological tests, illustrative films, and other demonstrational material will be used wherever possible.

Ec91, Ec92. Economics Seminar (A). Consideration of special social problems, or the study of economic problems of particular industries. Open to graduate students only.

The following subjects are offered as General Studies. For description of subjects see Division of General Studies.

G71. Principles of Psychology.

G72. Social Psychology.

G77. Social Institutions.

G78. Contemporary Social Problems.

G79. Comparative Political Institutions.

ENGLISH AND HISTORY

SUBJECTS E1 TO E99

E1. ENGLISH (ENTRANCE).

E11. ENGLISH COMPOSITION. Covers the principles of clear, accurate writing, with constant emphasis upon correctness and force of expression. Analysis of lectures, readings, and problems is used throughout the term as material for both oral and written work. Conferences with the instructor are held at frequent intervals. Oral work is an integral part of the course, each student presenting several short informal talks. Regular use of the library is required.

E12. ENGLISH COMPOSITION. Three options are provided as follows:

A. Contemporary Literature. Reading of representative short stories, plays, and poems, and the writing of frequent short critical discussions of the reading. The main purpose of the option is the continuation of training in writing and the inculcation of good standards of taste based upon experience and judgment. Conferences and oral work as in E11.

B. The Post-War World. Material is drawn from contemporary world problems, these serving as a basis for training in the organization and presentation of facts and ideas. Conferences and oral work as in E11.

C. Scientific Writing and Thought. An introduction to scientific method and to scientific literature in the broadest sense. It is primarily a study of the mind of the scientist as he attacks his problems and presents them in written form. The student will be expected to apply the methods developed to numerous problems and to present the results of his work both orally and in writing. Conferences as in E11.

E21. LITERATURE AND HISTORY. Three options are offered, with oral and written work, outside reading, and conferences:

A. Growth of the Western World. Presents as a unit the history of Europe and America from 1750 to 1870. Military and political events are subordinated to the social, economic, scientific, and cultural developments of the period.

B. History of Thought. Traces the historical connection between present day ideas and the theories of the great thinkers in science, philosophy, government, and economics from 1200 to 1789.

C. Literature. Covers the same period of time in the field of literature as that covered in the option in history. Only men in the first rank are dealt with, and their works are studied with the object of showing their place in world literature.

E22. LITERATURE AND HISTORY. Three options are offered, with oral and written work, outside reading, and conferences:

A. Growth of the Western World. A continuation from 1870 to the present time of the E21 option of the same name.

B. History of Thought. A continuation from 1789 to the present time of the E21 option of the same name.

C. Drama. Presents the principles of drama together with the study of those principles in representative plays of different periods. Each class-section is given laboratory practice in presenting a play during the term.

E35. REPORTS. The preparation and presentation of business and engineering reports. Practice in the investigation of subjects, the arrangement of material and its presentation in report form. Subjects covered range from simple memoranda and business letters to longer, more comprehensive reports. Emphasis is placed both on written reports and on oral presentation before committees.

E42. PROBLEM ANALYSIS. The theory and practice of effective and convincing presentation of an architectural proposition to a non-professional audience. Consists almost entirely of group work.

The following subjects are offered as general studies. For description see Division of General Studies.

G1 HISTORY OF SCIENCE
G2 HISTORY OF SCIENCE
G7 PROBLEMS OF MODERN PHILOSOPHY
G12 BIOGRAPHY IN SCIENCE
G21 HISTORY OF ENGINEERING
G23 HISTORY OF THE FAR EAST
G25 SOCIAL AND INDUSTRIAL HISTORY OF MODERN EUROPE
G26 SOCIAL AND INDUSTRIAL HISTORY OF UNITED STATES
G27 MILITARY HISTORY AND POLICY OF UNITED STATES
G29 DEVELOPMENT OF NAVIGATION AND CARTOGRAPHY
G31 ADVANCED COMPOSITION
G32 ADVANCED COMPOSITION
G34 AMERICAN LITERATURE
G35 CONTEMPORARY ENGLISH LITERATURE (Not 1938–39)
G37 CONTEMPORARY EUROPEAN LITERATURE
G38 PUBLIC SPEAKING
G40 THE BIBLE AS LITERATURE (Not 1938–39)
G42 SHAKESPEARE
G61 LITERATURE AND THE FINE ARTS
G62 HISTORY OF MUSIC
G63 INTRODUCTION TO MUSIC
G82 INTRODUCTION TO INTERNATIONAL RELATIONS

GENERAL STUDIES

THIS section includes those subjects of a general and essentially non-vocational character which are offered for the purpose of giving the student an opportunity to broaden his education. They are designed to introduce him to fields of thought and interests outside of his chosen professional work.

Sixteen units of general study subjects are required, eight of which may be selected by the Department, others elected by the student. While each student is free to elect from among the subjects listed below such as appeal to his particular personal tastes and interests, he is advised to confine his choice to subjects within one of the four groups offered. A considerable variety of subjects is offered, grouped for convenience under the headings: History of Science and Thought; History of Civilization; Literature and Fine Arts; Social Science. The list may be modified or extended from year to year.

HISTORY OF SCIENCE AND THOUGHT

First Term

G1 History of Science
G7 Problems of Modern Philosophy
G9 Geology

Second Term

G2 History of Science
G8 History of Philosophy
G10 Organic Evolution
G12 Biography in Science
G14 Descriptive Astronomy

HISTORY OF CIVILIZATION

First Term

G21 History of Engineering
G23 History of the Far East
G25 Social and Industrial History of Modern Europe
G27 Military History and Policy of the United States
G29 Development of Navigation and Cartography

Second Term

G22 Development of Transportation
G24 Development of Community Planning
G26 Social and Industrial History of the United States
G27 Military History and Policy of the United States
G28 Economic Geography

LITERATURE AND FINE ARTS

First Term

G31 Advanced Composition
G35 Contemporary English Literature (Not 1938–39)
G37 Contemporary European Literature
G51 French Literature
G53 French Literature
G551 German Drama
G561 German Fiction
G57 Dante in English
G61 Literature and the Fine Arts
G63 Introduction to Music
G65 Expressions of Graphic Art
G67 Design in Manufactured Products

Second Term

G32T Advanced Composition
G34 American Literature
G38 Public Speaking
G40 The Bible as Literature (Not 1938–39)
G42 Shakespeare
G52 French Literature
G54 French Literature
G552 German Drama
G562 German Fiction
G58 Dante in English
G62 History of Music
G64 Fine Arts
G68 Design in Manufactured Products

SOCIAL SCIENCE

First Term

G71 Principles of Psychology
G75 Humanics: A Study of Human Relations
G77 Social Institutions
G79 Comparative Political Institutions

Second Term

G72 Social Psychology
G76 Humanics: A Study of Human Relations
G78 Contemporary Social Problems
G82 Introduction to International Relations
G86 Principles of Sanitary Science and Public Health
G88 Biological Reproduction

Summer

G73 Psychology in Industry

G1. History of Science. The history of science from its beginnings. The Babylonians and Egyptians, the development and decline of Greek Science; the transmission of science into Western Europe; the science of the renaissance. The subject centers around the physical and biological sciences, but attention is paid to technical arts and sciences. Emphasis is placed on the development of scientific spirit and method. Illustrated by lantern slides.

G2. History of Science. A continuation of G1 covering in some detail the history of the various sciences to the end of the eighteenth century. Nineteenth century science is studied along the two lines of its most important developments—geology, biology, and the theory of evolution; chemistry, physics, and the atomic nature of matter.

General Studies Continued

Illustrated by lantern slides. (Either G1 or G2 may be taken independently.)

G7. Problems of Modern Philosophy. The self and the will. Lectures and discussions, outside readings and reports.

G8. History of Philosophy. A general survey of modern philosophy from the time of Descartes.

G9. Geology. A consideration of the forces which are now modifying the earth and its inhabitants, and a history of the changes produced by these forces, throughout the past, both upon the earth and its life. Shimer, *Introduction to Earth History.*

G10. Organic Evolution. A discussion of evolution, what it is and how it is shown in the organic world. There is especial reference to the evolution of man, his physical ancestry, his inherited impulses, and the development of his cultural environment. Shimer, *Evolution and Man.*

G12. Biography in Science. Offers training in the preparation and oral presentation of papers before organized groups, such as section meetings of a professional society. The papers are based on reading in the field of biography, chiefly of men of science. Not open to students below the fourth year.

G14. Descriptive Astronomy. A general survey of the facts and theories relative to the solar system and the sidereal universe. Illustrated by slides. Baker, *Astronomy.*

G21. History of Engineering. The history of engineering in its relations to pure science and to man's social and economic life; the position and importance of engineering in the history of civilization. Illustrated.

G22. Development of Transportation. A series of thirty lectures on the history and development of transportation from the beginning down to the present day. It deals with land, water and air transportation, and includes, as transportation agencies, the railways, highways, ocean, coastwise and inland waters, and commercial airplanes. The influence of these various means of transportation upon the industrial, economic and social development of the world forms the fundamental thesis of this subject.

G23. History of the Far East. Geographical, economic, social, and political backgrounds, with special attention to the changes from the static pre-modern civilization to the present-day dynamic culture.

G24. Development of Community Planning. A series of lectures and seminars on the development of community planning from the earliest times to the present. While primarily historical in character, the subject includes a consideration of the effect of changing social conditions on the scope and methods of comprehensive planning, and ends with a discussion of the contributions made by various professions in the solving of planning problems.

G25. Social and Industrial History of Modern Europe. A study of special topics showing some of the ways in which inventions, discoveries and theories have altered the course of social and industrial development in the recent past. Among the topics considered are the effect of inventions on the use of propaganda, the effect of inventions on modern war, the growth of the British Empire, the origins, remote and immediate, of the systems of party dictatorship in Italy, Germany and Russia.

G26. Social and Industrial History of the United States. This subject traces, by logical stages, the growth of a distinctive American civilization, emphasizing the non-political activities and interests of the people. The historical development of agriculture, commerce and industry will be studied in detail, along with such other topics as the rôle of invention, the social consequences of new modes of travel and transportation, the westward movement and the rise of cities, religious developments, the growth of the press.

G27. Military History and Policy of the United States. A course in American Military History. Some attention will be paid to the tactics of colonial and frontier warfare as well as those of the six important wars, but the emphasis will be placed on broad strategic considerations and on such problems as the development of mobilization, the influence of sea power, and the rise of such services as the Red Cross. Lectures, class discussions, papers.

G28. Economic Geography. Deals with the seas and the land masses of the world, with the geography of the human races, with the world's resources in mineral wealth and its resources of plant and animal origin; also with the distribution of commodities, with manufactured products, with the economic basis of world trade and with national control of raw materials.

G29. Development of Navigation and Cartography. Development of navigation and the evolution of nautical instruments and cartography are traced from the earliest period. The use of the compass, log, sextant, and charts are then considered, which lead to the modern piloting, dead reckoning, and astronomical methods of determining direction, distance, and position of ships and aircraft.

G31. Advanced Composition. Further practice for students interested in writing as an art. The composition of larger prose units including short stories, essays, articles, and verse. The subjects attempted and the forms employed in the required weekly papers are determined by the student's preference. Weekly conferences.

G32. Advanced Composition. Continuation of G31.

G34. American Literature. American writers, particularly those of the nineteenth and twentieth centuries, discussed with emphasis on their relation to contemporary life.

G35. Contemporary English Literature. Treats of a number of the most important English men of letters since 1890. (Not offered 1938–39.)

G37. Contemporary European Literature. An introductory study of some of the chief figures in European Literature of the past century and today.

G38. Public Speaking. Designed, through practice and criticism, to afford knowledge of the principles of public speaking and, in the process of doing so, to extend the range of the student's intellectual interests.

G40. The Bible as Literature. A study of the historical background and the literary treatment of the material of the Old and New Testaments. (Not offered 1938–39.)

General Studies Continued

G42. SHAKESPEARE. An analysis of representative plays with emphasis on the development of Shakespeare as a dramatist.

G51, G52. FRENCH LITERATURE. Outline of the history of French literature. Reading of illustrative specimens and some masterpieces complete: Chanson de gestes, medieval theatre, Villon, Montaigne, Rabelais, Corneille, Racine, Molière, Voltaire, Rousseau, the Romantic School and subsequent movements. Braunschvig, *Notre Littérature Étudiée dans les Textes*. Vols. 1 and 2. Each term may be taken independently.

G53, G54. FRENCH LITERATURE. Same as G51 and G52 with additional reading. Each term may be taken independently.

G551, G552. GERMAN DRAMA. Reading of a selection of representative plays by outstanding German and Austrian dramatists, including Lessing, Goethe, Schiller, Hauptmann, Grillparzer and Schnitzler. Occasional lectures on German drama. The course affords practice in spoken German. Each term may be taken independently.

G561, G562. GERMAN FICTION. Reading of masterpieces of the short story and the novel, with occasional lectures. The material is chiefly selected from the period between 1880 and the present time. These courses offer an opportunity to hear and speak German. Each term may be taken independently.

G57, G58. DANTE IN ENGLISH. A study of the Divine Comedy in English translation (bi-lingual text) with readings and lectures on the life and times of Dante.

G61. LITERATURE AND THE FINE ARTS. A study of what has recently been done in graphic arts and literature seen against the past so that the problems and products of our contemporaries may be judged.

G62. HISTORY OF MUSIC. Designed to offer to students whose background of musical knowledge has been, to a certain degree, established, an approach to the understanding of musical development. The subject matter, beginning with early forms, traces the evolution of the art through its various transitions to the twentieth century. *A History of Musical Thought*, Donald N. Ferguson.

G63. INTRODUCTION TO MUSIC. No previous knowledge of music is required. Many musical illustrations are performed in the classroom. The lectures and textbook endeavor to give simply and clearly the knowledge needed by an intelligent listener. Moore, *Listening to Music*.

G64. FINE ARTS. The required text (Helen Gardner, *Art Through the Ages*, Harcourt, Brace) is a history of the arts; but the lectures undertake a survey of the arts by topic, considering not only painting and sculpture but also the arts that come nearest to the usual interests of modern life, such as costume, furniture and furnishings, typography, camera art, etc. Visits to the Boston museums are required, and a paper is written, based upon observation of museum exhibits.

G65. EXPRESSIONS OF GRAPHIC ART. A series of talks and demonstrations on the differing characteristics of expression in black and white, as indicated by sketching, drawing, lithographing, engraving, and so forth. These will be accompanied by actual exercises in drawing.

G67. DESIGN IN MANUFACTURED PRODUCTS. A series of lectures demonstrating the value of a sound knowledge of design in the creation of machine-made products. They will show how the adaptation of line and form to the limiting characteristics of material and of production may add the element of beauty to that of utility.

G68. DESIGN IN MANUFACTURED PRODUCTS. A continuation of G67 in which the student may apply his preparatory study to the solution of problems related to his major professional interest.

G71. PRINCIPLES OF PSYCHOLOGY. A survey of the field of general psychology, with particular emphasis laid upon problems of personality and personal adjustment. Topics discussed will include: intelligence and learning, the problem of selecting a vocation, emotional behavior, motivation, the analysis of personality. Class demonstrations will include psychological tests and illustrative films.

G72. SOCIAL PSYCHOLOGY. Psychological analysis of various social phenomena directed toward an understanding of the problems of group life. The attempt will be made to acquaint the student with the ways in which attitudes, beliefs, standards, and wants are acquired, and with established techniques for influencing the behavior of others. Topics discussed will include: the psychology of suggestion and propaganda, the formation and alteration of public opinion, the process of socialization and its limitations, the psychology of language, the nature of leadership. Current social issues will be discussed in connection with these topics.

G73. PSYCHOLOGY IN INDUSTRY. A survey of such fields of psychology as the following: motivation, the analysis of personality, individual differences in skill and ability, and learning. Particular emphasis will be placed upon the use of data obtained from psychological research in industrial plants. Psychological techniques in employment selection, job analysis, the evaluation of the efficiency of the worker, accident prevention, and worker training will be treated in detail along with some of the broader problems of the relationship between worker and management. Films, aptitude tests, personality tests, and other demonstrational material will be used in order to give the student more than mere textbook knowledge of the subject matter.

G75. HUMANICS: A Study of Human Relations. The fundamental object is to give students a realization of the necessity for good method in dealing with human relations, as well as a grounding in what constitutes good method. Such basic influences as aptitudes, habits, attention, understanding, desires, and prejudices are analyzed and applied to typical situations which arise in the course of employment. Illustrative problems taken from actual cases are studied, but always with the emphasis on that structural analysis which characterizes good method. Except by special permission of the instructor, only juniors and seniors may elect the subject.

G76. HUMANICS: A Study of Human Relations. A continuation of G75 which applies the fundamentals already learned,—to job interviews, hiring, discipline cases, problems in coöperation, industrial conflict, etc. Case demonstrations of actual situations in which selected students act as executives are presented in the classroom;

General Studies Continued

the person taking the part of the employee is brought in from industry and the technique of the students handling the situation is subsequently discussed, often by actual business men familiar with the original situation. Except by special permission of the instructor, only juniors and seniors may elect the subject.

G77. Social Institutions. A sociological discussion of the evolution of social institutions out of human needs into the contemporary patterns we recognize as the family, industry, the school, the church and social welfare agencies. Consideration will be given to the social problems arising out of the advance of technology, and to the role of the engineer as a professional man, a citizen, and an individual in the solution of these problems.

G78. Contemporary Social Problems. Discussion of social situations demanding collective action: population problems, specific social industrial problems, crime, health and mental hygiene as a social problem, family disorganization.

G79. Comparative Political Institutions. This subject deals with the various theories of government viewed historically and comparatively. The modern trends as evidenced by Fascism, Communism, Socialism and the changes in constitutional democratic government will be discussed in detail in relation to social and economic changes.

G82. Introduction to International Relations. The nature of contemporary international problems, including a survey of their historical background, and study of the past and present efforts to deal with them. Lectures, discussions, written and oral reports.

G86. Principles of Sanitary Science and Public Health. A consideration of the human body as a mechanism and the effect of the environment on its health, well-being, and proper functioning. The subject matter will include such items as infection and resistance, sources of infection, modes of disease transmission, air, water, milk, foods, sewage, refuse, housing, insects, and other factors in relation to disease, and the organized machinery for safeguarding the health of urban communities. The subject is designed for its cultural value and not for professional practice. Sedgwick's *Principles of Sanitary Science and Public Health*, Prescott and Horwood.

G88. Biological Reproduction. For students without previous training in biology. Lectures, lantern slides, moving pictures, and clay modeling, in illustration of the basic phenomena of reproduction in plants and animals from protozoa to man. The physiological effects of the reproductive function are taken up and the basic principles of embryological development are illustrated. A matter of fact consideration from the biological standpoint.

MATHEMATICS

Subjects M1 to M99

M1. Algebra, Entrance.

M3. Solid Geometry, Entrance.

M4. Trigonometry, Entrance.

M11. Calculus. An elementary presentation of the fundamental ideas of the calculus; differentiation and integration of algebraic functions; derivatives; differentials; maxima and minima; applications to simple problems in geometry and mechanics, such as the determination of velocity, acceleration, areas, volumes and pressure. A brief discussion of the analytic geometry of the straight line and the conic sections, and the plotting of the curves in rectangular coördinates. Woods and Bailey, *Elementary Calculus, Revised Edition.*

M111. Calculus. An elementary subject adapted to the needs of students of Architecture.

M12. Calculus. Differentiation and graphical representation of trigonometric, inverse trigonometric, logarithmic and exponential functions, with applications to simple problems of geometry and mechanics, including related velocities, maxima and minima, simple harmonic motion, and curvatures; series. Woods and Baily, *Elementary Calculus, Revised Edition.*

M21. Calculus. Partial differentiation; integration of functions of one variable including use of tables; definite integrals; geometrical applications to areas and lengths of plane curves, volumes of solids; mechanical applications to work, pressure, centers of gravity and moments of inertia; double and triple integration with applications to areas, volumes, moments of inertia and centers of gravity. Woods and Bailey, *Elementary Calculus, Revised Edition.*

M22. Differential Equations. A treatment of ordinary differential equations including the principal types of first and second order equations, simultaneous equations, and linear equations with constant coefficients. The work is illustrated by numerous applications to geometry, chemistry, physics and mechanics. Phillips, *Differential Equations, Third Edition.*

M23, M24. Algebra and Geometry. Determinants, matrices, theory of equations, quadratic forms, conics and quadrics, curvilinear coördinates, elements of analytic and differential geometry.

M31. Differential Equations. Deals mainly with the equations which the student of electricity meets in his work. These equations will be discussed from the general point of view, but specific applications will be made to electrical problems. Franklin, *Differential Equations for Electrical Engineers.*

M331, M332. Mathematical Statistics (B). A general treatment of the mathematical methods of statistics and their applications to scientific and engineering data. Includes systems of frequency curves and moments, theory of large and small sampling, precision of measurements, finite differences, simple, partial and multiple correlation, association, contingency, statistical estimation and general distribution theory. These methods will be developed from the practical viewpoint throughout the first

Mathematics Continued

term and mathematically in the second term. The work of both terms will be applied to data drawn from various fields of applied science, including engineering, biology and physics. One hour per week will be devoted to a joint seminar with students in Ec34 and Ec37T, at which discussions of recent developments in statistical methods and industrial practice will be presented by instructors, students, and outside speakers.

M341, M342. Actuarial Mathematics. Includes readings, problems and discussions in advanced algebra, calculus of finite differences, compound interest, annuities certain and the construction of mortality tables. These subjects comprise Parts I, II and IV of the examinations given annually by the Actuarial Society of America. It is suggested that Part III be covered by electing M76 and M331. Students expecting to take the Actuarial Society's examinations are advised to follow M342 with a reading course.

M36, M37. Advanced Calculus (A). Fundamental principles, power series, partial differentiation, implicit functions, Gamma and Beta functions, line, surface and space integrals, vectors, ordinary differential equations, Bessel functions, partial differential equations, calculus of variations, elliptic integrals. Woods, *Advanced Calculus. New edition.*

M381, M382. Theory of Functions (A). Arranged for students who desire a general subject in analysis somewhat more advanced than M36, M37. Among the topics discussed are series, infinite products, the Riemann integral, functions of a complex variable, contour integration, asymptotic expansions, Fourier series, differential equations, integral equations, and various transcendental functions of importance in the applications of mathematics. Attention is given to the logical derivation of the processes of analysis used in connection with these topics. Whittaker and Watson, *Modern Analysis.*

M441. Projective Geometry (B). Homogeneous coördinates. Point, line and plane coördinates. Ranges and pencils. Principle of duality. Curves and surfaces of second order and of second class. Linear transformations. Projective measurement. Non-Euclidean geometry. Pentaspherical and Plücker coördinates. F. S. Woods, *Higher Geometry.*

M442. Elementary Differential Geometry (B). Plane and space curves. First and second differential form of a surface. Theorems of Meusnier and Euler. Lines of curvature, asymptotic lines, conjugate lines, geodesics. Theorems of Gauss and Codazzi. Developable surfaces, surfaces of rotation, Liouville surfaces. Differential parameters. Problems on mapping. W. C. Graustein, *Differential Geometry* and L. P. Eisenhart, *Differential Geometry.*

M451, M452. Fourier Series and Integrals (A). This subject is devoted to the elementary theory of Fourier series and integrals as developed along modern lines. There will be a definite attempt to stress applications in practice and to develop the necessary analysis from the beginning. There are in existence mimeographed notes on topics of Fourier series which have been taken up in the past in M451, M452, and while the course is intended to be more elementary, it is recommended that use be made of these notes for more detailed material.

M471, M472. Seminar in Analytic Number Theory (A). The purpose of this subject is to apply modern analytical technique to problems of the distribution of numbers of certain specific sorts, and to the problem of representing a number as the sum of numbers of certain specific sorts. An amount of analysis roughly equivalent to M451 and M452 will be presupposed. This course will cover a considerable amount of material on the borders of present research, and will give the student an opportunity to prepare a research paper under supervision. (Not offered 1938–39.)

M54. Mathematical Laboratory (B). Practical instruction in numerical, graphical and mechanical calculation and analysis as required in the engineering or applied mathematical sciences, numerical solution of equations; graphical methods; nomography and the construction of graphical charts; curve fitting to empirical data; approximate methods of integration, differentiation and interpolation; the 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). The first term is primarily devoted to a formulation of the fundamental concepts of infinitesimal analysis more precise than the intuitive treatment in the elementary calculus course. Among the topics treated are real numbers, functions, continuity, derivative, integral, sequences of functions, equi-continuity, uniform convergence, existence theorems, Taylor's series, Fourier series.

M563. Functions of a Complex Variable (A). An introductory subject covering the essential topics of the theory of functions.

M571, M572. Differential Equations (A). Presupposing the formal solution of differential equations as given in undergraduate Courses, this subject deals with the following topics: existence theorems of the various types, Cauchy polygons, Picard successive approximations, power series and majorant functions; the properties of functions defined by differential equations, especially linear differential equations; and partial differential equations. An idea of the direction of the subject can be had by consulting Goursat-Hedrick, *A Course in Mathematical Analysis, Volume II, part 2,* and Bieberbach, *Differentialgleichungen.*

M581, M582. Continuous Groups (A). A study of the basic concepts of group-theory, such as group, subgroup, invariant sub-group, finite and infinitesimal transformations; one-parameter groups and their applications to differential equations and geometry; r-parameter groups, structure constants, the fundamental theorems of Lie; invariant theories associated with continuous groups; differential invariants and applications to systems of partial differential equations.

M62. Modern Algebra (B). Polynomials, determinants, linear equations, linear transformation, matrices, bilinear, quadratic, and Hermitian forms, introduction to fields and algebras.

M641, M642. Advanced Differential Geometry (A). This subject contains some of the modern developments in differential geometry, especially those involving

Mathematics Continued

tensor calculus, and is particularly useful for students who wish to do research work in this field.

M651, M652. Analytical Mechanics (A). Analytical dynamics of particles and rigid bodies is treated mainly by Lagrange's equations in generalized coördinates and Hamilton's canonical equations. Contact Transformation, the Hamilton-Jacobi theory, the theory of vibrations, and non-holonomic systems are among the topics discussed.

M661, M662. Algebra of Quantum Theory (A). An introduction to the non-commutative algebras employed by Dirac, Weyl, Heisenberg and others, including the theory of group characters. Slater's matrices, and homopolar valence. Lectures, problems and assigned reading. Familiarity with quantum theory is not prerequisite.

M671, M672. Potential Theory (A). In the first term, the elementary theory. Logarithmic, Newtonian, potential. Potentials of simple and double distribution. Laplace's and Poisson's equations. Harmonic functions. Connection with function theory in the case of two dimensions. Harnack's theorems. Boundary value problems for the circle and the sphere. Poisson's integral. Spherical harmonics. Applications to physics. In the second term, general treatment of the boundary value problems of potential theory. Integral equations. The method of Perron-Remak. Green's function. Applications to conformal mapping. (Not offered in 1938–39.)

M681, M682. Calculus of Variations (A). Extension of the theory of maxima and minima as begun in calculus. The determination of functions, curves or surfaces with given maximum or minimum properties. Applications to geometry and physics; geodesics, minimal surfaces, isoperimetric properties of circle and sphere, Fermat's principle of least time (optics), Hamilton's principle, catenary, brachistochrone. Bolza, *Lectures on the Calculus of Variations;* Bliss, *Calculus of Variations;* Goursat, *Cours d'Analyse, vol. 2, chapter XXIII.* (Not offered in 1938–39.)

M691, M692. Characteristic Value Problems (A). Linear algebra, orthogonal functions, linear integral equations; the 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.* (Not offered in 1938–39.)

M73. Review of Mathematics. Review of algebra, plane and solid geometry, trigonometry, elementary calculus, differential equations.

M731, M732. Mechanics (B). Statics; frameworks and reciprocal force diagrams; least work and Castigliano's theorem; 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.

M75. Mathematics. Practical instruction in numerical, graphical and mechanical calculation and analysis necessary for the solution of problems in interior and exterior ballistics. (For U. S. Army Officers only.)

M76. Theory of Probability (A). Permutations and combinations. Elementary principles of the theory of probabilities. Bernoulli's Theorem. Bayes' Theorem. Distributive functions and continuous variables. Averages. Curve fitting. T. C. Fry, *Probability and Its Engineering Uses.*

M77. Vector Analysis (B). A treatment of the vector functions and operations required in theoretical work on electricity. Phillips, *Vector Analysis.*

M791, M792. Theoretical and Applied Elasticity (A). The fundamental mathematical theory of elasticity in three dimensions; elastic work of deformation, stress equations; stress functions; Mohr's stress diagram; bending of bars, plates, and tubes; instability; vibration of elastic systems; modern theory of strength; plasticity. Principles and methods used in practical engineering problems; principles of minimum energy and of virtual velocities; method of deflections, Ritz's method and the application of calculus of variations. Love, *Theory of Elasticity;* Föppl, *Drang und Zwang;* Timoshenko, *Theory of Elasticity.*

M831, M832. Analysis (B). The real and complex number system, elementary properties of point sets, limits, continuity, convergence of series, derivative, integral, infinite products, and other notions necessary for a rigorous treatment of calculus. Hardy, *Pure Mathematics.*

M841. Analysis (B). Presupposing the preliminary work of M831, M832, this subject presents the modern theory of functions of a complex variable, including single valued analytic functions, residues, analytic continuation, conformal representation, and integral functions.

M842. Analysis (B). Topics in theory of functions of a real variable, including the theory of measure, Lebesgue integration, Fourier series, and an elementary discussion of the Fourier integral.

M90. Mathematical Reading (A). Designed to give the student an opportunity to read advanced mathematical treatises under the supervision of some member of the department. The treatise chosen and the time allowed will be determined by the needs in each particular case. This subject is for graduate students who may find it desirable to do advanced work not provided for in the regular courses. May be taken by undergraduates only under exceptional circumstances.

The following subject is offered as a General Study. For description see Division of General Studies.

G8. History of Philosophy.

MILITARY SCIENCE AND TACTICS

SUBJECTS MS1 TO MS99

MS11. MILITARY SCIENCE. (Required in all Courses.) Consists of nine weeks of infantry drill, three weeks of instruction in rifle marksmanship, and three weeks of lectures on elementary infantry subjects.

MS12. MILITARY SCIENCE. (Required in all Courses.) Consists of ten weeks of infantry drill and ceremonies and five weeks of lectures on elementary subjects of military training.

MS21. MILITARY SCIENCE. (Required in all Courses.) Consists of five weeks of map and aerial photograph reading, eight weeks of military fundamentals, and two weeks of field fortification. Opportunity is given the student to choose the unit in which he desires to continue his training. Those who do not report their choice of a unit by the beginning of the second term will be arbitrarily assigned to a unit.

MS221. MILITARY SCIENCE. COAST ARTILLERY. Elements of heavy artillery; fire control instruments; target characteristics; ammunition; aiming and laying of guns; service of the piece.

MS222. MILITARY SCIENCE. ENGINEER CORPS. Theoretical instruction in demolitions, sketching and military bridging; practical work in rigging, demolition, small caliber rifle firing, and combat principles of small units.

MS223. MILITARY SCIENCE. SIGNAL CORPS. Tactical principles; principles of signal communication; telephone, telegraph and radio equipment; codes and ciphers; International Morse code practice.

MS224. MILITARY SCIENCE. ORDNANCE DEPARTMENT. General characteristics of ordnance matériel and ammunition.

MS226. MILITARY SCIENCE. CHEMICAL WARFARE SERVICE. Weapons; chemical agents; chemical warfare drill and command.

MS31. MILITARY SCIENCE, ADVANCED. Leadership. Students are given instruction in the duties and responsibilities of noncommissioned officers and junior officers in infantry drill; in the training of recruits; and in saber and command exercises.

MS311. MILITARY SCIENCE. COAST ARTILLERY, ADVANCED. Theory of position finding, fire control and gunnery for seacoast artillery. A study of the trajectory, dispersion, and determination of firing data.

MS312. MILITARY SCIENCE. ENGINEER CORPS, ADVANCED. Conferences and problems on the estimate of the situation and combat principles of small units, to include the infantry and engineer platoon; scouting and patrolling; weapons and musketry.

MS313. MILITARY SCIENCE. SIGNAL CORPS, ADVANCED. Signal Corps tactics; message center operation; various types of codes and ciphers, and methods used in breaking them down; instruction in International Morse code.

MS314. MILITARY SCIENCE. ORDNANCE DEPARTMENT, ADVANCED. Organization of Ordnance Department; property accounting; cannon construction; theory of recoil and design of recoil systems.

MS316. MILITARY SCIENCE. CHEMICAL WARFARE, ADVANCED. Chemical warfare agents; technique of chemical weapons; effect of weather on chemicals; combat principles of the infantry squad and platoon.

MS32. MILITARY SCIENCE, ADVANCED. Leadership. Students are assigned to companies and are given instruction in the duties and responsibilities of company officers and noncommissioned officers.

MS321. MILITARY SCIENCE. COAST ARTILLERY, ADVANCED. Theory of position finding, gunnery, and fire control for anti-aircraft artillery.

MS322. MILITARY SCIENCE. ENGINEER CORPS, ADVANCED. Conferences and problems on military bridging, field fortifications and military roads.

MS323. MILITARY SCIENCE. SIGNAL CORPS, ADVANCED. Theoretical and applicatory instruction on all telephone and telegraph equipment in use by the Signal Corps; applicatory instruction on Signal Corps field radio sets; instruction in International Morse code; pistol and pistol equipment.

MS324. MILITARY SCIENCE. ORDNANCE DEPARTMENT, ADVANCED. Small arms, automatic weapons, mobile artillery and fire control equipment. General characteristics and storage hazards of ammunition and explosives.

MS326. MILITARY SCIENCE. CHEMICAL WARFARE, ADVANCED. Technique and tactical employment of chemical agents; tactical employment of chemical troops; combat principles of the infantry company and battalion; pistol marksmanship.

MS41. MILITARY SCIENCE, ADVANCED. Leadership. Students are assigned to companies and are given instruction in the duties and responsibilities of junior officers in infantry drill and in the training of men in the enlisted grades. Military law.

MS411A. MILITARY SCIENCE. COAST ARTILLERY, ADVANCED. Applied gunnery; the conduct, observation and adjustment of fire for seacoast and anti-aircraft artillery; the development of fire control directors.

MS411B. MILITARY SCIENCE. COAST ARTILLERY, ADVANCED. Coast Artillery matériel, organization, and employment.

MS412. MILITARY SCIENCE. ENGINEER CORPS, ADVANCED. Military engineering and tactical problems, to include the battalion.

MS413. MILITARY SCIENCE. SIGNAL CORPS, ADVANCED. Instruction in methods of training men; emergency procurement and funds; Reserve Corps regulations.

MS414. MILITARY SCIENCE. ORDNANCE DEPARTMENT, ADVANCED. Duties and problems of Ordnance officers in connection with the storage, issue and maintenance of Ordnance supplies.

Military Science and Tactics Continued

MS416. MILITARY SCIENCE. CHEMICAL WARFARE, ADVANCED. Chemical estimate of the situation; solution of chemical warfare problems; combat principles of the infantry regiment; motor transportation.

MS42. MILITARY SCIENCE, ADVANCED. Leadership. Students are assigned to companies and are occupied primarily in imparting instruction and in the development of qualities of command and leadership in other students. Company administration.

MS421. MILITARY SCIENCE. COAST ARTILLERY, ADVANCED. Tactical employment of fixed, mobile, and anti-aircraft artillery. Orientation.

MS422. MILITARY SCIENCE. ENGINEER CORPS, ADVANCED. Problems applying the principles of field engineering; instruction in the regulations of the Officers' Reserve Corps.

MS423. MILITARY SCIENCE. SIGNAL CORPS, ADVANCED. Operation and maintenance of Signal Motor transport; operation and testing of a telephone plant.

MS424. MILITARY SCIENCE. ORDNANCE DEPARTMENT, ADVANCED. Storage, issue and maintenance of Ordnance supplies; administration of supply and mess management.

MS426. MILITARY SCIENCE. CHEMICAL WARFARE, ADVANCED. Review of the tactical principles of the employment of chemical troops and chemical agents; tactical principles of the infantry brigade and division; study of the Officers' Reserve Corps Regulations.

MODERN LANGUAGES

SEVERAL courses are offered in both French and German; one in Spanish, and one in Italian. Those in French and German are of Elementary, Intermediate and Advanced grade. In the Elementary and Intermediate subjects a careful foundation is laid for reading, writing and speaking the foreign language. Great care is taken to secure a good pronunciation, a mastery of the working essentials of grammar, a reasonable vocabulary for the expression of common ideas, training of the ear, and a broad reading vocabulary. The reading texts include scientific matter, fiction, drama, historical or descriptive works of a nature to open up to the student the genius, institutions and social point of view of the country studied. Part of the work consists of assignments for written translation of articles from recent foreign journals selected by each student according to his individual interests and needs. Occasional illustrated lectures are given to supplement the class exercises and stimulate interest. The General Study subjects offer the student an opportunity to carry his study beyond the Intermediate grade.

The one-year elective courses in Elementary Spanish and Elementary Italian are parallel to the courses in Elementary French and German. They give a training in pronunciation, essentials of grammar, and reading of varied matter. On completion a student should be able to make intelligent contact with the foreign country, be able to read correspondence and translate reading matter of moderate difficulty. In all subjects the foreign language is used as far as practicable in the classroom.

In the designation of subjects, the grades Elementary and Intermediate correspond to the definitions of the Modern Language Association of America and the College Entrance Examination Board. Elementary French = French 2; Elementary German = German 2; Elementary Italian = Italian 2; Elementary Spanish = Spanish 2; Intermediate French = French 3; Intermediate German = German 3.

SUBJECTS L1 TO L99

L11, L12. GERMAN, ELEMENTARY. The necessary foundation for the study of the German language and literature, or for scientific studies. It will also enable students to fulfill the entrance requirements in Elementary German. It consists of training in pronunciation, elementary grammar, acquisition of useful vocabulary and reading of easy matter, some of which deals with science and individual written translations from recent scientific works. Texts (subject to modification): Howe, *Elementary German;* Hagboldt: *Allerlei;* Malkowski: *Peter Krafft der Segelflieger;* Durian: *Kai aus der Kiste;* Wright: *German Science Reader.*

L21, L22. GERMAN, INTERMEDIATE. Includes a systematic review of grammar and individual written translations from recent scientific works. The reading, scientific as well as literary, gradually becomes more difficult. At the end of the course students should be able to read understandingly any ordinary newspaper or magazine article of a literary or popular scientific nature, to understand simple spoken German, and to express simple thoughts in German. As far as practicable the exercises are conducted in German. Texts (subject to modification): Osthaus and Bierman, *German Prose Composition;* Kästner, *Das fliegende Klassenzimmer;* Curts, *Readings in Scientific and Technical German.*

L31, L32. GERMAN, ADVANCED. Advanced readings, including scientific material selected from recent scientific literature. Exercises are conducted in German as far as practicable. Selected texts from the Goeschen Scientific Series.

L51, L52. FRENCH, ELEMENTARY. The necessary foundation for the study of the French language and literature, or for scientific studies; it also enables students to fulfill the entrance requirement in elementary French. Consists of training in pronunciation, elementary grammar, acquisition of useful vocabulary and readings of easy matter, part of which deals with French institutions and the history of France, practice in spoken French; also individual written translations from recent scientific

Modern Languages Continued

works. The last term will include the reading of some technical French. Texts (subject to modification): Fraser and Squair and Carnahan, *Standard French Grammar;* Havens and Moore, *Easy French Readings; L'Histoire de l'Art* or *L'Architecture* (both in "Encyclopédie par l'image" series).

L61, L62. FRENCH, INTERMEDIATE. Designed to enable students to meet the entrance requirements in intermediate French. Recitations partly conducted in French. A continuation of the study of grammar, pronunciation, and useful conversational forms; drill in composition and in translation into French of connected passages; reading of matter dealing with French geography, history and industrial activity; some standard modern authors; reading of scientific French; individual written translations from recent scientific works. Texts (subject to modification): Barton and Sirich, *New French Review Grammar;* Williams, *Technical and Scientific French;* Pargment, *Trente-trois Contes;* a selected play; Kullmer and Gerard, *Sketch Maps of France.*

L81, L82. SPANISH, ELEMENTARY. Pronunciation, elementary grammar, easy reading matter. Considerable practice in Spanish conversation. Texts (subject to modification): Hills and Ford, *First Spanish Course;* Hendrix, *A Cultural Spanish Reader;* Adams and Adams, *Popular Spanish Readings;* the New York newspaper *La Prensa.*

L91, L92. ITALIAN, ELEMENTARY. Pronunciation, elementary grammar, easy reading matter, practice in conversational phrases useful for travel. Texts (subject to modification): Russo, *Elementary Italian Grammar;* Tutt, *Italian Reader;* Capocelli, *L'Italia nel Passato e nel Presente,* Wilkins and Altrocchi, *Italian Short Stories.*

The following subjects are offered as General Studies. For description see Division of General Studies.

G51, G52. FRENCH LITERATURE.
G53, G54. FRENCH LITERATURE.
G551, G552. GERMAN DRAMA.
G561, G562. GERMAN FICTION.
G57, G58. DANTE IN ENGLISH.

HYGIENE

THE gymnasium of the Institute is located in the Walker Memorial building and affords ample accommodation for the training of classes in gymnastics.

The gymnasium is open to all students free of charge, and the instruction is especially arranged to fit individual needs. Bronze medals, known as the Cabot Medals for Improvement in Physical Development, are awarded to the five or six men showing the greatest physical improvement for the year. These medals were established by the late Samuel Cabot, for many years a member of the Corporation of the Institute.

The hangar building is equipped for boxing, wrestling and basket ball. This building is for competitive indoor sports and has seats for three hundred spectators. By using this building the Walker Gymnasium is left free for the regular gymnastics for which it was designed.

The Athletic Field gives an opportunity for track-team contests and interclass games. This field is provided with a quarter-mile running track, straightaway tracks for one hundred yard and two hundred twenty yard dashes, tennis courts, etc. It is under the direction of an Advisory Council on Athletics, composed of alumni and undergraduate students.

PT1, PT2. PHYSICAL TRAINING. All first-year men take two examinations during the first month, a complete physical examination at the Medical Department by a physician, and the other at Walker Memorial by the Physical Director, from which anthropometric charts are plotted. The class is then divided into sections for gymnastic exercise, each section having two hours a week for the last ten weeks of the first term and two hours a week for the first ten weeks of the second term, under the direction of the Physical Director. All first-year students are required to take these exercises. Regular exercises on the various athletic teams may be substituted for gymnastic work by consulting the Physical Director.

SUBJECTS OF INSTRUCTION TABULATED

The number at the left is the subject number.

The numbers following the names of subjects indicate the prerequisite subjects (those in italics may be taken simultaneously).

To the right of the prerequisites are noted the year and term and the Professional Courses in which the subjects are required.

(A) following the year, indicates that the subject is primarily for Graduate students. (B) indicates subjects for Graduate as well as Undergraduate students.

Some "B" subjects will not be credited to graduate students in Courses in which they are required subjects of the undergraduate schedule.

Then follows the time distribution of the subject in units (a unit representing fifteen hours work). The total credit for a subject is the sum of the units allotted to Exercise (Recitation, Lecture, Laboratory, Drawing or Fieldwork); and Preparation. To 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	1	I	2	—	2	Howard
1·01	Surv. & Top. Drawing	D12	2	2	I	0	4	0	Howard
1·02	Surveying	D12	3	S	VI	1	2	1	Howard
			2	S	VI-A				
			2	2	IX-B				
			4	1	IV-B, IV-C				
1·041	Surveying	D12	3	S	VII_3, XI	1	11	1	Howard
1·042	Surveying	D12	3	S	XVII	1	21	1	Howard
1·05	Surveying	1·00, 1·01	3	S	I	2	10	1	Howard
1·07	Geodetic Surveying	1·05, 1·13	4(B)	S	(Elective)	0	10	0	Howard
1·10	Surveying	M4, D12	3	S	III	5	18	1	Foster
1·12	Astron. & Spherical Trig.	M4, 1·00	2	2	I	3	—	4	Howard
1·13	Geodesy	M22, 1·12	3	2	I	2	—	4	Howard
1·135	Int. Vibration Theory	M22	4(B)	1	(Elective)	3	—	2	Ruge
1·136	Vibration Problems	1·135	G(A)	2	(Elective)	3	—	6	Ruge
1·138	Seismological Lab.	1·135 or *1·135*	4(B)	1 or 2	(Elective)		★		Ruge
1·141	Geodesy, Adv.	1·13	G(A)	1	(Elective)	2	—	4	Howard
1·142	Geodesy, Adv.	1·141	G(A)	2	(Elective)	3	—	6	Howard
1·15	Navigation	——	3	1	(Elective)	2	—	2	Howard
1·16	Aerial Surveying	1·05	4(B)	1	(Elective)	2	—	2	Howard
1·18	Map Read. & Top. Draw.	D12	2	2	VII_3, XI	0	2	0	Howard
1·20	Rail. & High. Fieldwk.	*1·05* or *1·041*	3	S	I	1	4	0	Babcock
1·21	Rail. & High. Curves	M21; 1·20 or 1·041	3	1	I, XI	2	—	2	Babcock
1·22	Quantity Surveying	1·20 or 1·041	3	2	I, VII_3, XI	2	—	2	Babcock
			G	1	I (A.E.)				
1·25	Eng. Construction	1·22, 2·04	4(B)	1	I, VII_3, XI	3	1	1	Breed
			G	S	I (A.E.)				
1·26	Railway Signaling	——	4(B)	2	(Elective)	2	—	3	Babcock
1·271	Transportation Eng.	1·21, 1·35	4(B)	1	(Elective)	4	2	5	Breed, Babcock
1·272	Transportation Eng.	1·271	4(B)	2	(Elective)	3	2	4	Bone
1·273	Transportation Eng.	——	G(B)	2	I (A.E.)	4	—	5	Babcock, Bone
1·28	Railway Design	1·271, *1·272*	4(B)	2	(Elective)	0	5	0	Babcock
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
1·32	Des. of Harbor Works	1·48	G(A)	1	(Elective)	1	3	3	Reynolds
1·34	Municipal Eng.	——	5(B)	1	IV-B, IV-C	3	—	4	Bone
1·35	Roads & Pavements	*1·21*	3	1	I	2	—	1	Breed
1·371	High. Transport. Adv.	1·35	G(A)	1	(Elective)	2	—	4	Breed, Bone
1·372	High. Transport. Adv.	1·371	G(A)	2	(Elective)	2	—	4	Breed, Bone
1·38	Highway Design	1·271, *1·272*	4(B)	2	(Elective)	0	5	0	Bone
1·39	Graphic Statics	8·02	2	1	I	1	2	1	Mitsch
1·40	Structures	2·04	3	2	I, XI	3	4	4	Fife
1·401	Structures	2·04	3	2	VII_3, IX-B, XVII	3	—	5	Fife

★ Time specially arranged.

Civil and Sanitary Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
1·402	Structures	——	G	1	I (A.E.)	4	—	8	Fife
1·41	Structures	1·40	4(B)	1	I, VII$_3$, XI, XVII	3	—	6	Spofford
1·411	Structures	1·402	G(B)	2	I (A.E.)	3	—	6	Fife
1·42	Structures	1·41	4(B)	2	I, XI, XVII	2	—	4	Spofford
1·421	Structures	1·41	4(B)	2	VII$_3$	2	—	4	Mitsch
‡1·422	Structures	1·41	4	2	XVII	3	—	6	Spofford
1·44	Stat. Structures	2·04	4	2	III	2	—	2	Wilbur
1·451	Structures	2·04	G	1	XIII-A	3	—	6	Fife
1·452	Structures	1·451	G	2	XIII-A	3	—	6	Fife
1·46	Structural Design	1·451	G	2	XIII-A	0	2	0	Mirabelli
1·48	Foundations	2·04	4(B)	1	I, XI,; XVII 1939–40.	3	—	4	Taylor
1·491	Soil Mechanics	2·04	G(A)	1	I (A.E.)	3	—	6	Taylor
1·492	Soil Mechanics	1·491	G(A)	2	I (A.E.)	3	—	6	Taylor
1·493	Soil Mech. Lab.	1·491	G(A)	1	I (A.E.)	0	3	3	Taylor
1·501	Bridge Design	*1·41*	4(B)	1	I	0	8	0	Mirabelli
1·502	Structural Design	1·501	4(B)	2	I	0	6	0	Mirabelli
1·51	Structural Theory Adv.	1·411	G(A)	2	(Elective)	3	—	6	Fife
			G	S	I (A.E.)				
1·52	Structural Design	1·41	4(B)	2	XI	0	3	0	Mirabelli
1·531	Reinf. Concrete Design	2·06	4(B)	1	(Elective)	4	6	0	Peabody
1·532	Reinf. Concrete Design	1·531	4(B)	2	(Elective)	2	6	0	Peabody
1·541	Reinf. Conc. Des. Adv.	1·42	G(A)	1	(Elective)	2	4	2	Mitsch
			G	S	I (A.E.)				
1·542	Reinf. Conc. Des. Adv.	1·541	G(A)	2	(Elective)	2	4	0	Peabody
1·551	Structural Design Adv.	*1·561*	G(A)	1	(Elective)	2	4	0	Spofford
1·552	Structural Design Adv.	1·551	G(A)	2	(Elective)	2	4	0	Spofford
1·561	Structural Theory Adv.	1·41	G(A)	1	(Elective)	4	—	8	Fife
1·562	Structural Theory Adv.	1·561	G(A)	2	(Elective)	2	—	6	Fife
1·571	Stat. Indet. Structures	1·42 or 1·421	G(A)	1	(Elective)	3	—	6	Spofford
1·572	Stat. Indet. Structures	1·571	G(A)	2	(Elective)	3	—	6	Spofford
1·58	Des. Reinf. Conc. Struct.	1·41	4(B)	2	I, XI	2	4	0	Mitsch
1·59	Concrete Research	——	G(A)	1 or 2	(Elective)		★		Carlson
1·60	Hydrographic Survey	M12, *1·05* or *1·041*	3	S	I, VII$_3$, XI	1	4	0	Gifford
1·62	Hydraulics	2·01	3	2	I, VII$_3$, IX-B, XI	4	—	6	Russell
1·63	Hydraulics	2·01	4	1	XV$_1$	2	—	3	Russell
1·64	Hydraulics	2·01	4	1	VI	3	—	6	Russell
			4	S	VI-A(B)$_2$				
			4	2	VI-A$_{1,2}$, VI-A(B)$_1$				
1·66	Hydraulics, Adv.	1·62	G(A)	1	(Elective)	2	—	6	Russell
1·68	Theory of Models	1·62	G(A)	1	I (A.E.)	2	—	4	Reynolds
1·691	River Hydraulic Lab.	1·62, *1·68*	G(A)	1	(Elective)	0	9	0	Reynolds
			G	2	I (A.E.)				
1·692	River Engineering	1·62	G(A)	2	(Elective)	2	—	4	Reynolds
1·70	Water Power Eng.	1·62	4(B)	1	(Elective)	3	4	4	Barrows
			G	1	I (A.E.)				
1·71	Water Power Eng.	1·70, 1·41	4(B)	2	(Elective)	2	4	3	Barrows
1·72	Flood Control	1·70	4(B)	2	(Elective)	2	4	3	Barrows
			G	2	I (A.E.)				
1·731	Water Power Eng. Adv.	1·42, 1·71, *1·851*	G(A)	1	(Elective)	3	—	6	Barrows
1·732	Water Power Eng. Adv.	1·731, *1·852*	G(A)	2	(Elective)	3	—	6	Barrows
1·75	Hydraulic & San. Eng.	1·62	4(B)	1	VII$_3$, XI	4	—	6	Camp
1·76	Sanitary Engineering	1·75	4(B)	2	(Elective)	2	—	3	Camp
1·78	Sanitary Engineering	1·75	4(B)	2	VII$_3$, XI	3	—	4	Camp
1·79	Sanitary Design	1·75	4(B)	2	(Elective)	0	2	0	Camp
1·801	Hydraulic & San. Des.	*1·75*	4(B)	1	VII$_3$, XI	0	3	0	Camp
1·802	Sanitary Design	*1·76* or *1·78*	4(B)	2	VII$_3$, XI	0	5	0	Camp

★ Time specially arranged. ‡ Not offered 1938–39.

Civil and Sanitary Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
1·811	Sanitary Eng. Adv.	1·75	G(A)	1	(Elective)	3	—	6	Camp
1·812	Sanitary Eng. Adv.	1·811, 1·76	G(A)	2	(Elective)	3	—	6	Camp
1·851	Water Power Des. Adv.	*1·731*	G(A)	1	(Elective)	0	8	0	Barrows
1·852	Water Power Des. Adv.	1·851, *1·732*	G(A)	2	(Elective)	0	8	0	Barrows
1·881	Sanitary Design Adv.	*1·811*	G(A)	1	(Elective)	0	6	0	Camp
1·882	Sanitary Design Adv.	*1·812*	G(A)	2	(Elective)	0	6	0	Camp
1·90	Prof. Prac. in Civ. Eng.	1·41	G(A)	2	(Elective)	1	—	2	Spofford

MECHANICAL ENGINEERING—2·00–2·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2·00	Applied Mechanics	*D12*, *M21*, 8·02	2	1	I, II, VI, VI-B, VI-A, IX-B, XIII, XIII-C, XV_1, XVI, XVII	3	—	5	Fuller
2·01	Applied Mechanics	2·00	2	2	I, II, VI, VI-A(A), $(B)_{2,3}$, IX-B, XIII, XIII-C, XV_1, XVI, XVII	3	—	5	Fuller
			3	1	$VI\text{-}A(B)_1$				
			4	1	VI-B(b)				
2·011	Applied Mechanics	*M21*, *8·02*	2	2	VII_3, XI, XII_2	3	—	5	Fuller
			3	1	X, XIX				
2·02	Applied Mechanics	2·01	3	S	II	2	6	0	Fuller
2·031	Struct. Mechanics, El.	M111	1	2	IV, IV-B, IV-C	3	—	6	Holmes
2·032	Structural Mechanics	2·031	2	1	IV, IV-B, IV-C	2	—	4	Holmes
2·033	Structural Mechanics	2·032	2	2	IV, IV-B, IV-C	2	—	4	Holmes
2·04	Applied Mechanics	2·01 or 2·011	3	1	I, II, VI, VI-C, $VI\text{-}A(B)_2$, IX-B, XIII, XIII-C, XIII-A, XV_1, XVI	3	—	5	Fuller
			3	S	VI-A(A), XVII				
			4	S	$VI\text{-}A(B)_{1,3}$				
			4	2	VI-B(b)				
2·041	Applied Mechanics	2·01	3	S	II-A	4	—	8	Fuller
2·042	Applied Mechanics	2·011	3	1	III, VII_3, XI, XII_2	3	—	5	Fuller
			3	2	X, XIX				
2·05	Applied Mechanics	——	G	S	II (A.O.)	4	—	6	Holmes
2·06	Applied Mechanics	2·04	3	2	II, XIII, XIII-A	3	—	5	L. S. Smith
			3	1	II-A				
2·07	Applied Mechanics	2·04	3	2	VI, $VI\text{-}A(A)_{1,2}$	3	—	5	Fuller
			4	2	$VI\text{-}A(B)_{1,2}$				
2·08	Applied Mechanics	2·04	4	1	II-A	4	—	8	Fuller
2·081	Applied Mechanics	2·04	4(B)	1	$II_{1,2,4,5}$	3	—	5	Riley
2·082	Applied Mechanics	2·06	4(B)	2	$II_{1,2,4,5}$, II-A	3	—	5	Fuller
2·10	Ordnance Engineering	2·04	4(B)	1	(Elective)	3	—	3	Holmes
2·11	Industrial Plant Eng.	*2·082*	4(B)	2	(Elective)	3	—	3	Peabody
2·121	App. Photoelasticity	2·04	4(B)	1 or 2	(Elective)	1	2	2	Murray
2·125	Res. in Photoelas.	2·121	G(A)	1 or 2	(Elective)		★		Murray
2·131	Dynamics of Engines	2·081	G(A)	1	(Elective)	2	—	4	Riley
2·132	Dyn. Aircraft Engines	2·131	G(A)	1	(Elective) (For Naval Officers only, XVI)	2	—	2	Riley
2·151	Dynamics	——	G	1	II (T.E.)	2	—	4	Riley
2·152	Dynamics	——	G	2	II (T.E.)	2	—	4	Riley
2·201	Adv. Mech. & Th. Elast.	2·082	G(A)	1	(Elective)	3	—	9	Fuller
2·202	Adv. Mech. & Th. Elast.	2·201	G(A)	2	(Elective)	3	—	9	Fuller
2·203	Theory of Elasticity	2·05	G	S	II (A.O.)	3	—	5	Fuller
2·221	Plasticity	2·082	G(A)	1	(Elective)	3	—	6	MacGregor
2·222	Adv. Plasticity Prob.	2·221	G(A)	2	(Elective)	3	—	6	MacGregor
2·223	Plasticity Res.	*2·221*	G(A)	1 or 2	(Elective)		★		MacGregor

★ Time specially arranged.

Mechanical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2·251	Fluid Mechanics	M22, 2·01	3	1	II, XIII	3	3	2	Hunsaker
2·252	Fluid Mechanics	2·251, 2·40	3	2	II	3	3	2	Hunsaker
2·253	Fluid Mechanics	M22, 2·01, *2·40*	3	1	II-A	5	2	5	Peters
2·254	Fluid Mechanics	M22, 2·01	3	S	(Elective)	3	—	3	Peters
2·255	Fluid Mechanics	2·254, 2·40	3	S	(Elective)	3	—	3	Peters
2·271	Hydromechanics	2·252 or M73	4	1	XIII-A	3	—	6	Peters
			G	1	II (T.E.)				
			G(A)	1	(Elective)				
2·272	App. Hydromechanics	2·271	G(A)	2	(Elective)	3	—	6	Peters
			G	2	II (T.E.)				
2·273	Adv. Hydromech. Prob.	2·271	G(A)	1 or 2	(Elective)		★		Peters
2·30	Engineering Metals	——	2	2	II	1	2	1	Kyle
2·304	Foundry Engineering	2·32, 2·35, 19·54	G(A)	1	(Elective)	3	—	6	Lessells
2·31	Engineering Metals	*2·30*	3	1	II	2	4	3	Kyle
2·32T	Engineering Metals	——	4	1	$II_{1, 2, 4}$ (not 1938–39)	1	2	2	Kyle
			4	2	XIII				
2·33T	Engineering Metals	2·31	4(B)	2	II_4	2	2	2	Kyle
2·331	Metal Processing	——	G	S	XIII-A	2	3	1	Kyle
2·332	Welding Eng., Adv.	2·32T	4(B)	2	(Elective)	1	3	2	H. F. Gray
2·34	Prop. of Metals under Stress	2·37	G(A)	2	(Elective)	1	2	3	Lessells
2·35	Engineering Materials	2·37	4(B)	1	II_4	2	1	3	Lessells
2·351	Materials of Eng.	*2·04*	3	1	II-A, XIII-A, XVI	2	—	2	Lessells
			4	2	XIII				
2·361	Adv. Str. of Materials	——	G(A)	S	(Elective)	4	1	4	Lessells
2·37	Test. Materials Lab.	2·04, 2·31 or 2·351	4	1	$II_{1, 2}$	1	3	2	Cowdrey
			3	2	II, XVI				
			4	S	II-A				
2·371	Test. Materials Lab.	2·04 or 2·042	3	2	I, XI, VI-A(A), XIII-A	0	2	1	Cowdrey
			4	1	X, XVII, XIX				
			4	2	VI-A(B), XIII				
2·372	Test. Materials Lab.	2·04, 2·31	4	1	II_4	1	3	4	Cowdrey
2·373	Test. Materials Lab.	——	3	1	XVII	0	5	3	Cowdrey
2·38	Test. Mat. Lab. (Concrete)	2·35	G	1	I (A.E.)	0	3	2	Cowdrey
2·391	Dyn. Str. of Metals	2·082, 2·35, 2·37	G(A)	1	(Elective)		★		deForest
2·392	Dyn. Str. of Metals	2·391	G(A)	2	(Elective)		★		deForest
2·40	Heat Engineering	M21, 8·02	3	1	II, II-A, VI, IX-B, XIII, XIII-C, XVI	4	—	5	Berry
			4	S	$VI\text{-}A(A)_{1, 2}$				
			4	1	$VI\text{-}A(B)_{1, 2}$				
2·41	Heat Engineering	M21, 8·02	3	1	XVII	3	—	5	Taft
2·411	Heat Engineering	M21, 8·02	4	1	I, XI	2	—	4	Taft
2·42	Heat Engineering	2·40	3	2	II, II-A, VI, IX-B, XIII, XIII-C, XVI	4	—	5	Berry
			4	1	$VI\text{-}A(A)_{1, 2}$				
			4	2	$VI\text{-}A(B)_{1, 2}$				
2·421	Heat Engineering	2·41 or 2·411	4	2	I, XI	2	—	4	Taft
2·43	Heat Engineering	2·40	4(B)	1	$II_{1, 3}$	3	—	5	Berry
			4	S	II-A				
2·44	Thermodyn. of Mixtures	2·42 or 2·421	4(B)	1	(Elective)	2	—	4	Moore
2·45	Eng. Thermodyn., Adv.	2·43	G(A)	2	(Elective)	3	—	9	Keenan
			G	2	II (T.E.)				
2·461	Refrigeration, Adv.	2·43	G(A)	1	(Elective)	3	—	9	Berry
2·462	Heat Transmission, Adv.	2·43	G(A)	2	(Elective)	3	—	9	Berry
2·50	Heat Measurements	8·04	4	1	XIV, XIX	1	2	1	Wilkes
2·501	Heat Measurements	8·04	3	1	IX-A	0	2	1	Wilkes
2·51	Heat Measurements	8·04	4(B)	1	II_3	1	2	3	Wilkes
			4	2	II-A				
2·52	Heat Measurements	8·04	4(B)	2	(Elective)	1	4	2	Wilkes

★ Time specially arranged.

Mechanical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2·53	Heat Measurements	2·50, 2·501, 2·52	G(A)	1	(Elective)		★		Wilkes
‡2·55	Power Plant Eng.	2·42 or 2·421	4(B)	1	$II_{1,3}$	3	—	3	Taft
2·551	Power Plant Eng.	2·42	4	2	II-A	3	—	5	Taft
‡2·56	Power Plant Eng.	2·55	4(B)	2	$II_{1,3}$	3	—	3	Taft
2·56T	Power Plant Eng.	2·42 or 2·421	4(B)	2	$II_{1,3}$ (1938–39 only)	5	—	7	Taft
2·57	Power Plants, Adv.	2·56	G(A)	1	(Elective)	3	—	6	Holt
2·58	Heat Eng. in Ind. Plants	2·42	4(B)	2	(Elective)	3	—	5	Taft
2·59	Torpedoes	——	G	1	II (T.E.)	2	—	4	Taft
2·60	Food Engineering	8·02	4	1	VII_2	2	—	2	W. H. Jones
2·601	Food Engineering	2·60	4	2	VII_2	3	—	3	W. H. Jones
2·621	Refrigeration Eng.	*2·43*	4(B)	1	II_3	3	—	3	W. H. Jones
2·622	Refrigeration Eng.	2·621	4(B)	2	II_3	3	—	5	Svenson
2·63	St. & Trans. of Foodstuffs	2·621	G(A)	1	(Elective)	3	—	6	W. H. Jones
2·64	Refrigeration Eng.	2·43	G(A)	2	(Elective)	3	—	6	Svenson
2·65	Mech. Eq. Bldgs. H. & V.	8·02	4	2	VII_3	3	1	3	Eames
2·651	Mech. Equip. of Bldgs.	——	4	1	IV	2	—	2	Moore
2·66	Heat., Vent. & Air Cond.	2·40 or 2·41	4(B)	1	$II_{3,5}$; XVII (1939–40)	3	—	5	Holt
2·671	Air Conditioning, Adv.	2·66	G(A)	1	(Elective)	3	—	6	Holt
2·672	Heat. & Vent. Design	2·671	G(A)	2	(Elective)	4	—	4	Holt
2·680	Engineering Lab.	2·40, 2·251	3	2	II	0	4	4	Eames
			4	2	II-A				
2·681	Engineering Lab.	2·40, 2·251	4(B)	1	$II_{1,3,4,5}$	0	3	3	Eames
			4	2	II_2				
2·682	Engineering Lab.	2·681	4(B)	1	II_1	0	3	3	Eames
2·683	Engineering Lab.	2·40, 2·251	3	2	XIII	0	2	2	Eames
2·684	Engineering Lab.	2·683	4	2	XIII	0	2	2	Eames
2·685	Engineering Lab.	2·40	3	2	XIII-C	0	4	4	Eames
2·686	Engineering Lab.	2·40 or 2·41 or	4	1	VI, IX-B	0	3	3	Eames
			3	2	XVI				
2·687	Hydraulic Lab.	1·62	4	2	I, XI	0	2	2	Eames
2·688	Engineering Lab.	10·29	4	2	X	0	3	3	Eames
2·69	Refrig. & Air Con. Lab.	2·43, 2·66	4(B)	2	II_3	0	6	6	Jones, Holt
2·691	Refrigeration Lab.	2·43 or 2·681	4(B)	2	(Elective)	0	2	2	Jones
2·692	Refrig. & Air Con. Lab.	2·69	G(A)	2	(Elective)	0	4	6	Jones, Holt
2·70	Machine Drawing	D12	2	1	II	0	4	0	Sloane
2·701	Machine Drawing	D12	2	1	IX-B	0	6	0	Sloane
			3	1	XVI				
2·71	Th. & App. of Mechanisms	M75	G	1	II (A.O.)	6	—	8	Swett
2·72	Machine Design	——	4	2	XIII-A	3	—	6	Townsend
2·731	Machine Design	2·04 or 2·041, 2·31	3	2	II	2	2	1	Townsend
		or 2·351	3	1	II-A				
2·732	Machine Design	2·731	4(B)	1	$II_{1,4,5}$	2	3	3	Swett
2·733T	Machine Design	2·731	4	2	II-A	2	3	3	Swett
2·74	Machine Design	2·04, 2·351	4	1	(Elective)	2	2	0	Townsend
2·751	Machine Design, Adv.	2·732	G(A)	1	(Elective)	3	5	2	Swett
2·752	Machine Design, Adv.	2·751	G(A)	2	(Elective)	3	5	2	Swett
2·761	Machine Design	——	G	1	II (T.E.)	2	4	2	Swett
2·762	Machine Design	——	G	2	II (T.E.)	1	2	2	Swett
2·77	Design of Prod. Mach.	2·732	4	2	II_4	2	2	2	Swett
2·791	Automotive Engines	2·42	4(B)	1	II_2	4	—	4	C. F. Taylor
2·792	Automotive Engines	2·791	4(B)	2	II_2	4	—	4	C. F. Taylor
2·793	Automotive Eng. Des.	*2·791*	4(B)	1	II_2	0	4	0	C. F. Taylor
2·794	Automotive Eng. Des.	2·793	4(B)	2	II_2	0	4	0	C. F. Taylor
2·795	Automotive Vehicles	——	4(B)	1	II_2	3	—	3	Fales, King
2·796	Automotive Vehicles	2·795	4(B)	2	II_2	3	—	3	Fales, King
2·797	Auto. Vehicle Design	2·04, 2·35, *2·795*	4(B)	1	II_2	0	4	0	Fales, King
2·798	Auto. Vehicle Design	2·797, *2·796*	4(B)	2	II_2	0	4	0	Fales, King
2·801	Auto. Eng. Prob., Adv.	——	G(A)	1	(Elective)		★		C. F. Taylor

★ Time specially arranged. ‡ Not offered 1938–39.

Mechanical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec.	Lab. Draw.	Prep.	Instructor in Charge
2·802	Auto. Eng. Prob., Adv.	——	G(A)	2	(Elective)		★		C. F. Taylor
2·803	Automotive Eng.	2·791, 2·795	G(A)	1	(Elective)		★		King
2·804	Automotive Eng.	2·803	G(A)	2	(Elective)		★		King
2·82	Diesel Engine Design	2·081, 2·42	4(B).	2	II-A(a)	0	6	0	Riley
2·83	Steam Turbine Eng.	2·42	4(B).	2	II-A(b)	4	—	2	Keenan
2·851	Machine Tool Lab.	——	2	1	II, XIII	1	3	0	English
2·852	Machine Tool Practice.	2·851	2	2	II, XIII	1	3	0	English
2·853	Machine Tool Lab.	——	2	1	VI, VI-A	1	3	0	English
2·854	Machine Tool Lab.	——	2	1	XIII-C	1	2	0	English
			2	2	IX-B, XIX				
2·871	Manufacturing Eng.	2·731 or *2·74*	4(B).	1	(Elective)	2	—	4	Buckingham
2·872	Prep. for Manufacturing	——	4(B).	1 or 2	(Elective)	2	—	4	Buckingham
2·88	Metrology & Dimens. Eng. Stand.	——	G(A)	1	(Elective)	3	—	6	Buckingham
2·901	Prin. of Fabric Struct.	8·02	4(B).	1	II_5	3	—	6	Schwarz
2·902	Prin. of Fabric Struct.	2·901	4(B).	2	II_5	3	—	6	Schwarz
2·903	El. of Textile Manufact.	2·01	4(B).	1	II_5	3	—	6	Schwarz
2·904	Pr. of Textile Manufact.	2·903	4(B).	2	II_5	3	—	6	Schwarz
2·905	Textile Tech. Anal.	8·04	G(A)	1	(Elective)	3	—	5	Schwarz
2·906	Textile Tech. Anal.	2·905	G(A)	2	(Elective)	3	—	5	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 Research Lab.	2·904	G(A)	1	(Elective)	0	6	0	Schwarz
2·912	Textile Research Lab.	2·911	G(A)	2	(Elective)	0	6	0	Schwarz
2·92	Prin. Textile Anal.	——	4	S	(Elective)	3	5	2	Schwarz
2·951	Manufacturing Practice	——	3	S	II-A		40 h.p.w.		Townsend
2·952	Manufacturing Practice	——	3	2	II-A		40 h.p.w.		Townsend
2·953	Manufacturing Practice	——	4	1	II-A		40 h.p.w.		Townsend
2·954	Manufacturing Practice	——	G	S	II-A		40 h.p.w.		Townsend
2·96	Study and Research	——	G	S	II-A	0	6	0	Townsend

MINING ENGINEERING—3·00–3·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec.	Lab. Draw.	Prep.	Instructor in Charge
3·01	Mining I	8·04, 12·01	3	1	III_1	7	—	7	Foster
3·02	Mining II	3·01	3	2	III_1	8	—	8	Foster
3·03	Econ. of Mining	3·02, or 3·08 or 3·82T; 3·21 or 3·23	4(B).	1	III	2	—	4	Hutchinson
3·04	Mining, Prin. of	3·03	4(B).	2	III	2	—	4	Hutchinson
3·061	Mining Eng., Adv.	3·04	G(A)	1	(Elective)		★		Hutchinson
3·062	Mining Eng., Adv.	3·04	G(A)	2	(Elective)		★		Hutchinson
3·08	Mining Practice	1·10	3	S	III	0	3	0	Hutchinson
3·101	Mine Valuation	3·04, 3·08	G(A)	1	(Elective)	3	—	8	Hutchinson
3·102	Mine Valuation	3·101	G(A)	2	(Elective)	3	—	8	Hutchinson
3·12	Mining Econ., Adv.	3·04	G(A)	2	(Elective)		★		Hutchinson
3·13T	Mining III	M21, 8·04	4(B).	1	III	2	2	2	Foster
3·14	Mining IV	3·03	4(B).	2	(Elective)	2	—	6	Staff
3·20	Ore Dressing I	5·02, 8·04	3	1	III	3	—	3	Schuhmann
3·21	Ore Dressing II	12·01, *3·22*, 3·20	3(B).	2	III_1	3	—	2	Locke
3·22	Ore Dressing Lab.	5·12, *3·21*	3(B).	2	III_1	1	7	2	Locke
3·23	Ore Dressing	12·01	3	2	III_1, XIX	1	2	2	Locke
3·241	Ore Dressing, Adv.	3·21, 3·22; or 3·23	G(A)	1	(Elective)		★		Locke
3·242	Ore Dressing, Adv.	3·21, 3·22; or 3·23	G(A)	2	(Elective)		★		Locke
3·251	Th. & Prac. of Flot.	3·21, 3·22; or 3·23	G(A)	1	(Elective)		★		Locke
3·252	Th. & Prac. of Flot.	3·21, 3·22; or 3·23	G(A)	2	(Elective)		★		Locke
3·26	Ore Dressing, Econ.	3·21, 3·22; or 3·23	G(A)	1 or 2	(Elective)		★		Locke
3·271	Ore Dressing, Design	3·21, 3·22; or 3·23	G(A)	1	(Elective)		★		Locke

★ Time specially arranged.

Mining Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
3·272	Ore Dressing, Design	3·21, 3·22; or 3·23	G(A)	2	(Elective)		★		Locke
3·81T	Petroleum I	8·04, 12·30	3	1	III_2	4	—	8	Mann
3·82T	Petroleum II	3·81T	3	2	III_2	4	—	5	Mann
3·85T	Petroleum III	3·82T	4(B)	1	III_2	3	—	5	Mann
3·86T	Petroleum IV	3·85T	4(B)	2	III_2	3	—	4	Mann
3·89	Oil Field Visits	1·10	3	S	III_2	0	3	0	Mann
3·901	Oil & Gas Land Val.	3·86T, 3·89	G(A)	1	(Elective)	3	—	8	Mann
3·902	Oil & Gas Land Val.	3·901	G(A)	2	(Elective)	3	—	8	Mann
3·911	Petroleum Eng., Adv.	3·86T	G(A)	1	(Elective)		★		Mann
3·912	Petroleum Eng., Adv.	3·86T	G(A)	2	(Elective)		★		Mann
3·921	Oil & Gas Law	3·86T	G(A)	1	(Elective)	2	—	4	Mann
3·922	Oil & Gas Law	3·86T	G(A)	2	(Elective)	2	—	4	Mann

ARCHITECTURE—4·00–4·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
4·021	Freehand Drawing	——	2	1	IV, IV-B, IV-C, VI-B(b)	0	4	0	Reid
4·022	Freehand Drawing	4·021	2	2	IV, IV-B, IV-C, VI-B(b)	0	4	0	Reid
4·031	Freehand Drawing	4·022	3	1	IV, IV-B, IV-C, VI-B(b)	0	4	0	Reid
4·032	Freehand Drawing	4·031	3	2	IV, IV-B, IV-C	0	4	0	Reid
4·041	Freehand Drawing	4·032	4	1	IV, IV-B, IV-C	0	4	0	Reid
4·042	Freehand Drawing	4·041	4	2	IV	0	4	0	Reid
4·051	Freehand Drawing	4·042	5(B)	1	IV	0	6	0	Reid
4·052	Freehand Drawing	4·051	5(B)	2	IV	0	6	0	Reid
4·053	Freehand Drawing	4·052	G(A)	1	(Elective)	0	6	0	Reid
4·054	Freehand Drawing	4·053	G(A)	2	(Elective)	0	6	0	Reid
4·06	Graphics	——	1	1	IV, IV-B, IV-C	2	4	0	Dean
4·071	Modeling	4·722	3	1	IV, IV-B, IV-C, VI-B(b)	0	3	0	Selmer-Larsen
4·072	Modeling	4·071	3	2	IV, IV-B, IV-C	0	3	0	Selmer-Larsen
4·081	Color, Comp. Th. & App.	4·732	4	1	IV, IV-B, IV-C, VI-B(b)	1	—	3	H. W. Gardner
4·082	Color, Comp. Th. & App.	4·081	4	2	IV, IV-B, IV-C, VI-B(b)	1	—	3	H. W. Gardner
4·091	Color, Comp. Th. & App.	4·082	5(B)	1	IV	1	—	4	Beckwith
4·092	Color, Comp. Th. & App.	4·091	5(B)	2	IV	1	—	4	Beckwith
4·11	Shades & Shadows	*4·06*	1	1	IV, IV-B, IV-C	0	2	2	H. W. Gardner
4·12	Perspective	*4·06* or *D12*	1	1	IV, IV-B, IV-C	2	2	3	Dean
4·312	Abstract Design	——	1	2	IV, IV-B, IV-C	10	—	5	H. W. Gardner
4·421	Architectural History	——	2	1	IV, IV-B, IV-C	3	1	5	Putnam
			3	1	VI-B(b)				
4·422	Architectural History	——	2	2	IV, IV-B, IV-C	3	1	5	Putnam
4·43	Architectural History	——	2	1	XVII	3	—	3	Putnam
4·461	Europ. Civilization & Art	4·422	3	1	IV, IV-B, IV-C	3	—	4	Seaver
4·462	Europ. Civilization & Art	4·461	3	2	IV, IV-B, IV-C	3	—	4	Seaver
4·471	Europ. Civilization & Art	4·462	4	1	IV, IV-B, IV-C	2	—	3	Seaver
4·472	Europ. Civilization & Art	4·471	4	2	IV, IV-B, IV-C	2	—	3	Seaver
4·481	Europ. Civilization & Art	4·472	5(B)	1	IV, IV-B, IV-C	2	—	3	Seaver
4·482	Europ. Civilization & Art	4·481	5(B)	2	IV, IV-B, IV-C	2	—	3	Seaver
4·491	Europ. Civilization & Art	4·482	G(A)	1	(Elective)	2	—	4	Seaver
4·492	Europ. Civilization & Art	4·491	G(A)	2	(Elective)	2	—	4	Seaver
4·50	Office Practice	——	5	S	IV-C		40 h. p. w.		F. J. Adams
4·51	Office Practice	——	5	2	IV-C	0	30	0	F. J. Adams

★ Time specially arranged.

Architecture Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
4·52	Office Practice	——	G	S	IV-C	40 h. p. w.			F. J. Adams
4·53	Professional Relations	——	5(B)	1	IV	1	—	2	Emerson, Clapp
4·60	Plan. & Housing Legis.	Ec83	G(A)	1	IV-C	2	—	4	Shurtleff
4·62	Site Plan. & Const.	——	4	2	IV-B, IV-C	0	6	0	Cautley, Eberlin
4·63	City Planning Admin.	——	G(A)	2	IV-C	2	—	4	Shurtleff
4·641	Hist. & Prin. City Plan	4·61	3	1	IV, IV-B, IV-C	2	—	2	F. J. Adams
4·642T	Th. of Site Planning	4·641	4(B)	2	IV-B, IV-C	2	—	3	McKeever
4·651	Th. & Prac. City Plan.	4·642	5(B)	1	IV-B, IV-C	3	—	3	F. J. Adams
4·652	Th. & Prac. City Plan.	4·651	5(B)	2	IV-B, IV-C	3	—	3	F. J. Adams
4·661	City Planning Research	4·652	G(A)	1	IV-C	2	—	4	F. J. Adams
4·662	City Planning Research	4·661	G(A)	2	IV-C	2	—	4	F. J. Adams
4·672	City Planning Design	4·671	4(B)	2	IV-B, IV-C	0	18	0	McKeever
4·681	City Planning Design	4·672	5(B)	1	IV-B, IV-C	0	24	0	McKeever
4·682	City Planning Design	4·681	5(B)	2	IV-B	0	12	0	F. J. Adams
4·691	City Planning Design, Adv.	4·682	G(A)	1	IV-C	0	36	0	F. J. Adams
4·692	City Planning Design, Adv.	4·691	G(A)	2	IV-C	0	36	0	F. J. Adams
4·711	Architectural Practice	——	1	1	IV, IV-B, IV-C	0	10	0	Bridge
4·712	Architectural Practice	——	1	2	IV, IV-B, IV-C	0	12	0	Bridge
4·721	Architectural Design II	——	2	1	IV, IV-B, IV-C	0	13	1	Beckwith
4·722	Architectural Design II	4·721	2	2	IV, IV-B, IV-C	0	13	1	Beckwith
4·731	Architectural Design III	4·722	3	1	IV, IV-B, IV-C	0	15	3	H. W. Gardner
4·732	Architectural Design III	4·731	3	2	IV, IV-B, IV-C	0	15	3	Clapp
4·741	Architectural Design IV	4·732	4	1	IV, IV-B, IV-C	0	24	1	Clapp
4·742	Architectural Design IV	4·741	4	2	IV	0	28	1	Larsen
4·751	Architectural Design V	4·742	5(B)	1	IV	0	29	0	Larsen
4·752	Architectural Design V	4·751	5(B)	2	IV	0	14	0	Anderson
4·761	Architectural Design VI	4·752	G(A)	1	(Elective)	0	36	0	Anderson
4·762	Architectural Design VI	4·761	G(A)	2	(Elective)	0	36	0	Anderson
4·78	Planning Principles	——	2	2	XVII	1	2	1	Clapp
4·811	Construction	2·031	3	1	IV, IV-B, IV-C	2	5	0	Gelotte
4·812	Construction	4·811	3	2	IV, IV-B, IV-C	2	5	0	Gelotte
4·93	General Science	——	2	1	IV, IV-B, IV-C	4	—	2	T. Davis
4·94	General Science	——	2	2	IV, IV-B, IV-C	4	—	2	Page

CHEMISTRY—5·00–5·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
5·00	Chemistry, Entrance	——	—	S	——	3	3	5	A. R. Davis
5·01	Chemistry, General	——	1	1	All Courses except IV, IV-B and IV-C	4	3	4	Wareham
5·02	Chemistry, General	5·01	1	2	All Courses except IV, IV-B and IV-C	4	3	4	Wareham
5·04	Chemistry	——	G	S	II (A.O.)	4	—	5	Wareham
5·061	Inorganic Chemistry	5·13 or 5·131	4(B)	1	V	2	—	3	Schumb
5·062	Inorganic Chemistry	5·061	4(B)	2	V	2	—	3	Schumb
‡5·071	Sem. Inorganic Chem.	5·062	G(A)	1	(Elective)	2	—	3	Schumb
‡5·072	Sem. Inorganic Chem.	5·071	G(A)	2	(Elective)	2	—	3	Schumb
5·08	Inorganic Lab., Adv.	5·13 or 5·131	G(A)	1 or 2	(Elective)	0	6	0	Young
5·10	Qualitative Analysis	5·02	2	S	V, X	3	11	4	Hamilton
			2	1	(Elective)				
5·11	Qualitative Analysis	5·02	2	1	VII, VII-A, $VIII_1$, IX-A, XI, XII, XV_2, XIX	3	4	2	Simpson
			2	S	$VIII_2$				
5·12	Quantitative Analysis	5·10 or 5·11	2	1	V, $VIII_2$, X	3	4	2	Hamilton
			2	2	VII, VII-A, IX-A, XI, XV_2, XIX				

‡ Not offered 1938–39.

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Chemistry Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
5·13	Quantitative Analysis	5·12	2	2	V	3	4	2	Hamilton
5·131	Quantitative Analysis	5·12	2	2	X	2	3	2	Marvin
5·141	Anal. Chemistry	5·12, 8·04	3	1	V	0	4	1	Woodman
			3	2	VII_2				
5·142	Anal. Chemistry	5·12	2	2	V	2	—	1	Simpson
5·16	Anal. Chemistry	5·131	4	2	X-A	1	3	1	Marvin
5·18	Qualitative Anal., Adv.	5·10	G(A)	1	(Elective)	1	8	1	W. T. Hall
5·26	Food Analysis	5·12	4(B)	1 or 2	(Elective)	0	5	0	Woodman
5·35	Applied Chemistry	5·02	3, 4	2	(Elective)	2	—	2	Marvin
5·41	Organic Chemistry I	5·12, 8·04	3	1	V, VII_3, IX-A, X, XI, XIV, XV_2	4	—	3	Huntress
			3	S	$VII_{1,2}$, VII-A				
			4	1	$VIII_2$				
5·412	Org. Chemistry & Lab.	5·04	G	S	II (A.O.)	3	3	4	Ashdown
5·413	Org. Chemistry & Lab.	5·412	G	1	II (A.O.)	3	3	0	Ashdown
5·414	Organic Chemistry Lab.	5·12, *5·41*	3	1	V	0	9	0	Hockett
5·416	Organic Chemistry Lab.	5·12, *5·41*	3	1	X	0	7	0	Milas
			3	2	XV_2				A. F. Thompson
5·417	Quant. Org. Anal.	5·41	4	1	V	0	4	0	A. F. Thompson
			4	2	(Elective)				
5·418	Organic Chemistry Lab.	5·12, *5·41*	3	1	XI, XIV	0	6	0	Hockett
			3	2	IX-A				
			4	1	$VIII_2$				
5·42	Organic Chemistry I	5·41	3	2	V, X	4	—	2	Ashdown
5·424	Organic Chemistry Lab.	5·414	3	2	V	0	9	0	Hockett
5·426	Organic Chemistry Lab.	5·416	3	2	X	0	5	0	Ashdown
5·428	Organic Chemistry Lab.	*5·41*	3	S	$VII_{1,2}$, VII-A	0	10	0	Huntress
5·43	Powder, Explosives and War Agents	5·42	4(B)	2	(Elective)	2	—	2	T. L. Davis
5·51	Organic Chemistry II	5·42	G(A)	1	(Elective)	2	—	3	Norris
5·52	Organic Chemistry II	5·51	G(A)	2	(Elective)	2	—	3	Norris
5·53	Organic Chemistry III	5·42	G(A)	1	(Elective)	2	—	4	T. L. Davis
5·54	Organic Chemistry III	5·53	G(A)	2	(Elective)	2	—	4	T. L. Davis
5·55	Ident. Organic Comp.	5·42, 5·414	G(A)	1	(Elective)	2	8	0	A. F. Thompson
‡5·56	Chem. Heterocyclic Comp.	5·42	G(A)	2	(Elective)	2	—	2	Morton
5·562	Carbohydrates	5·42	G(A)	1	(Elective)	2	—	4	Hockett
5·563	Cellulose & Polysac	5·562	G(A)	2	(Elective)	2	—	4	Purves
5·57	Chemistry of Dyes.	5·42	G(A)	2	(Elective)	2	—	4	Huntress
5·574	Free Rad. & Organo-Metallic Comp.	5·42	G(A)	1	(Elective)	2	—	2	Morton
5·58	Chem. of Natural Prod.	5·42	G(A)	1	(Elective)	3	—	3	Milas
5·581	Organic Lab., Adv.	5·42, 5·424	G(A)	1	(Elective)	1	5	1	Morton
5·582	Organic Lab., Adv.	5·42, 5·424	G(A)	2	(Elective)	0	5	1	Morton
‡5·583	Organic Physical Chem.	5·42, 5·62	G(A)	1	(Elective)	2	—	2	Morton
‡5·584	Mol. Str. of Carbon Comp.	5·42	G(A)	1	(Elective)	2	—	4	Ashdown
‡5·585	Th. & App. of Catalysis	5·41	G(A)	1	(Elective)	2	—	2	Milas
5·591	Recent Adv. in Org. Chem.	5·42	G	1	(Elective)	1	—	1	Norris
5·592	Recent Adv. in Org. Chem.	5·42	G	2	(Elective)	1	—	1	Norris
5·61	Physical Chem. I	M21, 8·03, 5·12	3	1	V, VII-A, $VIII_2$, X, XII_2, XIV, XV_2, XIX	4	—	4	Millard
5·611	Physical Chem. Lab. I.	*5·61*	3	1	V, VII-A, XIV	0	4	0	Dietrichson
5·612	Physical Chem. Lab. I.	*5·61*	3	1	X, XIX	0	2	0	Dietrichson
5·62	Physical Chem. II	5·61	3	2	V, VII-A, $VIII_2$, X, XII_2, XIV, XIX	4	—	4	Millard
5·621	Physical Chem. Lab. II	5·611, *5·62*	3	2	V, VII-A, XIV	0	4	0	Dietrichson
5·622	Physical Chem. Lab. II	5·612, *5·62*	3	2	X, XIX	0	2	0	Dietrichson
5·63	Int. to Thermodynamics	5·62	4(B)	1	V	3	—	5	Sherrill
5·64	Int. to Rad. Chemistry	5·62 or 5·71	4(B)	2	V	2	—	3	Harris

‡ Not offered 1938–39.

Chemistry Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
5·66	Surface & Colloid Chem.	5·62 or 5·71	4(B)	2	V	2	—	3	Oncley
5·683	Physical Chem., Elem.	5·02, 8·02	2	1	II, XVI	2	—	2	Beattie
5·684	Physical Chem., Elem.	M21, 5·12, 8·04	3	1	VII$_{1,2}$	3	—	3	Gillespie
			4	1	XI				
5·71	Physical Chem.	M21, 8·03, 5·13	G(A)	1	(Elective)	3	—	5	Sherrill
5·72	Physical Chem.	5·71	G(A)	2	(Elective)	3	—	5	Sherrill
5·741	Radiation Chem., Adv.	5·64 or 5·72	G(A)	1	(Elective)	2	—	4	Harris
5·742	Statistical Mech.	5·741	G(A)	2	(Elective)	2	—	4	Keyes
5·76	Thermodyn. & Chemistry	5·62	G(A)	1	(Elective)	3	—	6	Gillespie
5·77	Thermodyn. & Chemistry	5·76	G(A)	2	(Elective)	2	—	4	Beattie
5·79	Theory of Solutions	5·76	G(A)	2	(Elective)	2	—	4	Scatchard
5·81	Chem. Literature I	——	3	1	V	2	—	3	W. T. Hall
5·82	Chem. Literature II	5·81, 5·41, 5·61	3	2	V	1	—	1	Huntress
5·83	History of Chemistry	5·41	4(B)	2	V	2	—	2	T. L. Davis
5·842	Optical Methods	5·12, 8·04	4(B)	1 or 2	(Elective)	0	2	1	Woodman
5·844	Eng. Chemistry	——	2	1	XVII	3	0	3	Marvin
5·911	Journal Meeting in Inorg. Chem.	——	G(A)	1	(Elective)	1	—	1	Schumb
5·912	Journal Meeting in Inorg. Chem.	——	G(A)	2	(Elective)	1	—	1	Schumb
5·921	Journal Meeting in Org. Chem.	5·42	G	1	(Elective)	1	—	1	Norris
5·922	Journal Meeting in Org. Chem.	5·42	G	2	(Elective)	1	—	1	Norris
5·931	Journal Meeting in Phys. Chem.	——	G	1	(Elective)	1	—	1	Scatchard
5·932	Journal Meeting in Phys. Chem.	——	G	2	(Elective)	1	—	1	Scatchard
5·941	Research Conf. in Inorg. & Org. Chem.	5·42	G	1	(Elective)	1	—	1	Norris
5·942	Research Conf. in Inorg. & Org. Chem.	5·42	G	2	(Elective)	1	—	1	Norris
5·943	Research Conf. in Phys. Chem.	——	G	1	(Elective)	1	—	1	Scatchard
5·944	Research Conf. in Phys. Chem.	——	G	2	(Elective)	1	—	1	Scatchard
5·98	Research	——	G(A)	1 or 2	(Elective)		★		Norris
	Thesis	——	4	1	V	0	16	0	Keyes
	Thesis	——	4	2	V	0	16	0	Keyes

ELECTRICAL ENGINEERING—6·00–6·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6·00T	Elec. Eng. Prin.	*M22*, 8·03	2	2	VI, VI-A, VI-B, VIII	4	—	6	Frazier
			3	2	VII-A				
6·01	Elec. Eng. Prin.	6·00T	3	S	VI-A	4	—	6	Frazier
			3	1	VI, VI-C, VI-B, VIII				
			4	1	VII-A				
6·02	Elec. Eng. Prin.	6·01	3	2	VI, VI-B, VI-C	4	—	6	Gray
			3	1	VI-A				
6·03	Elec. Eng. Prin.	6·02	4	1	VI, VI-B(a)	6	—	8	Lawrence
			3	2	VI-A				
6·031	Elec. Eng. Prin.	6·02	3	1	XIV	4	—	6	Lawrence
			4	1	VI-C				
6·04	Elec. Eng. Prin.	6·03	4	S	VI-A(B)$_{1,2}$	6	—	9	Lawrence
			4	1	VI-A(A)$_{1,2}$				Woodruff
			4(B)	2	VI				
6·09	Int. to Elec. Eng.	——	2	1	VI, VI-A, VI-B	2	—	0	Moreland

★ Time specially arranged.

Electrical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6·12	Elec. Eng. Prin.	6·031	3	2	XIV	5	—	6	Lawrence
6·211	App. Elec. in Industry	6·02	4(B)	1	(Elective)	3	—	6	Dawes
6·212	App. Elec. in Industry	6·03	4(B)	2	(Elective)	3	—	6	Dawes
6·221	Elec. Power Generation	2·42	4(B)	1	(Elective)	3	—	6	Mulligan
6·222	Elec. Power Generation	6·03	4(B)	2	(Elective)	3	—	6	Mulligan
6·241	Elec. Railways	6·77, *6·03*	4(B)	1	(Elective)	3	—	6	Balsbaugh
6·242	Elec. Railways	6·241	4(B)	2	(Elective)	3	—	6	Balsbaugh
6·251	Elec. Mach. Design	*6·03*	4(B)	1	(Elective)	3	—	6	Dwight
6·252	Elec. Mach. Design	6·03	4(B)	2	(Elective)	3	—	6	Dwight
6·26	Elec. Insulation	8·04	4(B)	1	(Elective)	3	—	6	von Hippel
6·27	Illum. Eng. Prin.	8·04	3	2	VI-B	2	3	4	Moon
			4	2	(Elective)				
6·271	Illum. Eng. Prin.	6·27	4(B)	1	VI-B	2	3	4	Moon
6·272	Illum. Eng. Prin.	6·271	4(B)	2	VI-B	2	3	4	Moon
6·281	Prin. Wire Com.	6·02	4(B)	1	(Elective)	3	—	6	C. E. Tucker
6·282	Prin. Radio Com.	6·02	4(B)	2	(Elective)	3	—	6	Barrow
6·29	Storage Batteries	—	4	1	(Elective)	1	—	2	Lawrence
6·30	Elec. Com. Prin.	*6·02*	3	2	VI-C	3	—	6	Guillemin
6·31	Elec. Com. Prin.	6·30, 6·02	4(B)	S	VI-A_3	3	—	5	Bowles
			4	1	VI-C				
6·32	Elec. Com. Prin.	6·30, 6·02	4(B)	2	VI-A_3	3	—	5	Guillemin
6·32T	Elec. Com. Prin.	6·30, 6·02	4(B)	2	VI-C	4	—	8	Guillemin
6·331	Elec. Com. Lab.	6·02, *6·31*	4	1	VI-C	0	3	4	Fay
6·332	Elec. Com. Lab.	6·331	4	2	VI-C	0	4	4	Fay
6·333	Elec. Com. Lab.	6·02, *6·31*	4	S	VI-A(B)$_3$	0	6	6	Fay
			4	1	VI-A(A)$_3$				
6·34	Elec. Com. Lab.	—	4(B)	1 or 2	(Elective)		★		Fay
6·40	Elec. Eng. Elem.	*8·04*	3	1	I, II, XI, XVI, XVII.	4	—	6	Hudson
			3	2	IX-B, XV				
			4	S	II-A				
			4	1	III, X, XII_2, XIII				
			4	2	XIX				
			5	1	XIII-C				
6·42	Elec. Eng. Elem.	—	G	1	II (A.O.)	5	—	5	Hudson
6·47	App. Elec. in Industry	6·40	4	1	$II_{1, 2, 3, 4}$	2	2	4	Tucker, Dawes
6·48	Elec. Equip. Bldgs.	8·04	4	2	(Elective)	1	—	2	Hudson
6·501	Elec. Eng. Seminar	6·04 or 6·32	G(A)	1	(Elective)	2	—	10	Woodruff
			G	S	VI-A(A)				
			G	S or 1	VI-A(B)				
6·502	Elec. Eng. Seminar	6·501	G(A)	2	VI-A	2	—	2	Woodruff
6·511	Elec. Pow. Circuits	6·04	G(A)	1	(Elective)	3	—	7	Wildes
6·512	Elec. Pow. Circuits	6·04	G(A)	2	(Elective)	3	—	7	Wildes
6·513	Power System Stability	6·04	G(A)	1	(Elective)	3	1	6	Fitzgerald
6·514	Power System Stability	6·04	G(A)	2	(Elective)	3	1	6	Fitzgerald
6·515	Power Systems Lab.	*6·511, 6·513, 6·514, 6·651* or *6·652*	G(A)	1 or 2	(Elective)		★		Fitzgerald
6·521	Alt. Cur. Machinery	6·04, M31	G(A)	1	(Elective)	3	2	5	Lyon, Kingsley
6·522	Alt. Cur. Machinery	6·04, M31	G(A)	2	(Elective)	3	2	5	Lyon, Kingsley
6·531	Power System Economics	6·04, Ec12	G(A)	1	(Elective)	3	—	7	Balsbaugh
6·532	Power System Economics	6·04, Ec12	G(A)	2	(Elective)	3	—	7	Balsbaugh
6·541	Electric Power Gen.	6·03, Ec12	G(A)	1	(Elective)	3	—	6	Mulligan
6·542	Electric Power Gen.	6·03, Ec12	G(A)	2	(Elective)	3	—	6	Mulligan
6·551	Railroad Elec. Trac.	6·03, Ec12	G(A)	1	(Elective)	3	—	6	Balsbaugh
6·552	Railroad Elec. Trac.	6·551	G(A)	2	(Elective)	3	-	6	Balsbaugh
6·561	Adv. Network Theory	6·32	G(A)	1	(Elective)	3	2	5	Guillemin
6·562	Adv. Network Theory	6·561	G(A)	2	(Elective)	3	—	7	Guillemin

★ Time specially arranged.

Electrical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6·571	Illum. Eng., Prin.	8·04, M22	G(A)	1	(Elective)	2	3	4	Moon
6·572	Illum. Eng., Prin.	6·571	G(A)	2	(Elective)	2	3	4	Moon
6·58	Trans. in Linear Systems	6·04 or 6·32, M31	G(A)	1 or 2	(Elective)	3	—	7	M. F. Gardner
6·59	Communications Lab.	6·332 or 6·333	G(A)	1 or 2	(Elective)		★		Fay
6·60	Math. Anal. by Mech. Meth.	M22	G(A)	1	(Elective)	2	—	4	Caldwell
6·61	Super-High-Volt. Eng.	6·04	G(A)	1	(Elective)	3	—	6	Trump
6·62	Elec. Com. Prin.	6·32	G(A)	2	(Elective)	2	3	5	Bowles
6·631	Engineering Electronics	6·03	G(A)	1	(Elective)	3	—	7	Gray
6·632	Engineering Electronics	6·631	G(A)	2	(Elective)	2	3	5	Gray
6·64	Electric Insulation	6·26	G(A)	2	(Elective)	3	—	6	von Hippel
6·651	Elec. Power Distribution	6·04	G(A)	1	(Elective)	3	—	6	Balsbaugh
6·652	Elec. Power Distribution	6·04	G(A)	2	(Elective)	3	—	6	Balsbaugh
6·661	Elec. Mach. Dev. Prin.	6·03	G(A)	1	(Elective)	3	1	6	Dwight
6·662	Elec. Mach. Dev. Prin.	6·03	G(A)	2	(Elective)	3	1	6	Dwight
6·671	Vibrations	M31 or M22 and 2·081	G(A)	1	(Elective)	3	1	6	Woodruff
6·672	Vibrations	6·671	G(A)	2	(Elective)	3	1	6	Woodruff
6·68	Sp. Prob. in Elec. Eng.	——	G(A)	1 or 2	(Elective)		★		Hazen
6·69	Sound in Elec. Com.	M31, 6·04 or 6·32 or 8·05	G(A)	2	(Elective)	2	3	5	Fay
6·73	Elec. Meas. Lab., Adv.	6·76, 6·04	G(A)	1 or 2	(Elective)		★		Bennett
6·74	Elec. Eng. Lab., Adv.	6·04, 6·79	G(A)	1 or 2	(Elective)		★		C. E. Tucker
6·75T	Elec. Eng. Lab.	6·00T or 6·40	3	S	VI-A(A), $(B)_1$	1	2	4	Bennett
			3	1	VI, VI-C, VI-A$(B)_{2, 3}$, VI-B				
			4	1	VII-A				
6·76	Elec. Eng. Lab.	6·75T, *6·01*	3	1	VI-A$(B)_1$	2	2	5	Bennett
			3	2	VI, VI-B, VI-C, VI-A(A)				
6·77	Elec. Eng. Lab.	6·01 or 6·10	3	1	VI-A(B), XIV	2	2	4	C. E. Tucker
			3	2	VI, VI-C, VI-A(A)				
6·78	Elec. Eng. Lab.	6·77, *6·03*	4	1	VI, VI-A$(A)_{1, 2}$	1	3	5	C. E. Tucker
			4	S	VI-A$(B)_{1, 2}$				
6·781	Elec. Eng. Lab.	6·77, 6·03	4	S	VI-A$(B)_3$	1	2	4	C. E. Tucker
			4	1	VI-A$(A)_3$, VI-C				
6·79	Elec. Eng. Lab.	6·78, *6·04*	4	2	VI	1	2	4	C. E. Tucker
6·80	Elec. Eng. Lab.	——	4(B)	1 or 2	(Elective)		★		Tucker, Bennett
6·81	Elec. Eng. Lab.	*6·40*	4	2	XIX	1	1	2	Bennett
6·84	Elec. Eng. Lab.	*6·12*, 6·77	3	2	XIV	0	5	5	Tucker, Bennett
6·85	Elec. Eng. Lab.	*6·40*	4	1	III, IX-B, X, XII_2	0	2	3	C. E. Tucker
6·88	Elec. Eng. Lab.	*6·42*	G	2	II (A.O.)	0	3	6	C. E. Tucker
6·89	Elec. Eng. Lab.	*6·40*	3	1	I, XI	0	2	2	C. E. Tucker
			3	2	XV_1, XVI, XVII				
			4	S	II-A				
			4	1	XIII				
			5	1	XIII-C				
6·901	Manufacturing Prac.	——	3	1	VI-A$(A)_1$	40 h. p. w.			Timbie
			2	2	$(B)_1$				
6·902	Manufacturing Prac.	——	4	S	VI-A$(A)_1$	40 h. p. w.			Timbie
			3	2	$(B)_1$				
6·903	Manufacturing Prac.	——	4	2	VI-A$(A)_1$	40 h. p. w.			Timbie
			4	1	$(B)_1$				
6·904	Manufacturing Prac.	——	G	1	VI-A$(A)_1$	40 h. p. w.			Timbie
			G	S	$(B)_1$				
6·911	Public Utility Prac.	——	3	1	VI-A$(A)_2$	40 h. p. w.			Timbie
			3	S	$(B)_2$				
6·912	Public Utility Prac.	——	4	S	VI-A$(A)_2$	40 h. p. w.			Timbie
			3	2	$(B)_2$				

★ Time specially arranged.

Electrical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6·913	Public Utility Prac.	—	4	2	VI-A(A)$_2$	40 h. p. w.			Timbie
			4	1	(B)$_2$				
6·914	Public Utility Prac.	—	G	1	VI-A(A)$_2$	40 h. p. w.			Timbie
			G	S	(B)$_2$				
6·921	Public Utility Prac.	—	3	1	VI-A(A)$_2$	40 h. p. w.			Timbie
			3	S	(B)$_2$				
6·922	Public Utility Prac.	—	4	S	VI-A(A)$_2$	40 h. p. w.			Timbie
			3	2	(B)$_2$				
6·923	Public Utility Prac.	—	4	2	VI-A(A)$_2$	40 h. p. w.			Timbie
			4	1	(B)$_2$				
6·924	Public Utility Prac.	—	G	1	VI-A(A)$_2$	40 h. p. w.			Timbie
			G	S	(B)$_2$				
6·941	Communications Prac.	—	3	1	VI-A(A)$_3$	40 h. p. w.			Timbie
			3	S	(B)$_3$				
6·942	Communications Prac.	—	4	S	VI-A(A)$_3$	40 h. p. w.			Timbie
			3	2	(B)$_3$				
6·943	Communications Prac.	—	4	2	VI-A(A)$_3$	40 h. p. w.			Timbie
			4	1	(B)$_3$				
6·944	Communications Prac.	—	G	1	VI-A(A)$_3$	40 h. p. w.			Timbie
			G	S	(B)$_3$				

BIOLOGY AND PUBLIC HEALTH—7·00–7·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
7·01	General Biology	—	2	1	VII, VII-A, XI	2	3	2	Bunker
			3	1	IX-A				
7·02	Modern Biology	—	—	S	(Elective)	2	4	3	Sizer
7·03	Theoret. Biology	7·01, 7·06, 7·10	4(B)	2	VII$_1$	2	—	3	Blake
7·06	Botany	7·01	2	2	VII$_{1,2}$	2	4	3	Jennison
7·08	Parasitology	7·10	3(B)	2	VII$_1$	2	—	4	Blake
7·09	Parasitology, Adv.	7·08	G(A)	2	(Elective)	0	4	4	Blake
7·10	Invertebrate Zoology	—	3	1	VII$_1$, VII-A	2	6	4	Blake
7·131	Adv. Histology	7·14	4(B)	1	(Elective)	1	3	2	Blake
7·132	Adv. Histology	7·131	G(A)	2	(Elective)	1	3	2	Blake
7·14	Comparative Anatomy	7·01	2	2	VII$_{1,2}$, VII-A	2	6	2	Blake
7·17	Biol. Food Supplies	7·01	3	1	VII$_2$	4	—	2	Blake, Jennison
7·18	Tech. Aspects of Entom.	7·10	G(A)	1	(Elective)	2	—	3	Blake
7·20	Physiology	5·41, 7·14	3	2	VII$_{1,2}$, VII-A	3	3	4	Bunker
7·201	Adv. Physiology	7·20, 7·80, 5·684	G(A)	2	(Elective)	3	4	3	Sizer
7·22	Personal Hyg. & Nut.	7·20	4(B)	1	VII$_{1,2}$	2	—	2	Turner, Harris
7·23	Applied Nutrition	—	G(B)	2	(Elective)	3	—	3	Turner, Harris
7·28	Limnology	—	3	1	(Elective)	1	2	1	Jennison
7·29	Bacteriology	7·01	3	2	XI	1	4	2	Jennison
7·301	Bacteriology	7·01	3	1	VII, VII-A	2	4	4	Horwood
7·302	Bacteriology	7·301	3(B)	2	VII	2	4	3	Horwood
			4	2	(Elective)				
7·321	Bacteriology, Adv.	7·301, 7·80	G(A)	1	VII-A	3	—	4	Jennison
7·322	Bacteriology, Adv.	7·321	G(A)	2	(Elective)	1	4	2	Jennison
7·33	Plant Diseases	7·301	3	2	VII$_2$	1	—	2	Prescott
7·34	Limnological Field work	7·01, 5·12	3	S	VII$_3$, XI	0	5	0	Jennison
7·35	Planktonology	7·06, 7·10	G(A)	1	(Elective)	2	—	3	Blake
7·36	Microbiology	7·302	4	1	VII$_1$	1	2	2	Prescott
7·361	Indust. Microbiology	7·302	4	1	VII$_2$	1	4	2	Prescott
7·362	Indust. Microbiology	7·361	4(B)	2	VII$_2$	1	3	4	Proctor
7·371	Indust. Microbiology	7·362	G(A)	1	(Elective)	1	4	4	Dunn
7·372	Indust. Microbiology	7·371	G(A)	2	(Elective)	1	3	4	Dunn
7·38	Germicides & Antiseptics	7·302	G(A)	2	(Elective)	1	3	4	Dunn
7·41	Chem. Water & Sewage	5·12	3	1	VII, XI	1	3	1	Jennison

Biology and Public Health Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
7·42	Chemistry of Foods	5·12	3	2	VII_1	1	4	1	R. S. Harris
7·50	Communicable Diseases	7·301	3(B)	1	$VII_{1,3}$	3	—	3	J. W. Williams
7·52	Industrial Hygiene	7·50	4(B)	2	VII	3	2	3	Turner, Gould
7·53	Air Examination	8·04	3	1	VII_3	1	1	2	Jennison
7·531	Air Examination	8·04	G(B)	1	(Elective)	1	1	2	Jennison
7·541	Public Health Admin.	7·302	4(B)	1	$VII_{1,3}$	2	—	3	Turner
7·542	Public Health Admin.	7·302	4(B)	2	$VII_{1,3}$	2	—	3	Turner
7·55	Pub. Health Bact. Meth.	——	——.	S	(Elective)	2	4	2	J. W. Williams
7·551	Pub. Health Lab. Meth.	7·301	4(B)	1	VII_1	2	6	3	J. W. Williams
7·552	Immunological Meth.	7·301	4(B)	2	VII_1	1	5	1	J. W. Williams
7·57	Municipal Sanitation	7·301	3(B)	2	VII	4	—	3	Horwood
7·58	Vital Statistics	7·301, 7·50	4(B)	1	$VII_{1,3}$	2	—	3	Horwood
7·59	Sanitation	7·302, 7·57	4(B)	1	VII_3	2	3	3	Horwood
7·601	Health Education	7·01	G(A)	1	(Elective)	2	—	4	Turner
7·602	Health Education	7·601	G(A)	2	(Elective)	1	2	5	Turner
7·603	Public Health Education	7·541, 7·50	G(A)	2	(Elective)	2	—	4	Turner
7·604	School Health Admin.	7·601	G(A)	2	(Elective)	2	—	4	Turner
7·63	Pub. Health Field Wk.	7·542	G(A)	1	(Elective)	2	—	4	Turner
7·64	Public Health Prob.	7·542	G(A)	2	(Elective)	2	—	4	Turner
7·65	Health Hazards in Spec. Industries	7·52	G(A)	2	(Elective)	2	—	5	Horan
7·66	Epidemiology	7·302, 7·50	G(A)	1	(Elective)	2	—	6	Prescott
7·67	Functional Pathology	7·301, 7·20, 7·80	G(A)	1	(Elective)	3	—	4	J. W. Williams
7·68	Pathology	7·14, 7·552	G(A)	2	(Elective)	2	4	2	J. W. Williams
7·701	Tech. & Chem. of Food Supplies	7·301	3	1	VII_2	3	4	4	Proctor
7·702	Tech. & Chem. of Food Supplies	7·302	3	2	VII_2	2	2	4	Proctor
7·71	Food Technology	——	——.	S	(Elective)	2	4	2	Proctor
7·711	Tech. of Food Products	7·702	4(B)	1	VII_2	3	3	4	Proctor
7·712	Tech. of Food Products	7·711	4(B)	2	VII_2	2	3	4	Proctor
7·721	Adv. Food Technology	7·711	G(A)	1	(Elective)	1	3	2	Proctor
7·722	Adv. Food Technology	7·721	G(A)	2	(Elective)	1	3	2	Proctor
7·80	Biochemistry	5·41, 7·20	4(B)	1	$VII_{1,2}$, VII-A	3	5	5	Bunker
7·802	Quant. Biochemistry	5·424 or 7·80	4(B)	2	(Elective)	1	4	1	Gould
7·81	Zymology	7·80	G(A)	1	VII-A	2	4	3	Bunker, Gould
7·82	Biochemistry, Adv.	——	G(A)	2	VII-A	2	4	3	Bunker
7·831	Microbiol. Chem. Lab.	7·301, 7·36, 5·428	G(A)	1	(Elective)	0	5	1	Gould
7·832	Microbiol. Chem. Lab.	7·301, 7·36, 5·428	G(A)	2	(Elective)	0	5	1	Gould
7·84	Biophysics	6·761, 7·80, 8·09	4(B)	2	VII-A	1	5	3	Bunker
7·91	Biological Engineering I	——	G(A)	1	VII-A	6	—	3	Bunker, Horton
7·92	Biological Engineering II	——	G(A)	2	VII-A	4	—	2	Bunker, Horton
7·941	Research Problems	——	G(A)	1	(Elective)		★		Bunker
7·942	Research Problems	——	G(A)	2	(Elective)		★		Bunker

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	Rayton
8·01	Physics (Mechanics)	——	1	1	All Courses except IV, IV-B, and IV-C	4	2	5	Boyce
8·012	Physics (College Transfer)	——	1	1	——	5	—	6	Sears
8·02	Physics (Mech. and Heat)	8·01	1	2	All Courses except IV, IV-B, and IV-C	4	2	5	Boyce
8·03	Physics (Electricity)	8·01, M12	2	1	All Courses except IV, IV-B, and IV-C	4	1	5	Page, Frank
8·034	Physics (College Transfer)	——	2	2	——	5	—	6	Sears

★ Time specially arranged.


MCMXVI
MASSACHVSETTS INSTITVTE OF TECHNOLOGY

GRADUATION EXERCISES

. . . in Symphony Hall, Boston. In June, 1937, 534 degrees were awarded to 342 bachelors, 151 masters, 23 doctors of philosophy, and 18 doctors of science

Physics Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec.	Lab. Draw.	Prep.	Instructor in Charge
8·04	Physics (Elec. Optics & Modern Phys.)	8·03	2	2	All Courses except IV, IV-B, IV-C and VI-A(B)$_1$	4	2	4	Page, Frank
			3	S	VI-A(B)$_1$				
8·05	Vibrations and Sound	8·04, M22	4(B)	1	VI-C, VI-A$_3$	3	—	6	Morse
8·051	Sp. Problems in Acoustics	8·05	G(A)	1 or 2	(Elective)		★		Morse
8·07	Precision of Measure	M22	4	1	XIV	1	—	1	Goodwin
			3	1	XIII-A				
8·09	Physical Measurements	——	3	1	VIII	0	3	2	Stockbarger
			4	1	VII-A				
8·11	Experimental Physics	8·202, 8·312	4(B)	1	VIII	2	6	4	Harrison
8·12	Experimental Physics	8·11	4(B)	2	VIII	2	—	4	Harrison
8·13	Undergrad. Colloquium	——	4(B)	2	VIII	2	—	2	Mueller
8·15	Photography	8·04	3	2	VI-B(a)	2	—	1	Hardy
8·152	Adv. Photography	*8·15*	–	2	(Elective)	0	3	2	Hardy
8·161	Optics	8·04	3	1	VI-B, VIII	3	—	6	Hardy
			4	1	VII-A				
8·162	Optical Measurements	*8·161*	3	1	VI-B, VIII	0	3	2	Hardy
			4	1	VII-A				
8·171	Advanced Optics	8·161	4(B)	1	(Elective)	2	—	3	Hardy
8·173	Color Measurements	8·04	4(B)	2	II$_5$	0	3	2	Hardy
8·174	Motion Picture Photography	8·161	4(B)	1	(Elective)	1	—	3	Hardy
8·181	Optics, Seminar	8·161	G(A)	2	(Elective)	2	—	2	Hardy
8·191	Microscopy and Photomicrography	——	4	2	(Elective)	2	—	0	Hardy
8·194	Adv. Physical Optics	8·161	G(A)	2	(Elective)	1	2	2	A. F. Turner
8·201	Electronics	8·04, M22	3	2	VI-C, VI-A(A)$_3$, VIII	3	—	5	Nottingham
			4	2	VI-A(B)$_3$				
8·202	Electronic Lab.	*8·201*	3	2	VIII	0	3	2	Nottingham
8·21	Electronic Phen.	8·201, *8·212*, *8·50*	G(A)	1	(Elective)	2	—	4	Nottingham
8·212	Experimental Electronics	8·201, *8·21*, or *8·213*	G(A)	1	(Elective)	1	3	3	Nottingham
‡8·213	Advanced Electronics	M22, 8·201, 8·512 or 8·21	G(A)	1	(Elective)	3	—	9	Nottingham
‡8·214	Advanced Electronics	8·213	G(A)	2	(Elective)	3	—	9	Lamar
8·215	Sp. Prob. in Electronics	8·201	G(A)	1 or 2	(Elective)		★		Nottingham
8·26	Molecular Structure	8·311	G(A)	1	(Elective)	3	—	6	Mueller
8·27	X-Rays & Crys. Phys.	8·04, M22	4(B)	1	(Elective)	3	1	5	Warren
‡8·28	X-Ray Diffraction	8·27	G(A)	2	(Elective)	2	—	4	Warren
8·281	Crystal Chemistry	5·62 or 8·311	G(A)	2	(Elective)	2	—	4	Warren
‡8·29	Quantum Th. of the Solid State	8·11, 8·463	G(A)	2	(Elective)	3	—	6	Slater
8·30	Sp. Prob. in Crys. Phys.	8·27	G(A)	2	(Elective)		★		Warren
8·311	Atomic Structure	8·04	3	2	VIII	3	—	5	Slater
			4	2	VII-A				
8·312	Atomic Struct. Lab.	8·04, *8·311*	3	2	VIII	0	3	2	Stockbarger
			4	2	VII-A				
8·32	Line Spectra	8·311	G(A)	2	(Elective)	3	—	6	Albertson
8·341	Spectroscopy Sem.	8·32	G(A)	1	(Elective)	1	—	1	Harrison
8·342	Spectroscopy Sem.	8·32	G(A)	2	(Elective)	1	—	1	Harrison
8·343	Sp. Prob. in Spectros.	8·32	G(A)	1 or 2	(Elective)		★		Harrison
8·344	Prac. Spectroscopy	8·04	(B)	S	(Elective)	3	—	3	Harrison
8·345	Applied Spectroscopy	8·04	(B)	S	(Elective)		★		Harrison
8·346	Quant. Spectros. Anal.	8·04	(B)	S	(Elective)	1	—	1	Harrison
8·35	Excitation of Spectra	8·32	G(A)	2	(Elective)	2	3	4	Stockbarger
8·36a	Radiation Meas.	——	–	S	(Elective)	2	—	2	Stockbarger
8·36b	Radiation Meas. Lab.	——	–	S	(Elective)	0	3	2	Stockbarger
8·411	Nuclear Physics	8·311	4(B)	1	(Elective)	2	3	4	Evans

‡ Not offered in 1938–39. ★ Time specially arranged.

Physics Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
8·412	Nuclear Physics	8·411	4(B).	2	(Elective)	2	3	4	Evans
8·42	Sem. in Nuclear Phys.	8·411	G(A)	2	(Elective)	1	—	2	Van de Graaff
‡8·43	Th. of Nuclear Struct.	8·411, *8·521*	G(A)	2	(Elective)	2	—	6	Frank
8·441	Sp. Prob. in Nuclear Res.	8·311, 8·411	G(A)	1	(Elective)		★		Evans
8·442	Sp. Prob. in Nuclear Res.	8·441, 8·412	G(A)	2	(Elective)		★		Evans
8·461	Int. to Th. Physics I	8·04, M22	4(B).	1	VI-B(a), VIII	4	—	8	Vallarta
8·462	Int. to Th. Physics II	8·461	4(B).	2	VI-B(a), VIII	4	—	8	Frank
8·463	Int. to Th. Physics III	8·32, 8·461	G(A)	1	(Elective)	4	—	8	Slater
8·471	Hist. Dev. of Phys.	*8·461*	4(B).	1	$VIII_1$	3	—	6	Allis
‡8·481	Adv. Mechanics I	8·462 or 8·471	G(A)	1	(Elective)	3	—	9	Stratton
‡8·482	Adv. Mechanics II	8·481	G(A)	2	(Elective)	3	—	9	Stratton
8·491	Meth. of Theoret. Phys.	8·461, 8·462	G(A)	1	(Elective)	3	—	9	Morse
8·50	Heat & Thermodynamics	8·02, M22	3	1	VI-B(a), VI-C, $VIII_1$, VI-A$(B)_3$	3	—	4	Slater
			4	1	VI-B(b), VI-A$(A)_3$, XVIII				
8·512	Statistical Mechanics	8·50	G(A)	2	(Elective)	3	—	9	Allis
8·521	Quantum Mechanics	8·463	G(A)	2	(Elective)	3	—	9	Morse
8·54	Electromag. Theory	M77	4(B).	2	XVIII	3	—	6	Stratton
8·56	Electromag. Wave Theory	8·491	G(A)	1	(Elective)	3	—	9	Stratton
‡8·57	Cosmic Rays High Energy Phenomena	8·463	G(A)	1	(Elective)	2	—	6	Vallarta
8·58	Th. of Relativity	8·462	G(A)	2	(Elective)	3	—	9	Vallarta
8·591	Theoret. Seminar	——	G(A)	1	(Elective)	1	—	1	Morse
8·592	Theoret. Seminar	——	G(A)	2	(Elective)	1	—	1	Morse
8·60	Sp. Prob. Theoret. Phys.	——	G(A)	1 or 2	(Elective)		★		Slater
8·82	Electrochemistry	5·62, 5·621	4(B).	1	XIV	3	—	6	Goodwin

CHEMICAL ENGINEERING—10·00–10·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
10·11	Prob. of Chem. Eng.	5·02	2	1	X	1	—	0	Whitman
10·15	Thesis Reports	10·26	4	2	X	2	—	2	C. S. Robinson
10·16	Applied Chemistry	5·683	2	2	II, II-A, XVI	2	—	2	Lewis
10·17	Indust. Chemistry	5·41, 5·61	3	2	X	3	—	2	Lewis
10·18	Indust. Chemistry	10·17, 5·62	4	1	X	4	—	6	Weber
10·201	Industrial Chemistry	5·41, 5·611	4	1	XV_2	4	—	4	Weber
10·203	Industrial Chemistry	*5·42, 5·62*	4	1	V	3	—	4	Weber
10·21	Industrial Chemistry	10·201, or 10·203, or 10·18	4(B).	2	V, X, XV_2	2	—	2	Lewis
10·25	Indust. Chemistry	5·42, 5·62	G(A)	1	(Elective)	5	—	7	Lewis
10·26	Industrial Chem. Lab.	10·18	4(B).	1	X, XV_2	2	3	1	Weber
10·28	Chemical Eng.	*5·61*	3	1	X, XV_2 XIX	4	—	6	C. S. Robinson
10·29	Chemical Eng.	10·28	3(B).	2	X, XV_2	3	—	6	C. S. Robinson
10·30	Eng. Equipment	*10·32*	4	2	X-B	4	—	1	Whitman
10·31	Chemical Eng.	10·17, *10·29*	4(B).	1	X	4	—	5	McAdams
10·32	Chemical Eng.	10·31	4(B).	2	X, X-B	4	—	5	McAdams
10·33	Anal. Treat. of Chem. Eng. Processes	M22, or M41, 5·62	G(A)	1	(Elective)	3	—	6	Sherwood
10·35	Ind. Chemical Eng.	5·61, 10·28	4	1	XV_2	3	—	6	McAdams
10·36	Ind. Chemical Eng.	10·35	4	2	XV_2	3	—	6	McAdams
10·38	Explosives Plant Eng.	5·412	G	1	II (A.O.)	5	—	3	C. S. Robinson
10·39	Th. Int. Ballistics	10·38	G	2	II (A.O.)	4	—	6	C. S. Robinson
10·40	Chem. Eng. Thermodyn.	5·62, 10·29	G(A)	2	(Elective)	3	—	6	Weber
10·41	Distillation	10·32	G(A)	2	(Elective)	3	—	5	McAdams
10·45	Distil. & Absorption	10·32	G(A)	1	(Elective)	4	—	8	Gilliland
10·46	Absorption & Extraction	10·32	G(A)	2	(Elective)	3	—	6	Sherwood

‡ Not offered in 1938–39.

★ Time specially arranged.

Chemical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Lab. Prep.	Instructor in Charge
10·50	Heat Transmission	10·31	G(A)	2	(Elective)	2	—	4	McAdams
			G.	2	II (T.E.)				
10·52	Chemical Eng. II	10·32	G(A)	1	(Elective)	3	—	6	McAdams
10·53	Chem. Eng. Design	10·81, 10·82, 10·83	G(A)	1	X-A	3	—	9	Whitman
10·54	Economic Balance	*10·32*	G(A)	1	(Elective)	5	—	7	Gilliland
10·55	Economic Balance	10·32	G(A)	2	(Elective)	3	—	6	Sherwood
10·62	App. Chem. Therm.	5·62, 10·29	G(A)	2	(Elective)	3	—	6	Weber
10·63T	Industrial Chemistry II	5·62	G(A)	2	(Elective)	3	—	6	Lewis
10·65	Catal. & High Pres. Proc.	5·62, 10·29	G(A)	2	(Elective)	3	—	6	Gilliland
10·661	Int. to Colloid Chem.	5·42, 5·62	G(A)	1	VII-A	2	—	4	Hauser
10·662	Colloid Chemistry	10·661	G(A)	2	VII-A	2	—	4	Hauser
10·671	Colloid Seminar	5·62, 10·63, or *10·661*	G(A)	1	(Elective)	2	—	4	Hauser
10·672	Colloid Seminar	10·671	G(A)	2	(Elective)	2	—	4	Hauser
10·673	Colloid Chem. Lab.	*10·63 or 10·661*	G(A)	1, 2	(Elective)	0	3	0	Hauser
10·674	Colloid Chem. Lab.	10·673	G(A)	1, 2	(Elective)	0	3	0	Hauser
10·68	Corrosion	5·62	G(A)	1	(Elective)	2	—	4	Whitman
10·70	Prin. of Combust.	Gen. Inorg. Chem.	G(A)	1	(Elective)	4	—	6	Hotte
10·71	Fuel Engineering	10·70	G(A)	2	(Elective)	3	—	6	Hottel
10·74	Furnace Design	10·31	G(A)	1, 2	(Elective)	3	—	6	Hottel
10·76	Sem. Rad. Heat Trans.	10·31	G(A)	2	(Elective)	2	—	4	Hottel
10·79	Automotive Fuels	5·42, 5·62, 2·42 or 10·29	G(A)	1	(Elective)	2	—	4	Hottel
10·81	Sch. Chem. Eng. Practice (Bangor Station)	10·32	G(A)	1, 2	X-A	0	12	0	Whitman
10·82	Sch. Chem. Eng. Practice (Parlin Station)	10·32	G(A)	1, 2	X-A	0	12	0	Whitman
10·83	Sch. Chem. Eng. Practice (Buffalo Station)	10·32	G(A)	1, 2	X-A	0	12	0	Whitman
10·84	Sch. Chem. Eng. Practice (Bangor Station)	10·31	4	2	X-B	0	12	0	Whitman
10·85	Sch. Chem. Eng. Practice (Parlin Station)	10·31	4	2	X-B	0	12	0	Whitman
10·86	Sch. Chem. Eng. Practice (Buffalo Station)	10·31	4	2	X-B	0	12	0	Whitman
10·90	Exp. Research Problem	5·42, 5·62	G(A)	1, 2	(Elective)		★		Gilliland
10·911	Research Conf.	5·42, 5·62	G(A)	1	(Elective)	1	—	2	McAdams
10·912	Research Conf.	10·911	G(A)	2	(Elective)	1	—	2	McAdams
10·991	Seminar Chem. Eng.	10·32	G(A)	1	(Elective)	2	—	4	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.	Lab. Prep.	Instructor in Charge
12·01	Mineralogy	5·02	3	1	IX-A, XII	2	6	2	Buerger
12·03	Theoretical Mineralogy	12·01	4(B)	2	(Elective)	2	3	1	Buerger
12·05	Mineral. Seminar	12·03, 12·15	G(A)	1	(Elective)	2	—	4	Buerger
12·06	Mineral. Research	——	G(A)	1	(Elective)		★		Buerger
12·15	Petrography	12·211	3	2	XII	2	6	2	Fairbairn
12·16	Chem. Petrology Seminar	——	G(A)	1	(Elective)	2	—	4	Fairbairn
12·17	Petrological Research	12·15	G(A)	1 or 2	(Elective)		★		Fairbairn
12·18	Struct. Petrol. Seminar	——	G(A)	2	(Elective)	2	—	4	Fairbairn
12·211	Optical Crystallog.	8·02	3	1	XII_1	2	3	2	Buerger
12·26	Struct. Crystallog.	——	G(A)	2	(Elective)		★		Buerger
12·301T	General Geology	——	2	1	XII	3	4	2	Shrock
12·302	General Geology	12·301T	2	2	XII	3	4	2	Shrock, Shimer

★ Time specially arranged.

Geology Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
12·31	General Geology	12·30	3	1	III	3	2	3	Shimer, Shrock
12·321	App. Eng. Geology	—	3	1	I, IX-A	3	2	2	Mead
12·322	App. Eng. Geology	12·321	3	2	(Elective)	3	—	3	Mead
12·33	Field Geology	12·302 or 12·31	4(B)	1	III	0	3	2	Shrock
12·38	Geomorphology	12·31	4(B)	1	XII_1	3	—	6	Morris
12·40	Geology, Economic	12·01, 12·31	3	2	III, XII	3	—	6	Newhouse
12·41	Econ. Geology Lab.	12·40	4(B)	1	(Elective)	0	8	0	Newhouse
‡12·42	App. Econ. Geology	12·40	4(B)	2	(Elective)	3	—	6	Newhouse, Mead
12·431	Econ. Geol. Lab., Adv.	12·41	G(A)	1	(Elective)	0	4	1	Newhouse
12·432	Econ. Geol. Lab., Adv.	12·41	G(A)	2	(Elective)	0	4	1	Newhouse
12·433	Econ. Geol. Sem., Adv.	12·40	G(A)	1	(Elective)	2	—	6	Newhouse
12·434	Econ. Geol. Sem., Adv.	12·40	G(A)	2	(Elective)	2	—	6	Newhouse
12·44	Econ. Geol. of Fuels	G9	4(B)	2	(Elective)	1	—	1	Whitehead
12·511	Paleontology	12·31 or G9	3	1	(Elective)	1	2	4	Shimer
12·512	Paleontology	12·511	3	2	(Elective)	1	3	5	Shimer
12·52	Paleontology, Adv.	12·512	G(A)	1 or 2	(Elective)	1	3	3	Shimer
12·53	Index Fossils	12·511	G(A)	2	(Elective)	2	4	2	Shimer
12·54	Micropaleontology	12·512	G(A)	1	(Elective)	1	3	2	Shimer
12·55	Org. Evolution, Adv.	G10	G(A)	1 or 2	(Elective)	2	1	3	Shimer
12·581	Sedimentation	12·301	4(B)	1	XII_1	2	3	2	Shrock
12·582	Sedimentation	12·581	G(A)	2	(Elective)	2	3	2	Shrock
12·60	Glacial Geology	12·302	4(B)	2	(Elective)	2	3	6	Morris
‡12·62	Geology Climates Sem.	12·302	G(A)	2	(Elective)	2	—	5	Shimer
12·63	Physical Geol. Sem.	—	G(A)	1	(Elective)	2	—	5	Mead
12·64	Geology of N. America	12·302	G(A)	1	(Elective)	2	—	5	Shimer
12·66	Research	—	4(B)	1 or 2	(Elective)		★		Shimer
12·70	Structural Geology	12·301 or 12·321	3	1	XII	3	—	6	Mead
12·71	Structural Geology, Adv.	12·70	G(A)	2	(Elective)	3	—	6	Mead
‡12·75	Metamorphic Geology	12·302	G(A)	2	(Elective)	3	—	6	Mead, Fairbairn
12·79	Applied Eng. Geol.	12·321	G	2	I (A.E.)	3	—	3	Mead
12·80	Geology Coal & Petrol.	12·302 or G9	3(B)	2	III_2	4	—	3	Whitehead
12·81	Geology of Petrol., Adv.	12·80	G(A)	2	(Elective)	3	—	6	Whitehead
12·851	Th. Geophysics, Adv.	8·461	G(A)	1	(Elective)	3	—	6	Slichter
12·852	Th. Geophysics, Adv.	8·461	G(A)	2	(Elective)	3	—	6	Slichter
12·86	Seismology, Elem.	—	4(B)	1	(Elective)	2	—	2	Slichter
12·87	Intro. Geophysical Prospecting	—	4(B)	2	(Elective)	2	—	2	Slichter

NAVAL ARCHITECTURE AND MARINE ENGINEERING—13·00–13·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
13·01	Naval Architecture	M12, 8·01	3(B)	1	XIII, XIII-A, XIII-C	3	—	5	Keith
13·02	Naval Architecture	13·01	3(B)	2	XIII, XIII-A	3	—	5	Keith
13·021	Naval Architecture	13·01	3	2	XIII-C	2	—	3	Chapman
13·11	Th. of Warship Des.	—	3	1	XIII-A	4	—	10	Rossell, Keith
13·12	Th. of Warship Des.	—	3	2	XIII-A	4	—	10	Rossell
13·13	Th. of Warship Des.	—	4	1	XIII-A	3	—	6	Keith
13·14	Th. of Warship Des.	—	4	2	XIII-A	3	—	8	Keith
13·15	Th. of Warship Des.	—	G	1	XIII-A	3	—	6	Rossell
13·16	Th. of Warship Des.	—	G	2	XIII-A	3	—	6	Rossell, Keith
13·21	Warship Design	—	3	1	XIII-A	0	5	0	Keith
13·22	Warship Design	—	3	2	XIII-A	0	5	0	Rossell
13·23	Warship Design	—	4	1	XIII-A	0	5	0	Rossell
13·24	Warship Design	—	4	2	XIII-A	0	5	0	Rossell
13·25	Warship Design	—	G	1	XIII-A	0	6	0	Rossell
13·26	Warship Design	—	G	2	XIII-A	0	6	0	Rossell
13·27	Warship Design	—	4	1	(Elective)	0	8	0	Rossell

‡ Not offered 1938–39. ★ Time specially arranged.

Naval Architecture and Marine Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
13·28	Warship Design	—	4	2	(Elective)	0	8	0	Rossell
13·34	Ship Construction	—	3	1	XIII	4	—	4	Owen, Burtner
			5	1	XIII-C				
13·37	Merchant Shipbuilding	—	4	2	XIII-A	2	—	2	Keith
13·40	Yacht Architecture	—	2	2	XIII	2	4	1	Owen
13·41	Ship Drawing	—	3	1	XIII	0	3	0	Owen
13·43	Ship Design	—	3	2	XIII	0	6	0	Owen
13·45	Ship Design	13·43	4(B)	1	XIII	0	8	0	Owen
†13·47	Ship Design	13·021, 13·52	5	2	XIII-C	0	6	0	Owen
13·48	Model Making	—	4	2	XIII-A	0	2	0	Owen
13·52	Marine Engineering	2·40	3	2	XIII, XIII-C	4	—	4	Burtner, Chapman
13·54	Marine Engineering	2·06, 13·52	4(B)	1	XIII	2	—	3	F. M. Lewis
13·55	Marine Engineering	2·42, 13·52	4	2	XIII	2	—	3	Burtner
†13·56	Marine Engineering	13·52	5	1	XIII-C	3	—	3	Chapman
13·58	Marine Engineering	—	4	1	XIII-A	3	—	4	Chapman
13·61	Marine Eng. Design	2·04, 2·40, 13·52	4(B)	1	XIII	0	4	1	Burtner, F. M Lewis
13·62	Marine Eng. Design	13·61	4(B)	2	XIII	1	5	0	Burtner
13·64	Marine Eng. Design	13·58	4	2	XIII-A	0	3	0	Chapman
13·73	Mechanical Vibration	2·06	G(A)	1	(Elective)	3	—	6	F. M. Lewis
			G	1	II (T.E.)				
13·74	Mechanical Vibration	13·73	G(A)	2	(Elective)	3	—	6	F. M. Lewis
			G	2	II (T.E.)				
13·75	Adv. Marine Eng.	—	G(A)	1	(Elective)	3	—	9	Burtner
13·76	Adv. Marine Eng.	—	G(A)	2	(Elective)	3	—	9	Burtner
‡13·78	Propeller Th. & Exp. Research	—	G(A)	1	(Elective)		★		
†13·81	Ship Operation	13·021, 13·52, 13·83	5(B)	1	XIII-C	3	—	5	Chapman
†13·82	Ship Operation	13·56, 13·81	5(B)	2	XIII-C	3	—	5	Chapman
13·83	Port Facilities	—	3	1	XIII-C	3	—	4	Chapman
13·90	Experimental Research	—	G(A)	1 or 2	(Elective)		★		F. M. Lewis

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	Int. to Bus. Manage.	Ec12	4(B)	1	XII_2, XIII	3	—	3	Fernstrom
15·12	Int. to Bus. Manage.	15·11	4(B)	2	XII_2	3	—	3	Fernstrom
15·20	Ocean Ship. Admin.	—	5	2	XIII-C	2	—	4	Fernstrom
15·25	Indust. Traf. Manage.	15·70	G(A)	1	(Elective)	3	—	6	Fernstrom
15·41	Finance	Ec12, 15·50	4	1	XV	3	—	6	Armstrong
15·42	Financial Problems	15·41	4(B)	2	(Elective)	3	—	6	Armstrong
15·46	Fin. Adm. of Industry	15·41 or Ec47	G(A)	2	(Elective)	3	—	6	D. S. Tucker
15·50	Accounting	Ec11	3	1	XV_2	5	—	4	Porter, Fiske
			3	2	XV_1				
15·51	Indust. Accounting	15·50	4(B)	1, 2	(Elective)	5	—	4	Porter, Fiske
15·52	Accounting	—	2	2	XIII-C	4	—	2	Porter, Fiske
			3	1	(Elective)				
			3	2	I				
			4	2	XVII				
15·55	Prob. in Account. Policy	15·50	G(A)	1	(Elective)	3	—	6	Fiske
15·56	Anal. of Business State	15·55, 15·41 or Ec47	G(A)	2	(Elective)	3	—	6	Fiske
15·58	Problems in Accounting Control	15·51, 15·71, 15·81	G(A)	2	(Elective)	3	—	6	Robnett

† 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.
‡ Not offered 1938–39.
★ Time specially arranged.

Business and Engineering Administration Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
15·61	Law of Contracts	*Ec12*	G	1	XIII-A	3	—	6	Schaefer
			3(B).	1	XIII-C, XV				
15·62	Law of the Market	15·61	4(B).	2	(Elective)	3	—	6	Schaefer
15·64	Law of Business Org.	15·61	4(B).	2	VI-A(B)	3	—	6	Schaefer
			G	2	VI-A(A)				
15·70	Production	—	2	1	XV	3	—	6	Fernstrom
15·71	Production	15·70	4(B).	1	(Elective)	3	—	6	Schell
15·72	Technique of Executive Control	15·70	4(B).	2	(Elective)	3	—	6	A. Williams
15·73	Management Lab.	15·11 or 15·70 or 2·731	4	1, 2	(Elective)	4	—	2	A. Williams
15·75	Manufact. Analysis	15·70	G(A)	1	(Elective)	3	—	6	Schell
15·81	Marketing	*Ec12*, Ec32	3	1	XV_1	3	—	6	Tallman
			3	2	XV_2				
15·82	Sales Management	15·81	4(B).	2	(Elective)	3	—	6	Cunningham
15·83	Marketing Research	15·81	4(B).	1	(Elective)	3	—	6	Cunningham
15·85	Indust. Marketing	15·81	G(A)	1	(Elective)	3	—	6	Cunningham
15·86	Marketing of Consumer Goods	15·81	G(A)	2	(Elective)	3	—	6	Cunningham
15·88	Advertising	15·81	G(A)	2	(Elective)	2	—	6	H. Bugbee
15·92	Industrial Problems	15·41, 15·61, 15·70, 15·81	4(B).	2	XV	2	—	6	Schell
15·94	Contemp. Prob. Seminar	15·41, 15·61, 15·70, 15·81	G(A)	2	(Elective)	3	—	6	Schell
15·95	Sp. Prob. in Management	—	G(A)	1 or 2	(Elective)		★		Schell
15·96	Adm. Theory and Practice	15·41, 15·61, 15·70, 15·81	G(A)	2	(Elective)	3	—	6	Schell
	Thesis	—	4	2	XV	0	10	0	Robnett
	Graduate Thesis	—	G(A)	–	XV	—	—	—	Robnett

AERONAUTICAL ENGINEERING—16·00–16·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
16·01	Intro. to Aero. Mech.	M22	3	1	XVI	4	2	6	Rauscher
			4(B).	1	(Elective)				
16·02	Intro. to Aero. Mech.	16·01	3	2	XVI	4	2	4	Rauscher
			4(B).	2	(Elective)				
16·03	Hydrodyn. and its Appl. to Aero.	16·02	G(A)	1	(Elective)	3	—	6	R. H. Smith
16·04	Hydrodyn. and its Appl. to Aero.	16·03	G(A)	2	(Elective)	3	—	6	R. H. Smith
16·07	Adv. Topics in Aeromechanics	16·02	G(A)	1	(Elective)	3	—	6	R. H. Smith
16·08	Adv. Topics in Aeromechanics	16·02	G(A)	2	(Elective)	3	—	6	R. H. Smith
16·10	Aerodyn. of Airpl. Des.	2·04, 8·04, 16·01, 16·71	3	2	XVI	3	—	3	Ober
16·11	Aerodyn. of Airpl. Des.	16·02, 16·10	4(B).	1	XVI	4	2	4	Koppen
16·14	Airpl. Design Prob.	16·11, 16·17	4(B).	2	(Elective)	2	4	6	Koppen
16·17	Airpl. Des. Practice	16·10, *16·11*	4(B).	1	XVI	0	8	0	Koppen
16·18	Adv. Airpl. Des. Prac.	16·14	G(A)	2	(Elective)	0	6	3	Koppen
16·20	Structures	2·04	3	2	XVI	3	—	5	Newell
16·21	Structures	16·20	4(B).	1	XVI	3	—	5	Newell
16·22	Aircraft Structures	16·21	4(B).	2	XVI	3	—	5	Newell
16·25	Adv. Aircraft Struct.	16·17, 16·21	G(A)	2	(Elective)	3	—	6	Newell
16·31	Airship Theory	16·02, 16·10	G(A)	1	(Elective	2	—	3	R. H. Smith
16·36	Airship Structures	M22, 16·31	G(A)	2	(Elective)	2	—	4	R. H. Smith
16·41	Instrumentation	16·02 or 2·081	G(A)	1	(Elective)	3	—	9	Draper

★ Time specially arranged.

Aeronautical Engineering Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec.	Lab. Draw.	Prep.	Instructor in Charge
16·42	Aeronautical Inst.	16·41	G(A)	2	(Elective)	3	—	9	Draper
16·43	Instrumentation Lab.	*16·41*	G(A)	1	(Elective)	0	3	6	Draper
16·44	Meteorological Inst.	16·901	G(B)	2	(Elective)	2	3	5	Draper
16·45	Sp. Prob. in Aero. & Met. Inst.	16·44 or 16·42	G(A)	1	(Elective)		★		Draper
16·46	Vibration Measure	16·41, 13·73 or 6·671 or 8·05	G(A)	2	(Elective)	2	3	6	Draper
16·52	Aircraft Prop. Design	16·11	G(A)	2	(Elective)	2	2	4	Ober
16·53	Adv. Airplane Eng. Des.	2·792	G(A)	1	(Elective)	1	4	3	C. F. Taylor
16·54	Adv. Airplane Eng. Des.	16·53	G(A)	2	(Elective)	1	4	3	C. F. Taylor
16·60	Adv. Aeron. Prob.	16·11 or 16·25 or 16·31 or 16·63	G(A)	1 or 2	(Elective)		★		R. H. Smith
16·62	Aeronautical Lab.	*16·11*	4(B).	1	XVI	2	2	3	Ober
16·63	Aero. Lab. & Res. Meth.	16·62	4(B).	2	(Elective)	2	2	2	Ober
16·68	Aeronautical Seminar	16·11	G(A)	2	(Elective)	2	—	2	Staff
16·71	Airplane Shopwork	——	3	S	XVI	0	8	2	Markham
16·72	Aircraft Product. Meth.	——	3	S	XVI	0	8	2	Markham
16·75	Constr. Details of Aircraft	16·11	4(B).	2	XVI	3	4	2	Koppen
16·81	Aeronautics	M21, 2·04	4(B).	1 or 2	(Elective)	3	—	1	Markham
16·811	Aeronautics	——	G(B)	1	XIII-A	3	—	1	Ober
16·901	Int. Meteorology	M22	4(B).	1	(Elective)	2	—	2	Willett
16·911	Synoptic Meteorology	8·04, L12, *16·901*, *16·921*	G(A)	1	(Elective)	3	—	6	Willett
16·912	Synoptic Meteorology	16·911, *16·922*	G(A)	2	(Elective)	3	—	6	Willett
16·921	Meteorological Lab.	16·901, *16·911*	G(A)	1	(Elective)	0	15	0	Willett
16·922	Meteorological Lab.	16·921, *16·912*	G(A)	2	(Elective)	0	12	0	Willett
16·931	Dyn. Meteorology	16·912, 16·922, 8·462, 8·50, *M36*	G(A)	1	(Elective)	5	—	10	Rossby
16·932	Dyn. Meteorology	16·931	G(A)	2	(Elective)	5	—	10	Rossby
16·941	Meteorol. Seminar	*16·931*	G(A)	1	(Elective)	2	—	2	Rossby
16·942	Meteorol. Seminar	16·941, *16·932*	G(A)	2	(Elective)	2	—	2	Rossby
16·961	Phys. Oceanography	8·04	G(A)	1	(Elective)	2	—	4	Rossby
16·962	Phys. Oceanography	16·961	G(A)	2	(Elective)	2	—	4	Rossby

BUILDING ENGINEERING AND CONSTRUCTION—17·00–17·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec.	Lab. Draw.	Prep.	Instructor in Charge
17·22T	Building Construction	D12	2	2	XVII	3	3	2	Dietz
17·31	Building Construction	17·22T	3	1	XVII	3	3	2	Staley
17·32	Building Construction	17·31	3	2	XVII	3	3	2	Voss
‡17·40	Estimating & Job Manage.	17·32	4	2	XVII	2	3	1	Voss
17·41	Building Construction	17·32	4	1	XVII (1938–39 only)	3	3	2	Voss
‡17·41T	Construction Problems	17·32	4	1	XVII (Elective)	0	4	0	Voss
17·42	Building Construction	17·41	4	2	XVII (1938–39 only)	3	3	2	Voss
‡17·42T	Construction Problems	17·41T	4	2	XVII (Elective)	0	4	0	Voss
17·46	Building Construction	——	4	2	III	3	—	3	Staley
17·50	Job Management	——	4	2	XVII (1938–39 only)	2	—	0	Voss
17·52T	Structural Problems	2·04	3	2	XVII	3	4	3	Peabody
17·53	Structural Analysis	17·52	4	1	XVII (1938–39 only)	2	3	1	Voss
‡17·53T	Structural Design	17·52T	4	1	XVII (Elective)	3	8	3	Peabody
‡17·531	Structural Design	17·52T	4	1	XVII	3	4	3	Peabody
17·54	Structural Analysis	17·53	4	2	XVII (1938–39 only)	2	3	1	Voss
‡17·54T	Structural Design	17·53T	4	2	XVII (Elective)	3	8	3	Peabody
‡17·541	Structural Design	17·531	4	2	XVII (Elective)	3	4	3	Peabody
17·73T	Materials	5·844	3	1	XVII	2	—	2	Voss
17·74T	Materials	17·73T	3	2	XVII	4	—	4	Dietz
17·75	Materials	4·93, 4·94	3	1	IV, IV-B, IV-C	2	2	1	Voss
17·76	Materials	17·75	3	2	IV, IV-B, IV-C	4	—	1	Dietz

★ Time specially arranged.

‡ Not offered 1938–39.

METALLURGY—19·00–19·99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
19·01	Int. to Metallurgy	——	2	1	XIX	1	—	0	R. S. Williams, Waterhouse
19·03	Fire Assaying	5·12, 12·01	3	1	III_1	1	4	1	Reed
			3	2	XIX				
19·05	Fire Assaying, Adv.	19·03	G(A)	1	(Elective)		★		Reed
19·06	Fire Assaying, Adv.	19·03	G(A)	2	(Elective)		★		Reed
19·07	Met.: Copper, Lead	5·13, 19·22	4(B)	1	XIX	5	—	4	Hayward
19·071	Met.: Copper, Lead	5·13, 19·22	4(B)	1	(Elective)	4	—	3	Hayward
19·09	Met.: Copper, Lead, Zinc	5·12	4(B)	1	III_1, XIV	4	—	4	Hayward
19·11	Met. & Electrochem. Lab.	——	4	1	III_1, XIV, XIX	0	4	0	Hayward
19·12T	Met.: Gen. Zinc & Min. Met.	19·071, 19·19	4(B)	2	XIX	4	—	4	Hayward
19·13	Non-Fer. Metal., Adv.	19·07, 19·12T	G(A)	1	(Elective)		★		Hayward
19·14	Metal. Com. Metals	5·02	4	2	(Elective)	3	—	3	Hayward
19·15	Production Metal.	——	G	1	II(A.O.)	3	—	5	Waterhouse
19·16	Gen. Metal., Adv.	19·12T	G(A)	2	(Elective)		★		Hayward
19·18	Metal. Calc., Adv.	19·12T	G(A)	2	(Elective)	2	—	6	Hayward
19·19	Met.: Iron & Steel	5·02, 19·22	4(B)	1	XIX	4	—	3	Waterhouse
19·20	Met.: Iron & Steel	——	4	2	XIII-A	2	—	1	Waterhouse
19·211	Met.: Iron & Steel	5·02	4	1	III	2	—	1	Waterhouse
19·22	Metal. Plant Visits	——	4(B)	S	XIX	0	3	1	Hayward
19·23	Met.: Iron & Steel, Adv.	19·19	G(A)	1	(Elective)		★		Waterhouse
19·24	Met.: Iron & Steel, Adv.	19·19	G(A)	2	(Elective)		★		Waterhouse
19·25	Metal. Plant Design	19·07, 19·19	G(A)	1	(Elective)	0	13	0	Waterhouse
19·26	Metal. Plant Design	19·07, 19·19	G(A)	2	(Elective)	0	13	0	Waterhouse
19·27	Metallurgical Plants	19·07, 19·19	4(B)	1 or 2	(Elective)	3	—	3	Waterhouse
19·31T	Metal. Thermodyn.	5·62	4(B)	1	XIX	3	—	6	Chipman
19·32T	Prin. of Steel Mak.	19·31T	4(B)	2	XIX	2	—	4	Chipman
19·50	Metallography	8·04	3	2	$VIII_2$	2	2	1	Homerberg, Cohen
			4	1	II_4				
			G	1	XIII-A				
19·51T	Metallography I	5·12, 8·04	3	1	XIX	2	3	2	R. S. Williams, Cohen
19·52T	Metallography II	19·51T	3	2	XIX	2	3	2	Homerberg, Cohen
19·54T	App. of Metallography	19·50 or 19·52T	4(B)	1	XIX	1	2	2	Homerberg, Cohen
			4	2	II_4				
19·57	Physical Metal.	——	G	1	II (A.O.)	4	—	6	R. S. Williams
19·58	Physical Metal. Adv.	19·57	G	2	II (A.O.)	4	—	6	R. S. Williams
19·59	Physical Metal. Adv.	——	G	1	II (T.E.)	4	—	4	R. S. Williams
19·60	Physical Metal. Adv.	19·59	G	2	II (T.E.)	1	5	2	Homerberg
19·61	Physical Metal. Adv.	19·50 or 19·52T	G(A)	1	(Elective)		★		R. S. Williams
19·62	Physical Metal. Adv.	19·50 or 19·52T	G(A)	2	(Elective)		★		R. S. Williams
19·63	Cor. & Heat Res. Alloys	19·50 or 19·52T	4(B)	1	(Elective)	2	—	4	R. S. Williams
19·631	Metallog. & Corrosion	5·12, 8·04	4	1	III_2	3	2	1	R. S. Williams, Cohen
19·64	Light Alloys	19·50 or 19·52T	4(B)	2	(Elective)	2	—	4	R. S. Williams
19·66T	Heat Treatment	19·50 or 19·51T	3	2	XIX	1	2	1	Zavarine
19·67	Heat Treatment	19·50	G	1	II (T.E.)	1	2	2	Zavarine
19·69	Physics of Metals	19·50 or 19·52T M22 19·50 or 19·51T	4(B)	2	XIX	2	—	4	J. T. Norton
19·70	X-Ray Metallography	M22	4(B)	1	XIX	2	1	3	J. T. Norton
			4	2	II_4				
19·71	Physics of Metals, Adv.	19·69, 19·70	G(A)	1 or 2	(Elective)		★		J. T. Norton
19·72	Theory of Metal Hard.	19·50 or 19·52T	G(A)	2	(Elective)	2	—	4	Zavarine
‡19·73	Ferromagnetism	——	G(A)	1	(Elective)	2	—	4	Bitter

‡ Not offered 1938–39

★ Time specially arranged.

Metallurgy Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
19·75	Atomic Arrangements in Alloys	——	G(A)	1	(Elective)	2	—	4	Bitter
19·81	Electrochem., Elem.	8·04, 5·02	4	1	(Elective)	2	—	2	Thompson
19·82	Applied Electrochem.	8·82	4(B).	2	XIV	3	—	6	Thompson
19·83	Electrochem. Lab.	8·82	4(B).	1	XIV	0	9	3	Thompson
19·85	Electric Furnaces	8·04, 5·02	4(B).	1	(Elective)	1	2	2	Hayward
19·87	Electrochem., Adv.	8·82	G(A)	1	(Elective)	3	—	6	Thompson
19·901	Ceramics	5·02, 8·04	3	1	XIX	2	3	3	F. H. Norton
19·91	Optical Ceramics	8·04	4(B).	1	(Elective)	0	6	2	F. H. Norton
19·92	The Nature of Glass	——	-	S	(Elective)	1	1	0	F. H. Norton
19·93	Fund. Ceramic Process.	19·901, 5·61, 2·50	G(A)	1	(Elective)	3	4	4	F. H. Norton
19·94	Phys. Prop. Cer. Prod.	19·93	G(A)	2	(Elective)	2	3	4	F. H. Norton
19·95	Spec. Prob. Ceramics	19·901, 19·91	G(A)	1	(Elective)		★		F. H. Norton
19·96	Spec. Prob. Ceramics	19·901, 19·91	G(A)	2	(Elective)		★		F. H. Norton
19·97	React. in Cer. Materials on Heating	——	-	S	(Elective)	1	1	0	F. H. Norton

DRAWING—D1–D99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
D11	Engineering Drawing and Descriptive Geometry	M2, M3	1	1	All courses except IV, IV-B and IV-C	0	6	0	——
D12	Engineering Drawing and Descriptive Geometry	D11	1	2	All courses except IV, IV-B and IV-C	0	6	0	——
D13	Descriptive Geometry (College Transfer)		1	1	Transfer students with credit in Eng. Drawing but not in Desc. Geom.	0	6	0	——
D21	Perspective	D12	2	1	VI-B (b)	2	0	2	——

ECONOMICS AND SOCIAL SCIENCE—EC1–EC99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
Ec11	Economic Principles	E12	2	2	VI-B(b), XV	3	—	3	D. S. Tucker
			3	1	I, II, II-A, III, V, VII, VII-A, VIII, IX-A, IX-B, X, XI, XII, XIII, XIII-C, XIV, XVII, XVIII, XIX				
			3	2	VI-B(a)				
			4	1	IV, IV-B, IV-C, XVI				
Ec12	Economic Principles	Ec11	3	1	VI, VI-C, VI-A(B), XV	3	—	3	D. S. Tucker
			3	2	I, II, III, V, VII, VII-A, VIII, IX-A, IX-B, X, XI, XII, XIII, XIII-C, XIV, XVII, XVIII, XIX				
			4	1	VI-A(A)				
			4	2	IV, IV-B, IV-C, VI-B, XVI				
			4	S	II-A				
Ec14	Current Economic Problems	Ec12	4(B).	2	(Elective)	3	—	3	Ingraham
Ec15	Principles of Economics	E12	4(B).	1	XIII-A	3	—	5	Armstrong
Ec17	Economic Theory	Ec12	G(A)	1	(Elective)	3	—	6	Ingraham
Ec19	Math. Approach to Economics	Ec12, M22	G(A)	1	(Elective)	3	—	6	H. A. Freeman

Economics and Social Science Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
Ec28	Business Cycles	Ec12	G(A)	2	(Elective)	3	—	6	Ingraham
Ec32	Statistics	M12	2	2	XV	3	—	3	H. A. Freeman
			3	2	XII_2				
Ec34	Engineering and Laboratory Statistics	M22	4	2	(Elective)	3	—	6	Wadsworth H. A. Freeman
Ec37T	Statistical Methods for Quality Control	M22	G(A)	1	(Elective)	3	—	6	H. A. Freeman
Ec40	Money & Banking	Ec11	3	2	XV	3	—	3	R. E. Freeman
Ec45	Monetary & Bank. Prob.	Ec12	4(B)	1	(Elective)	2	—	4	R. E. Freeman
Ec47	Investment Finance	Ec12	G(A)	1	(Elective)	3	—	6	D. S. Tucker
Ec48	Investment Analysis	Ec47 or 15·42	G(A)	2	(Elective)	3	—	6	D. S. Tucker
Ec54	Corporations	Ec12	5(B)	2	XIII-C	3	—	3	Armstrong
Ec55	Economics of Transportation	Ec12	4(B)	1	(Elective)	2	—	4	H. A. Freeman
Ec57	Public Utilities:	Ec12	G(A)	1	(Elective)	3	—	6	Armstrong
Ec59	Internat. Economic Relations	Ec12	G(A)	1	(Elective)	3	—	6	R. E. Freeman
Ec61	Labor Relations	Ec12	4(B)	1	XV	2	—	4	Maclaurin
			5	1	XIII-C				
Ec62	Labor Problems	Ec61	4(B)	2	(Elective)	2	—	4	Maclaurin
Ec67	Labor Relations Seminar	Ec61	G(A)	1	(Elective)	3	—	6	Maclaurin
Ec68	Personnel Probs. & Labor Relations	Ec61	G(A)	2	(Elective)	3	—	6	Maclaurin
Ec72	American Government	Ec12	3	2	(Elective)	3	—	6	Schaefer
Ec78	Gov't Control of Industry	Ec12	G(A)	2	(Elective)	3	—	6	Thresher
Ec82	Prin. of Sociology	Ec12	3, 4(B)	2	(Elective)	3	—	3	Arensberg
Ec83	Urban Sociology	Ec12	5(B)	1	IV-B, IV-C	3	—	3	Palmer
Ec84	Soc. Econ. Factors in City Planning	Ec83	5(B)	2	IV-B, IV-C	3	—	4	Palmer
Ec87	Methods of Soc. Invest.	Ec12	4(B)	1	(Elective)	2	—	3	McGregor
Ec88	Psychol. in Bus. & Ind.	Ec12	4(B)	2	(Elective)	2	—	4	McGregor
Ec91	Economics Seminar	—	G(A)	1	(Elective)	3	—	6	R. E. Freeman
Ec92	Economics Seminar	—	G(A)	2	(Elective)	3	—	6	R. E. Freeman

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	Copithorne
E11	English Composition	—	1	1	All courses	3	—	5	Fassett
E12	English Composition	E11	1	2	All courses	3	—	5	Fassett
E21	Literature & History	—	2	1	All courses	3	—	5	A. T. Robinson
E22	Literature & History	—	2	2	All except $VI\text{-}A(B)_1$	3	—	5	A. T. Robinson
			3	S	$VI\text{-}A(B)_1$				
E35	Reports	E22	3	1	XV_1, XVII	2	—	4	Bartlett
			3	2	XV_2				
E42	Problem Analysis	—	3	2	IV, IV-B, IV-C	2	—	2	Urbach

GENERAL STUDIES—G1–G99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
G1	History of Science	—	–	1	—	3	—	3	Woodbury
G2	History of Science	—	–	2	—	3	—	3	Woodbury
G7	Prob. of Modern Philos.	—	–	1	—	2	—	2	A. T. Robinson
G8	History of Philosophy	—	–	2	—	2	—	2	Wiener
G9	Geology	—	–	1	—	3	—	3	Shimer
G10	Organic Evolution	—	–	2	—	3	—	3	Shimer
G12	Biography in Science	—	4	2	VI, VI-B, VI-C, VI-A(B)	3	—	3	Bartlett
			3	2	VI-A(A)				

General Studies Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
G14	Descriptive Astronomy	—	–	2	—	2	—	2	Goodwin
G21	Hist. of Engineering	—	–	1	—	2	—	2	Woodbury
G22	Dev. of Transportation	—	–	2	—	2	—	2	C. B. Breed
G23	Hist. of the Far East	—	–	1	—	3	—	3	Hexter
G24	Develop. Community Plan.	—	–	2	—	2	—	2	F. J. Adams
G25	Soc. & Ind. Hist. Mod. Europ.	—	–	1	—	3	—	3	Roberts
G26	Soc. & Ind. Hist. of U. S.	—	–	2	—	3	—	3	Bates
G27	Mil. Hist. & Policy of U. S.	—	–	1 or 2		3	—	[illegible]	Rutter
G28	Economic Geography	—	2	2	XIII-C	3	—	[illegible]	Prescott
G29	Dev. of Navig. & Cartog.	—	–	1	—	2	—	2	Woodbury
G31	Advanced Composition	E22	–	1	—	2	—	2	Fassett
G32	Advanced Composition	—	–	2	—	3	—	3	Fassett
G34	American Literature	—	–	2	—	2	—	2	Eaton
‡G35	Contemp. English Lit.	—	–	1	—	3	—	3	Rogers
G37	Contemp. European Lit.	—	–	1	—	3	—	3	Rogers
G38	Public Speaking	—	–	2	—	3	—	3	Copithorne
‡G40	The Bible as Literature	—	–	2	—	3	—	3	Rogers
G42	Shakespeare	—	–	2	—	3	—	3	Rogers
G51	French Literature	—	–	1	—	2	—	2	Langley
G52	French Literature	—	–	2	—	2	—	2	Langley
G53	French Literature	—	–	1	—	2	—	4	Langley
G54	French Literature	—	–	2	—	2	—	4	Langley
G551	German Drama	L22	–	1	—	2	—	2	Koch
G552	German Drama	L22	–	2	—	2	—	2	Koch
G561	German Fiction	L22	–	1	—	2	—	4	Currier
G562	German Fiction	L22	–	2	—	2	—	4	Currier
G57	Dante in English	—	–	1	—	2	—	2	Langley
G58	Dante in English	—	–	2	—	2	—	2	Langley
G61	Literature & Fine Arts	—	–	1	—	2	—	2	Greene
G62	History of Music	—	–	2	—	3	—	3	D. M. Fuller
G63	Introduction to Music	—	–	1	—	3	—	3	D. M. Fuller
G64	Fine Arts	—	–	2	—	2	—	2	H. L. Seaver
G65	Expressions of Graphic Art	—	–	1	—	2	—	2	Chamberlain
G67	Des. Manuf. Products	—	–	1	—	3	—	3	Müller
G68	Des. Manuf. Products	—	–	2	—	3	—	3	Müller
G71	Prin. of Psychology	—	–	1	—	2	—	2	McGregor
G72	Social Psychology	—	–	2	—	2	—	2	McGregor
G73	Psychology in Industry	—	–	S	—	2	—	2	McGregor
G75	Humanics	—	–	1	—	3	—	3	Magoun
G76	Humanics	—	–	2	—	3	—	3	Magoun
G77	Social Institutions	—	–	1	—	2	—	2	Palmer
G78	Contemp. Soc. Problems	—	–	2	—	2	—	2	Palmer
G79	Comp. Pol. Institutions	—	–	1	—	3	—	5	Schaefer
G82	Intro. Internat. Relations	—	–	2	—	3	—	3	T. Smith
G86	Prin. San. Sci. & P. H.	—	4	2	IV-B, IV-C	2	—	2	Horwood
G88	Biological Reproduction	—	–	2	—	2	—	2	Bunker

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	Currier
L12	German, Elem.	L11	–	2	(Elective)	3	—	5	Currier
L21	German, Int.	L12, or Elem. Entrance German	–	1	(Elective)	3	—	5	Kurrelmeyer

‡ Not offered 1938–39.

Modern Languages Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec.	Lab. Lec.	Draw.	Prep.	Instructor in Charge
L22	German, Int.	L21	–	2	(Elective)	3	—		5	Kurrelmeyer
L31	German, Adv.	L22, or Int. Entrance German	–	1	(Elective)	3	—		5	Kurrelmeyer
L32	German, Adv.	L31	–	2	(Elective)	3	—		5	Kurrelmeyer
L51	French, Elem.	——	–	1	(Elective)	3	—		5	Koch
L52	French, Elem.	L51	–	2	(Elective)	3	—		5	Koch
L61	French, Int.	L52 or Elem. Entrance French	–	1	(Elective)	3	—		5	Langley
L62	French, Int.	L61	–	2	(Elective)	3	—		5	Langley
L81	Spanish, Elem.	——	–	1	(Elective)	3	—		5	Koch
L82	Spanish, Elem.	L81	–	2	(Elective)	3	—		5	Koch
L91	Italian, Elem.	——	–	1	(Elective)	3	—		5	Langley
L92	Italian, Elem.	L91	–	2	(Elective)	3	—		5	Langley

MATHEMATICS—M1–M99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec.	Lab. Lec.	Draw.	Prep.	Instructor in Charge
M1	Algebra (Entrance)	——	–	S	——	2	—		5	——
M3	Solid Geom. (Entrance)	——	–	S	——	2	—		5	——
M4	Trigonometry (Entrance)	——	–	S	——	2	—		5	——
M11	Calculus	M1, M3, M4	1	1	All courses except IV, IV-B and IV-C	3	—		6	Douglass
M111	Calculus	M1, M3, M4	1	1	IV, IV-B, IV-C	3	—		6	Gelotte
M12	Calculus	M11	1	2	All courses except IV, IV-B and IV-C	3	—		6	Douglass
M21	Calculus	M12	2	1	All courses except IV, IV-B, IV-C	3	—		6	Hitchcock
M22	Diff. Equations	M21	2	2	All except IV, IV-B, IV-C, VII_1, 2, XIII-C, XV_2	3	—		6	Zeldin
M23	Algebra & Geometry	M12	2	1	VI-B(a), XVIII	3	—		6	Struik
M24	Algebra & Geometry	M23	2	2	VI-B(a), XVIII	3	—		6	Struik
M31	Diff. Equations	M22	3	1	VI, VI-C, VI-A(B)	2	—		4	Franklin
			3	S	VI-A(A)					
M331	Math. Theory of Statistics	M22	4(B).	1	(Elective)	3	—		6	Wadsworth
M332	Math. Theory of Statistics	M331	4(B).	2	(Elective)	3	—		6	Wadsworth
M341	Actuarial Mathematics	M12	4	1	(Elective)	3	—		6	Wadsworth H. A. Freeman
M342	Actuarial Mathematics	M12	4	2	(Elective)	3	—		6	Wadsworth
M36	Calculus, Adv.	M22	G(A)	1	(Elective)	3	—		6	Douglass
			3	1	XIII-A					
M37	Calculus, Adv.	M36	G(A)	2	(Elective)	3	—		6	Douglass
			3	2	XIII-A					
M381	Theory of Functions	M22	G(A)	1	(Elective)	3	—		6	Cameron
M382	Theory of Functions	M381	G(A)	2	(Elective)	3	—		6	Cameron
M441	Projective Geometry	M22	3	1	VI-B(a)	3	—		6	Struik
			4(B).	1	XVIII					
M442	Elem. Diff. Geometry	M441	4(B).	2	XVIII	3	—		6	Struik
M451	Fourier Series & Integrals	M22	G(A)	1	(Elective)	3	—		9	Wiener
M452	Fourier Series & Integrals	M451	G(A)	2	(Elective)	3	—		9	Wiener
‡M471	Sem. in Anal. Number Th.	M451, M452	G(A)	1	(Elective)	3	—		9	Wiener
‡M472	Sem. in Anal. Number Th.	M471	G(A)	2	(Elective)	3	—		9	Wiener
M54	Mathematical Lab.	M22	4(B).	2	(Elective)	3	—		6	Douglass
M551	Funct. of Real Variable.	M22	G(A)	1	(Elective)	3	—		9	Franklin
M552	Funct. of Real Variable.	M551	G(A)	2	(Elective)	3	—		9	Franklin
M563	Funct. of Comp. Variable	M22	G(A)	S	(Elective)	3	—		6	Franklin
M571	Diff. Equations	M22	G(A)	1	(Elective)	3	—		9	Martin

‡Not offered 1938–39.

Mathematics Continued

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
M572	Diff. Equations	M571	G(A)	2	(Elective)	3	—	9	Martin
M581	Continuous Groups	M22	G(A)	1	(Elective)	3	—	9	Zeldin
M582	Continuous Groups	M581	G(A)	2	(Elective)	3	—	9	Zeldin
M62	Modern Algebra	M22	3(B).	2	XVIII	3	—	6	Hitchcock
M641	Adv. Diff. Geometry	M22	G(A)	1	(Elective)	3	—	9	Struik
M642	Adv. Diff. Geometry	M641	G(A)	2	(Elective)	3	—	9	Struik
M651	Analytical Mechanics	M22	G(A)	1	(Elective)	3	—	9	Crout
M652	Analytical Mechanics	M651	G(A)	2	(Elective)	3	—	9	Crout
M661	Algebra of Quantum Th.	M62	G(A)	1	(Elective)	3	—	9	Hitchcock
M662	Algebra of Quantum Th.	M661	G(A)	2	(Elective)	3	—	9	Hitchcock
‡M671	Potential Theory	M22	G(A)	1	(Elective)	3	—	9	Phillips
‡M672	Potential Theory	M671	G(A)	2	(Elective)	3	—	9	Phillips
‡M681	Calculus of Variations	M22	G(A)	1	(Elective)	3	—	9	Martin
‡M682	Calculus of Variations	M681	G(A)	2	(Elective)	3	—	9	Martin
‡M691	Characteristic Value Prob.	M22	G(A)	1	(Elective)	3	—	9	Franklin
‡M692	Characteristic Value Prob.	M691	G(A)	2	(Elective)	3	—	9	Franklin
M73	Review of Mathematics	——	3	S	XIII-A	20	—	0	Douglass
M731	Mechanics	M22	3(B).	1	XVIII	3	—	6	Crout
			4	1	XIII-A				
M732	Mechanics	M731	3(B).	2	XVIII	3	—	6	Crout
			4	2	XIII-A				
M75	Mathematics	——	G	S	II (A.O.)	5	—	7	Wadsworth
M76	Th. of Probability	M21	G(A)	2	(Elective)	3	—	9	Struik
M77	Vector Analysis	M22	3(B).	1	XVIII	3	—	6	Hitchcock
			3	2	VI-B(a), $VIII_1$				
M791	Th. & App. Elasticity	M22	G(A)	1	(Elective)	3	—	9	Crout
M792	Th. & App. Elasticity	M791	G(A)	2	(Elective)	3	—	9	Crout
M831	Analysis	M22	3(B).	1	XVIII	3	—	6	Levinson
M832	Analysis	M831	3(B).	2	XVIII	3	—	6	Levinson
M841	Analysis	M832	4(B).	1	XVIII	3	—	6	Cameron
M842	Analysis	M841	4(B).	2	XVIII	3	—	6	Cameron
M90	Math. Reading	——	G(A)	1 & 2	(Elective)		★		Phillips

MILITARY SCIENCE—MS1–MS99

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
MS11	Military Science	——	1	1	All courses	0	3	0	Johnston
MS12	Military Science	——	1	2	All courses	0	3	0	Johnston
MS21	Military Science	——	2	1	All courses	3	—	0	Irvine
MS221	Coast Artillery	——	2	2	All courses except $VI\text{-}A\ (B)_1$	3	—	0	Jackson
			3	1	$VI\text{-}A(B)_1$				
MS222	Engineer Corps	——	2	2	I, II, VI, VI-A(A), $(B)_{2, 3}$, VII_3, IX-B, X, XI, XIII, XIII-C, XV_1, XVI, XVII, XIX	3	—	0	Wray
			3	1	$VI\text{-}A(B)_1$				
MS223	Signal Corps	——	2	2	VI, VI-A (A), $(B)_{2, 3}$, VI-B, VI-C, VIII, IX-B, XV_1, XVI	3	—	0	Lawton
			3	1	$VI\text{-}A(B)_1$				
MS224	Ordnance Dept.	——	2	2	II, V, VIII, X, XV_1, XV_2, XVI, XIX	3	—	0	Nisley
MS226	Chemical Warfare Ser.	——	2	2	V, VII, X, XV_2	3	—	0	Johnston
MS31	Military Science, Adv.	——	3	1	All courses	0	1	0	Nisley
MS311	Coast Artillery, Adv.	A basic course	3	1	All courses	2	—	1	Fisken
MS312	Engineer Corps, Adv.	A basic course	3	1	I, II, III, VI, VI-A, VII_3, IX-B, X, XI, XIII, XIII-C, XV_1, XVI, XVII, XIX	2	—	1	Wray

★ Time specially arranged. ‡ Not offered 1938–39.

Military Science and Tactics Continued

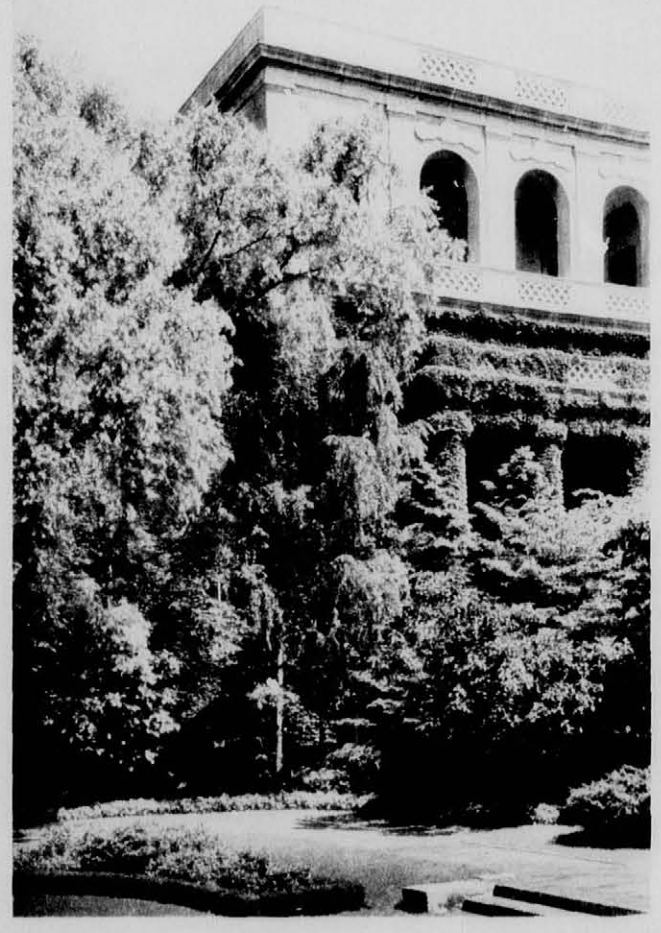
No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
MS313	Signal Corps, Adv.	A basic course	3	1	VI, VI-A, VI-B, VI-C, VIII, IX-B, XIV, XV_1, XVI	2	—	1	Lawton
MS314	Ordnance Dept., Adv.	A basic course	3	1	II, V, VIII, X, XIV, XV_1, XV_2, XVI, XIX	2	—	1	Nisley
MS316	Chemical Warfare Ser.	A basic course	3	1	V, VII, X, XIV, XV_2	2	—	1	Johnston
MS32	Military Science, Adv.	——	3	2	All courses	0	1	0	Nisley
MS321	Coast Artillery, Adv.	A basic course	3	2	All courses	2	—	1	Fisken
MS322	Engineer Corps, Adv.	A basic course	3	2	I, II, III, VI, VI-A, VII_3, IX-B, X, XI, XIII, XIII-C, XV_1, XVI, XVII, XIX	2	—	1	Irvine
MS323	Signal Corps, Adv.	——	3	2	VI, VI-A, VI-B, VI-C, VIII, IX-B, XIV, XV_1, XVI	2	—	1	Lawton
MS324	Ordnance Dept., Adv.	A basic course	3	2	II, V, VIII, X, XIV, XV_1, XV_2, XVI, XIX	2	—	1	Nisley
MS326	Chemical Warfare Ser. Adv.	A basic course	3	2	V, VII, X, XIV, XV_2	2	—	1	Johnston
MS41	Military Science, Adv.	MS31	4	1	All courses	0	1	0	Johnston
MS411A	Coast Artillery, Adv.	——	4	1	All courses	2	—	1	Fisken
MS411B	Coast Artillery	——	3, 4	1	All courses	2	—	2	Jackson
MS412	Engineer Corps, Adv.	——	4	1	I, II, III, VI, VI-A, VII_3, IX-B, X, XI, XIII, XIII-C, XV_1, XVI, XVII, XIX	1	—	1	Irvine
MS413	Signal Corps, Adv.	——	4	1	VI, VI-A, VI-B, VI-C, VIII, IX-B, XIV, XV_1, XVI	1	—	1	Lawton
MS414	Ordnance Dept., Adv.	——	4	1	II, V, VIII, X, XIV, XV_1, XV_2, XVI, XIX	1	—	1	Nisley
MS416	Chemical Warfare Ser. Adv.	——	4	1	V, VII, X, XIV, XV_2.	1	—	1	Johnston
MS42	Military Science, Adv.	MS31, MS32	4	2	All courses	0	1	0	Johnston
MS421	Coast Artillery, Adv.	——	4	2	All courses	2	—	1	Jackson
MS422	Engineer Corps, Adv.	——	4	2	I, II, III, VI, VI-A, VII_3, IX-B, XI, XIII, XIII-C, XV_1, XVI, XVII, XIX	1	—	1	Irvine
MS423	Signal Corps Adv.	——	4	2	VI, VI-A, VI-B, VI-C, VII, IX-B, XIV, XV_1, XVI	1	—	1	
MS424	Ordnance Dept., Adv.	——	4	2	II, V, VIII, X, X-B, XIV, XV_1, XV_2, XVI, XIX	1	—	1	Nisley
MS426	Chemical Warfare, Adv.	——	4	2	V, VII, X, X-B, XIV, XV_2	1	—	1	

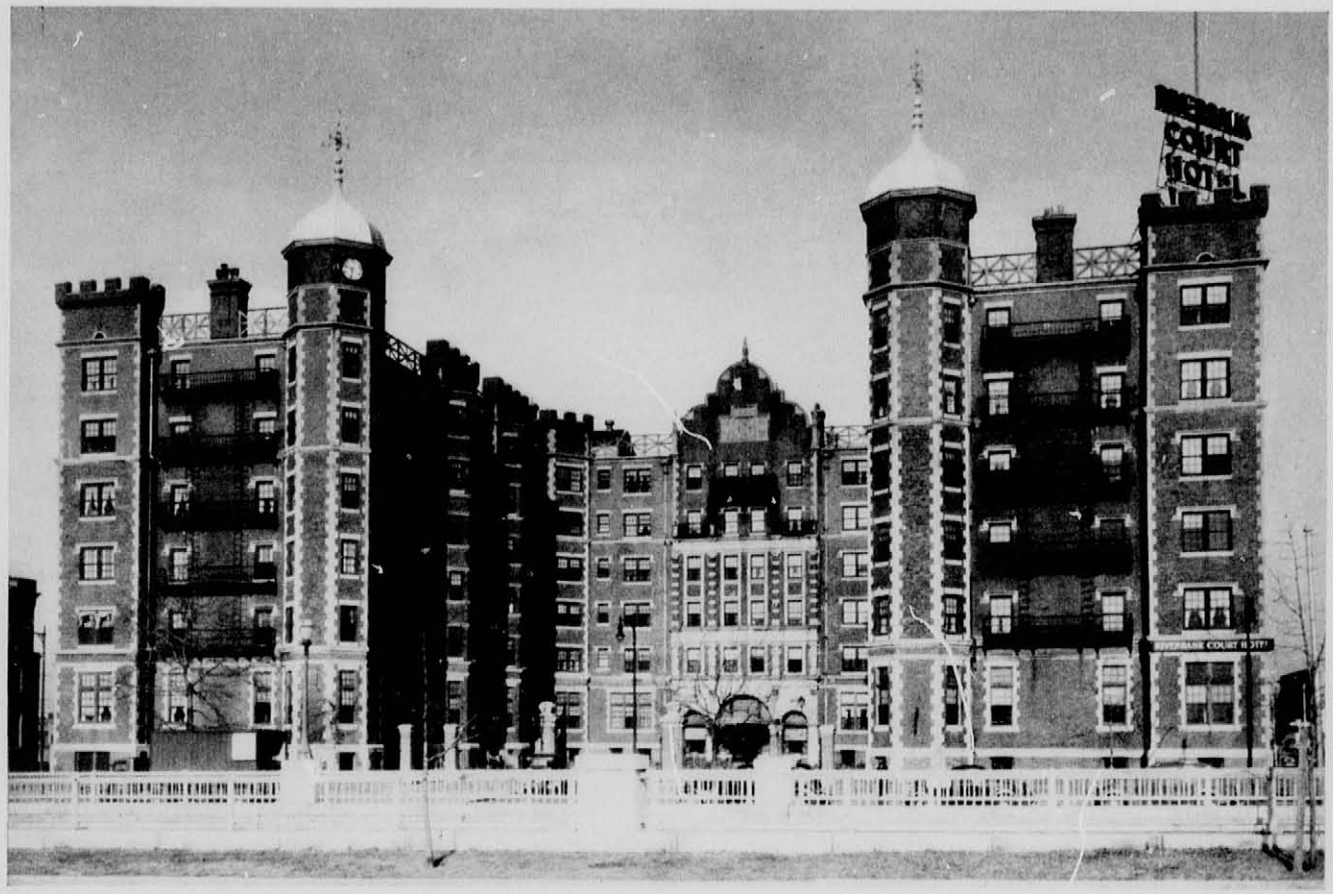
HYGIENE

No.	Subject	Prerequisite	Year	Term	Taken by	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
PT1	Physical Training	——	1	1 (last 10 w.)	All courses	0	1	0	McCarthy
PT2	Physical Training	——	1	2 (1st 10 w.)	All courses	0	1	0	McCarthy

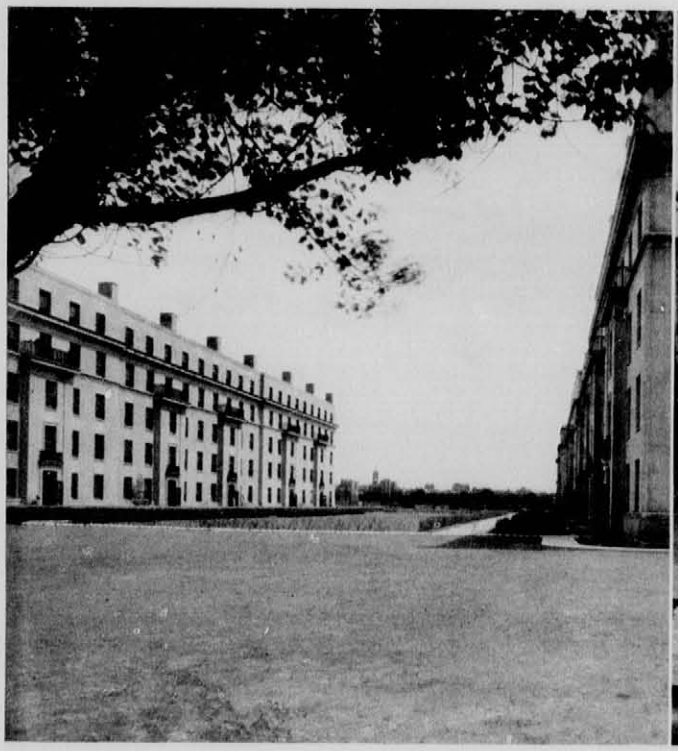
THE SENIOR HOUSE

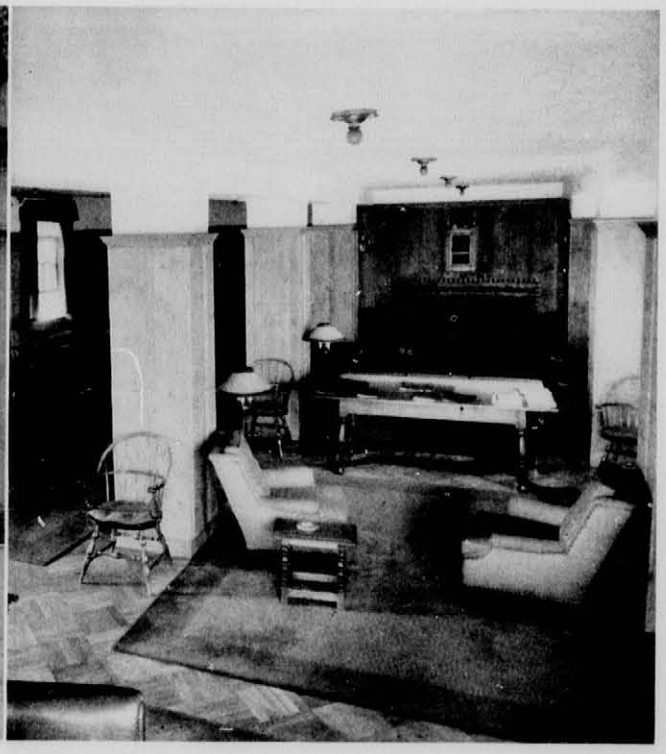
AS THE adjacent pictures testify, the Senior House is admirably equipped for comfortable living. Separation of living quarters of graduates, seniors, and other undergraduates is based on the principle that the most natural cultural advance comes from social intercourse among men of different interests but of equivalent intellectual outlook and that their social development depends upon these contacts.





Above. *In the fall of 1938 this hotel, across Massachusetts Avenue from the Institute buildings, becomes the Graduate House*
Below. *Views, exterior and interior, of the undergraduate dormitories. For views of the Senior House, see preceding page*





APPENDICES

APPENDIX A

STUDENT AID AND PRIZES

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

The extent of these resources is indicated by the facts that, since its establishment in 1930, over 1750 men have borrowed more than $1,150,000 from the Technology Loan Fund; that, during 1938–39, $102,800 and $115,000 will be available for undergraduate and graduate scholarship aid respectively.

TECHNOLOGY LOAN FUND

It is the general policy to make a loan only to men who have completed at least one year of residence at the Institute with a good academic record. In *exceptional* cases, applications will be considered after one term of residence and in *very special and unusual* cases from entering students who have met, with high standing, all entrance requirements.

The maximum amount loaned to an individual in a single year may not exceed the tuition fee, with the additional stipulation that the maximum total loans granted to an applicant may not exceed $1,800 during his undergraduate period, or $2,400 during his undergraduate and graduate periods.

To receive favorable consideration an applicant must:

1. Be endorsed as to character and personality by: (*a*) an alumnus of the Institute from the Community in which he has resided, or by some other citizen of standing in that community; (*b*) the Principal or Head Master of the high school or preparatory school, or the President or Dean of the college or university he has previously attended; (*c*) his Registration Officer or the Head of his Course.

2. Have passed, with a standing satisfactory to the Board, the physical examination required annually of all Institute students.

3. Submit a statement of his financial needs and such other information as the Board may deem necessary, on the application form supplied by the Board, such application to have the approval of his parent or guardian.

4. Be prepared to furnish such life insurance as collateral as may be required by the Board.

A recipient of a loan will be required to sign promissory notes in $50 units up to the amount of his loan, each note carrying interest at two per cent per annum from the date of its issue to a date not exceeding two years after he leaves the Institute, and at five per cent per annum thereafter. Interest is to be paid semi-annually. Each note shall have a definite maturity, such maturities to be spaced at intervals of six months, beginning on or before the December thirty-first following the recipient's expected date of graduation, but payments may be anticipated.

Upon signing notes, the student will be supplied with copies thereof. After leaving the Institute he will be required to advise the Board annually, or at more frequent intervals, as to his whereabouts, the character of the work in which he is engaged, the remuneration he is receiving and his plans for the repayment of his obligations to this Fund.

FRESHMAN SCHOLARSHIPS

Approximately 150 Freshman Competitive awards covering part tuition for the first year are made annually to students entering from secondary schools. They are confined to students who make application to the Office of the Dean of Students before July 1 of the year in which they plan to enter.

Selection is based, to a large degree, upon the candidate's entrance record, College Boards, Regents, and preparatory or high school records; in other words, upon the evidence that he has the academic aptitude and training to enable him to pursue Institute studies with profit to himself and, in due time, to graduate creditably. However, and this is *considered of utmost importance*, the candidate is expected to give evidence through recommendations from former teachers, prominent citizens of his local community, and Institute graduates that he possesses excellent qualities of character and personal bearing, as well as willingness and ability to coöperate with the demands of an engineering, scientific, or architectural curriculum.

Except where distance from Cambridge precludes, a personal interview between an officer of the Institute and the applicant is required and, to facilitate these arrangements, early application is desired. Interviews with some nearby representative of the Institute will be arranged for candidates who live at a distance from Cambridge.

Besides the Freshman Competitive awards, other freshman scholarships are open to qualified applicants under terms set forth below. Most of these grants depend in part upon a candidate having some special qualification in addition to presenting evidence that he has high scholastic ability, i.e., that he be from a particular locality, a graduate of a particular school, etc. The figures in parentheses are the dates of establishment:

ALUMNI REGIONAL (1926). As a means of coöperating with Alumni in various Technology centers in attracting to the Institute students of exceptional ability and promise from all parts of the United States, several Regional Scholarships, carrying an award of full tuition, are offered in Chicago, Cincinnati, Cleveland, Denver, Detroit, District of Columbia, Kansas City, Los Angeles, New York, Northern New Jersey, Philadelphia, Pittsburgh, Portland, Ore., St. Louis, and Schenectady. 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, and Marine Corps Officers, who are admitted as undergraduate students to the Institute, will pay half the regular tuition upon the recommendation of the Faculty Committee on Undergraduate Scholarships, the total number not to exceed

ten each year. Preference will be given to qualified applicants admitted to the first-year class. Applications should be addressed to the Office of the Dean of Students and should be accompanied by documentary evidence that the applicant's father is a commissioned officer in the regular Army, Navy, or Marine Corps. 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, recommended by the Superintendent of Schools, to whom application must be made not later than June 1 of the year in which the applicant plans to enter the Institute. Preference will be given to individuals who have, as of July 1, fulfilled all entrance requirements of the Institute, with the further stipulation that no individual will be eligible to receive a Bridgeport Scholarship until he has fulfilled all entrance requirements of the Institute.

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 Head Master, or Principal, of the applicant's school, and such application must be filed with the Head Master, or Principal, not later than June 1 of the year in which the applicant plans to enter the Institute. Awards will be by competition, based upon special examinations given by the Institute, with the stipulation that no successful candidate will be entitled to benefit from an award unless he or she satisfies, prior to admission, all entrance requirements of the Institute.

CLASS OF '96 FUND (1923). Received from the Class of 1896 to found a scholarship to be awarded subject to the approval of the Secretaries of the Class. Preference in making awards will be given to descendants of members of the Class of 1896, including freshmen, and grants from this fund are to be considered as loans to be repaid by the recipients when and if able.

CLASS OF '09 FUND (1937). Established as the Class of 1909 Scholarship Fund," the net income to "be used to assist such deserving students as may be selected from time to time . . . , preference being given to direct descendants of members of the Class of 1909."

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 not later than June 1 of the year in which the applicant plans to enter the Institute. Preference will be given to individuals who have, as of July 1, fulfilled all entrance requirements of the Institute, with the further stipulation that no individual will be eligible to receive an East Bridgewater Scholarship until he has fulfilled all entrance requirements of the Institute.

FALL RIVER AND SWANSEA (1932). Established by the Institute through a bequest of Elizabeth R. Stevens known as the Albert G. Boyden Fund. Five scholarships for the freshman year, three carrying stipends of full tuition and two carrying stipends of half tuition, are annually offered to qualified applicants residing in Fall River or Swansea, Massachusetts. Application must be made to the Superintendent of Schools, either of Fall River or of Swansea, not later than June 1 of the year in which the applicant plans to enter the Institute. Preference will be given to individuals who have, as of July 1, fulfilled all entrance requirements of the Institute, with a further stipulation that no individual will be eligible to receive one of these scholarships until he has fulfilled all entrance requirements of the Institute.

LLORA CULVER KRUEGER FUND (1936). Established from the residuary estate of the late Emma Robinson Culver "for needy and worthy Massachusetts Institute of Technology students who come from Schenectady or its immediate vicinity, preferably those recommended by the local Regional Scholarship Committee."

GEORGE H. MAY (1914). Gift of $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.

NEW ENGLAND C. M. T. C. (1931). Established by the Institute and carrying a stipend of full tuition for the freshman year. It is awarded to a member of one of the Citizens' Military Training Camps of the First Corps Area, United States Army, selected from the "Whites" or the "Blues," based upon the reports and records transmitted to the Headquarters of the First Corps Area. Application must be made to the Commanding General of the First Corps Area not later than August 1 of the year in which the applicant plans to enter the Institute. The applicant must furnish evidence to the Commanding General that he has not sufficient funds to defray all expenses at the Institute together with such other information as may be requested. Preference will be given to individuals who, at the time of making application, have fulfilled all entrance requirements of the Institute, with the further stipulation that no man will be eligible to receive the New England C. M. T. C. Scholarship until he has fulfilled all entrance requirements of the Institute.

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 Freshman 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 and financial assistance, of his good character, and of his general worthiness and professional promise. Applications should, except as noted below, be made not later than February 11 on blanks to be obtained at Room 3–108.

The scholarships or funds described are arranged in the alphabetical order of their names, the figures in parentheses being the dates of establishment:

ELISHA ATKINS (1894). Founded by Mrs. Mary E. Atkins of Boston with a gift of $5,000.

THOMAS WENDALL BAILEY (1914). Bequest of Thomas Wendall Bailey, the income to assist "needy students in the Department of Architecture."

CHARLES TIDD BAKER (1922). Bequest of $20,000 from Charles Tidd Baker, one half of the net income "applied each year to the assistance of poor and worthy students."

BILLINGS STUDENT (1900). Bequest of $50,000 from Robert C. Billings "to found the Billings Student Fund. Any student receiving benefit from this fund is expected to abstain from the use of alcohol or tobacco in any of their varied forms."

LEVI BOLES (1915). Bequest of $10,000 from Frank W. Boles in memory of his father, Levi Boles, the "net income thereof to be applied annually to the assistance of needy and deserving students."

JONATHAN BOURNE (1915). Bequest of $10,000 from Hannah B. Abbe to constitute a fund "known as the Jonathan Bourne Scholarship Fund, the income only to be used in aid of deserving students."

ALBERT G. BOYDEN (1931). Bequest of $40,000 from Elizabeth R. Stevens as a permanent fund, to be known as the Albert G. Boyden Fund, "income only to be awarded as scholarships to assist worthy and needy students, preference to be given to young men or women residents of the town of Swansea or the city of Fall River."

HARRIET L. BROWN FUND (1932). Bequest of Harriet L. Brown "to be held in trust as a scholarship . . . the income to be given to such needy and deserving young women desiring to become students at M. I. T. as would otherwise be unable to attend; and in case of two or more applicants of equal merit, preference shall be given to a native of either Massachusetts or New Hampshire."

MABEL BLAKE CASE (1920). Gift from Lucius Clapp to form a fund "to aid worthy students who may not be able to complete their studies without help."

NINO TESHER CATLIN (1926). Gift from Maria T. Catlin to establish a fund in memory of her son, Nino T. Catlin of the Class of 1918, the income "to be awarded to needy and deserving students."

LUCIUS CLAPP (1905). Gift from Lucius Clapp to form a fund "to aid worthy students who may not be able to complete their studies without help."

CLASS OF '96 FUND (1923). Received from the Class of 1896 to found a scholarship to be awarded subject to the approval of the Secretaries of the Class. Preference in making awards will be given to descendants of members of the Class of 1896, including freshmen, and grants from this fund are to be considered as loans to be repaid by the recipients when and if able.

CLASS OF '09 FUND (1937). Established as the "Class of 1909 Scholarship Fund," the net income to "be used to assist such deserving students as may be selected from time to time . . . , preference being given to direct descendants of members of the Class of 1909."

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.

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."

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."

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."

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."

HEALTH EDUCATION (1928). Two scholarships carrying full tuition open to young women preparing themselves for professional work in Health Education have been established by the Institute. These scholarships are awarded before July 31 upon the basis of previous academic record, professional accomplishment in the field of health or of education, need, and likelihood of future contribution to Health Education. Application should be made directly to the Head of the Department of Biology and Public Health.

GEORGE HOLLINGSWORTH (1916). Bequest of $5,000 from Rose Hollingsworth to found the George Hollingsworth Scholarship.

T. STERRY HUNT (1894). Bequest of $3,000 from T. Sterry Hunt, for seven years Professor of Geology at Technology, to found a scholarship in his name. Restricted to students of Chemistry and preference is given to those in the higher years.

WILLIAM F. HUNTINGTON (1892). From Susan E. Covell, the Institute received a gift of $5,000 to constitute a fund in memory of William F. Huntington of the Class of 1875, the "income to apply to payments of tuition of needy and deserving students . . . preference to be given to students in Civil Engineering."

DAVID L. JEWELL (1928). Bequest of $25,000 from Colonel David L. Jewell "to be known as the David L. Jewell Fund, the income therefrom to be used to pay the tuition charges of five young men who may be selected by the President or Board of Trustees of the Institute as worthy of assistance, and who, were it not for such assistance, might be unable to pursue their studies at such Institute."

JOY (1886). Established by the gift of Nabby Joy and created pursuant to a decree of the Supreme Judicial Court of Massachusetts for the benefit of "one or more women studying Natural Science at M. I. T."

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 an M. I. T. scholarship for graduates of that school.

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 Coöperative Course in Electrical Engineering."

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."

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."

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."

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. . . ."

JOHN ROACH (1937). Bequest of $2,400 from Emeline Roach to constitute a fund "to be known as the John Roach Scholarship Fund, the income to be used to provide an annual scholarship to a needy and deserving student pursuing the Course in Naval Architecture and Marine Engineering."

WILLIAM BARTON ROGERS (1904). Established by the Institute in commemoration of the early association of President William Barton Rogers with the College of William and Mary. Stipend $400 per year; granted to a student nominated by the faculty of the College of William and Mary.

WILLIAM P. RYAN MEMORIAL (1935). Established by friends of the late Professor William P. Ryan of the Class of 1918, the income to be used for scholarship aid (graduate or undergraduate) in Chemical Engineering, the award to be made by the Scholarship Committee on recommendation of the Head of the Department of Chemical Engineering.

JOHN P. SCHENKL (1922). Bequest of $20,000 from Johanna Pauline Schenkl "to be held in trust to establish one or more scholarships in the Department of Mechanical Engineering" in memory of her father, John P. Schenkl.

THOMAS SHERWIN (1871). Founded with a gift of $5,000 from the English High School Association in memory of Thomas Sherwin. Holders must be graduates of the English High School of Boston and must be pursuing a regular course at the Institute.

HORACE T. SMITH (1931). Bequest from Horace T. Smith of the Class of 1898, to provide scholarships to worthy students, preference to be given to graduates of the East Bridgewater (Massachusetts) and Bridgeport (Connecticut) High Schools.

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 transfers 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."

RTHUR 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."

LOUIS WEISSBEIN (1915). Bequest of $4,000 from Louis Weissbein "to found a scholarship to be awarded each year to a promising student, preference to be given a Jewish boy in making the award." Since the donor was an architect, this scholarship, in accordance with the wish of the Executor of the donor's estate, is given, if possible, to a Jewish student in the Department of Architecture.

FRANCES ERVING WESTON (1912). Bequest of Frances Erving Weston, "to aid a native-born American Protestant girl of Massachusetts."

SAMUEL MARTIN WESTON (1912). Bequest of Frances Erving Weston to found a scholarship in memory of her husband, Samuel Martin Weston, "to aid a native-born American Protestant boy, preference to be given one from Roxbury."

AMASA J. WHITING (1927). Bequest of $2,000 from Mary W. C. Wh..ng "to constitute a fund to be known as Amasa J. Whiting Fund . . . the income . . . to pay or help to pay tuition of deserving students whose means are limited. . . . Preference shall be given to students coming from the town of Hingham, Massachusetts."

ELIZABETH BABCOCK WILLMANN (1935). Bequest from Elizabeth Babcock Willmann, "to help in paying the tuition of girl students taking the Chemistry Course."

MORRILL WYMAN (1915). Bequest of Morrill Wyman, the income of which is "applied in aid of deserving and promising students, but without exclusion in regard to rank, upon the understanding that if in after life the person receiving aid shall find it possible, he shall reimburse the said fund for moneys so applied, but there shall be no legal obligation to make such reimbursement."

GRADUATE FELLOWSHIPS AND SCHOLARSHIPS

GRADUATE scholarships are awarded only to students pursuing programs leading to higher degrees. Applications from new students must, therefore, be accompanied by an application for admission to the Graduate School, with the Department in which the student desires to major indicated. Except for Institute students, an official transcript of the applicant's college record is required; also at least three letters sent by persons personally acquainted with his academic work. Both applications must be made on forms which may be obtained from the Secretary of the Committee on the Graduate School.

Awards to students who have not been in residence at least one term will be limited to the amount of full tuition ($600). Fellowships carrying stipends in excess of tuition are, in general, awarded only to students who have demonstrated their ability to carry on graduate study and research in residence.

In the award of graduate scholarships the Committee on the Graduate School considers first, the ability of the applicant to pursue advanced study and research; second, his pecuniary need. Scholarship awards become available in two installments, at the beginning of each of the two regular terms. Grants are not made unreservedly, and their continuance from term to term is dependent on the recipient maintaining a satisfactory standard of scholarship. The recipient of a scholarship grant is expected to complete the period of study for which the grant is made. In case he discontinues his work before the end of such period, he will be expected to refund the amount received from the grant, unless released therefrom for satisfactory reasons by the Committee.

Applications and credentials must be filed with the Secretary of the Committee on the Graduate School *on or before March 1.* This rule applies to renewal of previous grants as well as new applications. Late applications will receive consideration only if funds become available subsequent to the first allotment of awards. Announcement of awards will be made on April 1, and must be accepted or declined in writing not later than April 15.

ASSISTANTSHIPS AND TEACHING FELLOWSHIPS

Assistantships and Teaching Fellowships are staff appointments made upon recommendation of heads of Departments to whom applications should be addressed. They carry salaries from $1,000 to $1,200 for full time appointments and from $500 to $800 for half-time appointments, depending upon experience and length of service. Full time assistants are able to take approximately one-third time schedules of graduate study and research. Teaching fellows and half-time assistants may carry half-time schedules of graduate work. Staff appointments which include graduate study as a part of the program are in all cases contingent upon the applicant being admitted to the Graduate School for a course of study leading in the case of assistants to either the Master's or Doctor's degree, and in the case of teaching fellows to the Doctor's degree. Provision for meeting the tuition of staff members working for higher degrees is made by scholarship funds designated for this purpose. Applications for these scholarships and for admission to the Graduate School should be filed with the Secretary of the Graduate School at the same time application is made for a staff appointment. Graduate students on the staff may also apply for financial assistance from the Technology Loan Fund.

TRAVELING FELLOWSHIPS

A limited number of traveling fellowships are open to Institute graduates and to members of the instructing staff. Students planning to study abroad should consult the Dean of the Graduate School in regard to special privileges offered by universities and technical schools of various countries in coöperation with the Institute of International Education.

Holders of Institute Traveling Fellowships are expected to present to the Dean of the Graduate School on or before April 1 and October 1 of each year a full report of the progress of their work. This report should include not only a statement of the lectures and laboratory courses attended and special courses of reading and study pursued, but also an account of the progress of the research or other original investigation upon which they are engaged. Mention should also be made in the case of study abroad of the extent to which vacation time has been utilized in travel or general study.

HONORARY FELLOWS

A student who is working for the degree of Doctor of Philosophy, Doctor of Science or Doctor of Public Health, either at the Institute or under an Institute Fellowship at another institution, may, as a mark of distinction, be appointed a "Fellow" upon the recommendation of the Faculty. A certificate of appointment bearing the seal of the Institute and signature of the President and of the Secretary of the Corporation will be issued to each Fellow upon the approval of his appointment by the Corporation. The appointment being honorary carries no stipend.

POST-DOCTORATE FELLOWSHIPS

ARTHUR D. LITTLE (1936). Two fellowships, established by the Institute in memory of Arthur D. Little of the Class of 1885, open to holders of the Doctorate who have shown outstanding ability in research in the field of Chemistry or Chemical Engineering. Stipend, $1,500 and facilities for research provided in the laboratories of the Institute.

FUNDS APPLICABLE TO FELLOWSHIPS AND GRADUATE SCHOLARSHIPS

AUSTIN (1899). Bequest of Edward Austin to assist needy meritorious students and teachers in payment for their studies. Approximately $18,000 to meet the tuition fees of full-time students and members of the Instructing Staff who are working toward the Master's or Doctor's degrees, and for special fellowships.

AUSTIN RESEARCH (1909). Open to candidates for the Doctor's degree who have shown exceptional ability in the field of research. Stipend, $1,000.

WILLIAM SUMNER BOLLES (1924). Founded by William P. Bolles, to establish and maintain either a fellowship, a traveling scholarship, or a resident scholarship, the recipient to have character, ability, and promise. Stipend, $1,200.

MALCOLM COTTON BROWN (1922). Established by Charles A. Brown and Caroline C. Brown in memory of their son, Lieut.

Malcolm Cotton Brown of the Class of 1919, for the purpose of stimulating advanced study and research in Physics. Open to a senior in high standing in the Course in Physics and available for study abroad as well as for graduate work at the Institute of Technology. Only in exceptional cases where a recipient has greatly distinguished himself is the award made for a second year to the same student. (Not available 1938–39.)

COLLAMORE (1916). Bequest of Helen Collamore to aid women students in graduate courses. Available, $650.

CHARLES H. DALTON (1896). Founded by Charles H. Dalton for the payment of fees of American male students, graduates of the Institute, who may wish to pursue advanced chemical study and research especially applicable to textile industries. Stipend, $350.

FRANCES AND WILLIAM EMERSON FUND (1930). Awards not exceeding $600 to students in the School of Architecture, upon recommendation of the Dean of Architecture.

REBECCA R. JOSLIN (1924). Available for loans to students pursuing advanced work in Chemical Engineering. Any student receiving benefit from this fund is expected to abstain from the use of tobacco in any form.

WILFRED LEWIS (1930). Established by Wilfred Lewis as a fellowship in the Department of Mechanical Engineering. Stipend, $250.

ARTHUR D. LITTLE (1936). Two fellowships, established by the Institute in memory of Arthur D. Little of the Class of 1885, open to students pursuing courses leading to the Doctor's degree in the field of Chemistry or Chemical Engineering. Stipend, $1,000.

MOORE (1914). Gift of Mrs. F. Jewett Moore to assist some Institute graduate who wishes to continue studies in Europe, especially in Organic Chemistry. Preference will be shown to one who has distinguished himself in this subject while an undergraduate. Stipend, $1,500.

WILLARD B. PERKINS (1898). Bequest of Willard B. Perkins of the Class of 1872, the income available every fourth year for a traveling scholarship in Architecture. Stipend, $1,500. (Available 1938–39.)

ELLEN H. RICHARDS MEMORIAL (1912). Established by subscription for the promotion of research in Sanitary Chemistry, the branch of science to the development of which Mrs. Richards so greatly contributed. The income used for the award of fellowships to advanced students competent to pursue research in this field, for the employment of research assistants, and in such other ways as will best promote investigation in Sanitary Chemistry.

HENRY BROMFIELD ROGERS (1921). Founded by Anna Perkins Rogers for fellowships and scholarships for women graduates of the Institute or other colleges whose graduate work is carried on at the Institute. Available, $1,100.

RICHARD LEE RUSSEL (1904). Founded by Theodore E. Russel in memory of his brother Richard Lee Russel to assist some worthy student of high standing in the Department of Civil Engineering to continue his studies either as post-graduate or undergraduate. Stipend, $150. (Not available 1938–39.)

HENRY SALTONSTALL (1901). Bequest of Henry Saltonstall to aid students, whether undergraduates or graduates, pursuing advanced courses. Stipend, $500.

JAMES SAVAGE (1873). Founded by James Savage for a graduate student of the Institute, or of some similar institution of equal standing, who wishes to engage in the advanced study of some branch or branches of knowledge taught in the Institute. Stipend, $1,000. (1938–39.)

SUSAN H. SWETT (1888). Founded by Susan H. Swett for a student specially fitted to pursue advanced study, holder to be a graduate of the Institute, or of some similar institution of equal standing and to be eligible for a second year's award. Stipend, $500.

FRANK HALL THORP FELLOWSHIP IN INDUSTRIAL CHEMISTRY (1932). Established as a memorial to Professor Frank Hall Thorp, the income from $10,000 to be awarded on nomination by the Department of Chemical Engineering to a member of the graduating class of the Massachusetts Institute of Technology to enable him to pursue advanced study and research in the field of Industrial Chemistry. Stipend, $500.

LOUIS FRANCISCO VERGES (1924). Established by Caroline A. Verges for a meritorious student, either graduate doing research in the field of the sugar industry, or if there be no such candidate, for an undergraduate in the Department of Civil Engineering. Stipend, $500.

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."

JONATHAN WHITNEY (1912). Established by Mrs. Frances B. Greene to aid students who need financial assistance in obtaining an education at the Institute. Income available for graduate students, $22,000.

SPECIAL FELLOWSHIPS AND GRADUATE SCHOLARSHIPS

1938–1939

TRAVELING FELLOWSHIP IN ARCHITECTURE. For travel and study abroad under the direction of the School of Architecture. Open to regular and special students in the fifth or the graduate years of Courses IV or IV-B who have passed at least two years in the School, one of which must have been in the fifth or the graduate year. Stipend, $1,500.

CELLULOSE CHEMISTRY FELLOWSHIPS. Three fellowships open to students in the Department of Chemistry who are prepared to undertake research in the field of Cellulose Chemistry. Stipend, $750.

CELLULOSE CHEMISTRY SCHOLARSHIP. Open to a student who has completed one year of graduate work and is prepared to undertake research in Cellulose Chemistry. Stipend, $600.

DU PONT FELLOWSHIP. Gift of E. I. du Pont de Nemours and Company. Open to a graduate student to be nominated in alternate years by the Departments of Chemistry and Chemical Engineering, respectively. Available during 1938–39 to a student in Chemical Engineering. Stipend, $750.

HASKINS LABORATORY FELLOWSHIP IN ELECTRONICS. Open to persons holding the degree of Doctor of Science or Doctor of Philosophy in Physics or Electrical Engineering, and whose training has particularly fitted them for experimental work in Applied Electronics. Stipend, $2,000.

POLYMERIZATION PROCESS CORPORATION FELLOWSHIP. For research in hydrocarbons. Stipend, $1,100.

REDFIELD PROCTOR TRAVELING FELLOWSHIP. Gift of Redfield Proctor of the Class of 1902, for graduate study abroad in an English-speaking university, approved by the Dean of the Graduate School. Open to a graduate of the Institute, or in case there is no suitably qualified candidate among the graduates of the Institute, open to a graduate student who has been in residence for at least one year. Stipend, $1,500.

SLOAN FELLOWSHIP IN AUTOMOTIVE ENGINEERING. Gift of Alfred P. Sloan, Jr., of the Class of 1895 for Graduate Study and Research in the field of Automotive Engineering. Stipend, $1,000.

ALFRED P. SLOAN FOUNDATION FELLOWSHIPS IN BUSINESS ADMINISTRATION AND ECONOMICS. For post-industrial graduate study in Departments of Business Administration and Economics and Social Science. Invitational to graduates of high scholastic standing in science and engineering, between twenty-five and thirty-five years of age, with at least five years of industrial experience of sufficient promise to merit the granting of a year's leave of absence by present employers. Stipends, up to $1,750 for single and up to $2,750 for married recipients.

TEXTILE GRADUATE SCHOLARSHIPS. Established by the Proprietors of the Locks and Canals of the Merrimack River and open to graduates of the Lowell Textile Institute. $3,900 available.

PRIZES

ROBERT A. BOIT (1921). Bequest of $5,000 from Robert A. Boit, to provide annual prizes "to stimulate the interest in the best use of the English language." Awards are made to first- and second-year men on the basis of essays written on topics announced by the Department of English and History.

CABOT MEDALS (1901). Gift of Samuel Cabot of the Class of 1870, awarded to five members of each first-year class who have shown the greatest physical improvement during the year.

JAMES MEANS MEMORIAL (1925). A medal and monetary prize of $100 offered annually for the best thesis on an aeronautical subject. Joint theses may be entered and, if successful, duplicate medals will be awarded and the prize divided. Open only to candidates for the Bachelor's degree.

WILLIAM BARTON ROGERS AWARDS (1937). Four prizes of $500 each to members of the Senior Class who, in the opinion of the Faculty Committee on Undergraduate Scholarships, have demonstrated "outstanding qualities, weight to be given to non-academic or extra-curricular as well as academic accomplishment, and consideration of financial need to be disregarded."

STRATTON (1930). Established by the late President Samuel W. Stratton. Prizes of $50, $30, and $20 awarded for the best presentation of scientific papers by undergraduates, the final competition being held at a public meeting.

The following annual prizes are awarded to students of the School of Architecture:

ALPHA RHO CHI MEDAL (1932). To the graduating senior of the School of Architecture who has shown an ability for leadership, performed willing service for his school and department, and given promise of real professional merit through his attitude and personality.

BOSTON SOCIETY OF ARCHITECTS (1892). Gift of the Society. Prize of $100 for the best design submitted by a present student of Harvard, Technology, or the Boston Architectural Club on one of the regular conjunctive programs.

CHAMBERLIN (1913). Gift of Boston Society of Architects. Prize of $25 to a student in the graduate class in Architecture.

F. W. CHANDLER (1914). Gift of Boston Society of Architects in memory of Professor Chandler. Five prizes of $10 each awarded for sketch problems in the fourth, fifth, and graduate years.

CLASS OF 1904 (1925). Gift of the Class of 1904. Three prizes of $5 each awarded to students in the third-year class in Architecture for sketch problems.

FREEHAND DRAWING (1920). Prize of $25 to the student whose work is judged to be the best in a competition at the end of the year.

LIBRARY (1931). Awarded to the second-year student receiving the highest award on a designated project.

ROTCH (1895). Gift of Arthur Rotch. Two prizes of $200 awarded at the end of the fifth year to the regular and the special student having the best general records. The special student must have spent at least two years in residence to be eligible.

SCHOOL OF ARCHITECTURE MEDALS (1922). A bronze medal of the School awarded at the end of the academic year to the winner of each prize, and also to students in the fifth and graduate years with the highest number of "medal" values.

STUDENT MEDAL OF THE AMERICAN INSTITUTE OF ARCHITECTS (1914). Awarded on the recommendation of the School to the member of the fifth-year class whose record for the Course is the best.

SUMMER SKETCHING (1921). For the best set of outdoor summer sketches in pencil or pen and ink or measured drawings, and for the best set of outdoor summer sketches in water colors or wash; two prizes totaling $25.

WILLIAM R. WARE (1923). In memory of the founder of the School, prizes totalling $50 for week-end conjuntive problems with Harvard and the Boston Architectural Club.

H. LANGFORD WARREN (1923). In memory of Professor Warren, prizes totalling $50 for week-end conjunctive problems with Harvard and the Boston Architectural Club.

The following annual prize is offered to students in the Department of 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.

The following annual prize is offered to students in the Department of 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.

APPENDIX B

STUDENT HOUSING

THE GRADUATE HOUSE

General Notice

All rooms are fully furnished and equipped for immediate occupancy.

The rental includes heat, light, continuous hot and cold water, intercommunicating telephone service, porter service, soap and towel supply, and laundry service for bed linen and towels.

A more complete description of the Graduate House and its facilities is in preparation.

Inquiries should be addressed to

Professor Avery A. Ashdown, *Master*
The Graduate House, M. I. T.
Cambridge, Massachusetts

SENIOR AND UNDERGRADUATE HOUSES

THE student housing facilities provided at The Massachusetts Institute of Technology have been carefully planned and organized to afford an economical, comfortable place in which to live, an environment conducive to study and an opportunity to participate in those social and extra-curricular activities which properly supplement scholastic work.

In addition to the Institute Dormitories (Senior and Undergraduate houses) accommodating 625 students, the Institute recognizes 25 national fraternities, whose houses are situated on private property in Cambridge, Boston, and Brookline. Local apartment and rooming houses are also available, but lack the advantages of residence in the Dormitories and fraternity houses, due to the more intimate contact of the latter with Technology life and activities.

Approximately 90% of the fraternity men are pledged during, or prior to, the first week of the Freshman year and may assume residence at the fraternity house of their choice upon pledging. Parents of students who anticipate fraternity affiliation for their son should, if possible, grant him permission to act on his own initiative, and should consider all available housing facilities before signing binding agreements. Fraternity contacts are encouraged prior to entrance, and under certain conditions Dormitory leases may be terminated to allow students to transfer from the Dormitories to a fraternity house (see following page).

The Senior House

Ware, Atkinson, Runkle, Holman, Nichols, and Crafts Halls—the Faculty Group—are reserved exclusively for members of the Senior Class. They have a capacity of 206 men.

A Library and Living Room are on the first floor of Crafts, and in Ware, the two lounge rooms are similarly located. A private dining room, with a maximum capacity of sixteen guests, is in the basement of Ware. The first-floor rooms in all of the other halls are designed for single occupancy. On the upper floors most of the quarters are suites, comprising a living room, a dressing room, and a sleeping room, arranged for two students. A few of the suites are suitable for three men. All rooms are equipped for immediate occupancy. Many of the rooms have lavatory installation supplemented by adequate toilets and showers.

A member of the Institute Staff, who is familiar with the general aims and problems of Senior students, is resident house master and he, with the assistance of a student house committee, has supervision of the Senior House.

The Undergraduate Houses

Walcott, Bemis, Goodale, Munroe, Hayden and Wood—the Alumni Group—are reserved exclusively for undergraduate students. They have a capacity of 419 men. Most of the rooms are for single occupancy—some interconnecting—with a limited number of double and triple suites as noted on the floor plans. There are lavatory installations in all these rooms, supplemented by adequate toilets and showers on each floor of every hall.

The government of the Senior and Undergraduate houses is administered as a part of the general plan of student self-government at the Massachusetts Institute of Technology, with the coöperation of the Dormitory Board, appointed by the President and acting in an advisory capacity.

The whole question of discipline and maintenance of good order is in the hands of the students themselves. The student committee organizes and supervises all activities, athletic and social, and coöperates with all recognized undergraduate activities at the Institute. Application for residence in the dormitories implies the willingness to coöperate with the student government and contribute to its success.

A House Tax of five dollars per resident per year, included in the rental, is turned over to the committee for athletics, dances, dinners and a variety of social activities.

The Dormitory Board, referred to above, is responsible for general regulations, sanitation, service and maintenance, the allotment of rooms and the enforcement of the terms of the lease. Friendly relations between the Board and the student committee have been maintained to such a degree that disciplinary action seldom has been found necessary.

Equipment

Single Rooms. Special bed or couch, all hair inner spring mattress with cover, pillow, couch cover, blankets, chiffonier, desk and chair, study chair, bookcase, rug, draperies, desk lamp, wastebasket, and interconnecting telephone. All linen and towels are furnished, and regularly replaced, by porters who make up the rooms each day.

Double and Triple Rooms. These rooms are furnished in a manner similar to the single rooms, but in addition have study tables and wardrobes where necessary. As the rooms are *fully equipped for occupancy*, additions by the students to the standard equipment are permitted only upon agreement with the manager of the dormitories.

Service. In addition to space, the rental includes heat, light, continuous hot and cold water, intercommunicating telephone service, porter and cham-

ber service, soap and towel supply, and laundry service for bed linen and towels.

Application for Rooms

Applications for the Senior House and for the Undergraduate Houses should be made to D. L. Rhind, Bursar. The following single rooms are reserved for students entering the first year:

Bemis: 101, 104, 105, 108, 111, 113, 201, 204, 205, 208, 211, 213, 301, 304, 305, 308, 311, 313, 401, 404, 405, 408, 411, 413, 501, 504, 505, 508, 511, 513.

Goodale: 103, 105, 110, 112, 203, 205, 210, 212, 303, 305, 310, 312, 403, 405, 410, 412, 503, 505, 510, 512.

Walcott: 101, 104, 111, 114, 201, 204, 207, 210, 213, 301, 304, 307, 310, 313, 401, 404, 407, 410, 413, 501, 504, 507, 510, 513.

Munroe: 201, 204, 210, 213, 301, 304, 310, 313, 401, 404, 410, 413, 501, 504, 510, 513.

Hayden: 101, 104, 107, 110, 113, 201, 204, 207, 210, 213, 301, 304, 307, 310, 313, 401, 404, 407, 410, 413, 501, 504, 507, 510, 513.

Wood: 101, 104, 107, 110, 113, 201, 204, 207, 210, 213, 301, 304, 307, 310, 313, 401, 404, 407, 410, 413, 501, 504, 507, 510, 513.

Applications for double and triple suites must bear the signatures of the two or three men who desire to occupy them. No application fees are required.

Allotment of Rooms

Seniors, Juniors, Sophomores. The assignment of rooms by the Dormitory Board will be in order of application, but the Board reserves the right to reject any applicant for sufficient reason. Priority in the assignment of rooms, except those specifically reserved for entering first-year students, is granted to men already living in the houses whose applications are filed on or before March 15. Notices of assignments and leases will be forwarded to these applicants as soon as possible after March 15 and the leases, properly executed, must be returned to the Cashier's Office, Room 10–180, within one month; otherwise the rooms will be reassigned.

First-Year Students. Rooms will be assigned in order of date of application and leases will be forwarded to applicants whose admission has been approved by the Director of Admissions as first-year students, about August 15, and leases must be returned to the Cashier's Office, 10–180, properly executed, by September 15; otherwise the rooms will be reassigned. Unsuccessful applicants will be notified and their names kept on the waiting list in order of the date of application. They should report to the Cashier's Office, 10–180, on Registration Day to inquire about possible assignment to rooms released by cancellation, or withdrawal. All vacancies will be filled in order from this first year waiting list.

Occupancy

Rooms leased for the Institute year may be occupied from the Monday before the opening of the fall term until the Saturday after commencement—about 38 weeks. During the summer term, rooms are rented by the week.

Rentals, Payments, and Refunds

The rental of the single rooms and suites varies according to space, floor, exposure, and lavatory installation. These prices are clearly indicated on the floor plans presented on later pages.

Rentals for academic year will be by formal lease bearing the signatures of applicants, as well as their parents or guardians. Payments will be regularly due *without* notice—one-half before the beginning of the first term (about the end of September) and one-half before the beginning of the second term (about February 1). *No bills will be sent.*

Payments for rooms occupied during the summer terms are due in advance for each four weeks of occupancy. The summer rates are, Undergraduate Houses $4.00 per man per week.

The Dormitory Board extends the following privileges in the cancellation of lease. These privileges are subject to change without notice.

Leases may be cancelled without charge before September 1 upon written notice to the Bursar.

Students who desire to move to recognized fraternity houses will be refunded a proportionate part of their payments, less $10, up to noon of the Wednesday following Registration Day of the first term, provided authorized representatives of the fraternities request such transfer.

Other students who desire to move from the Dormitories and who do not contemplate leaving the Institute will be refunded a proportionate part of their payments, less $10, on condition that another student can be immediately secured to take over the remaining portion of the lease, and provided the application for release is filed prior to noon of the Wednesday following Registration Day of the first term.

Students who apply for release, except as specified above, will be refunded a proportionate part of their payments, less $50, when and if another student can be secured to take over the remaining portion of the lease. This last arrangement can be made only with the consent of the Dormitory Board.

Leases are automatically cancelled upon the withdrawal of a student from the Institute or transfer to a coöperative course and a proportionate refund

allowed. The student is not allowed, however, to sublet or transfer his room, or his share in a room, without the consent of the Dormitory Board.

FURTHER INFORMATION

Keys. Key cards for individual room keys and post office box keys may be obtained at the Dormitory Office on the first floor of Munroe Hall. A deposit of $1.00 for the two is required, but this is refunded upon surrender of the keys.

Dormitory Office. Located on the first floor of Munroe with a clerk in attendance from 7.00 a.m. to 11.00 p.m. All necessary information may be obtained there. The office of the manager of the dormitories is adjacent to the Dormitory Office.

Burton Room. Adjoining the Dormitory Office in Munroe is a large comfortably furnished common room known as the Burton Room. Women are not allowed in the dormitories except on special occasions, but they are permitted to visit the Burton Room at any time when the Office is open.

A library of non-technical books is maintained for the use of dormitory occupants in connection with the library in the near-by Walker Memorial.

Mail and Express. Packages and mail matter for students living in the dormitories should be addressed as follows: *Massachusetts Institute of Technology Dormitories, Cambridge, Massachusetts.* Individual post office lock boxes are provided for each man and are located at the Dormitory Office.

Telephone Service. Persons calling the dormitories from outside should ring KIRkland 5300. Through a system of intramural telephone service, the Office is enabled easily to call any occupant. Telephone pay stations for out-going calls are located at the Office and fifteen other points near the entrances of the halls.

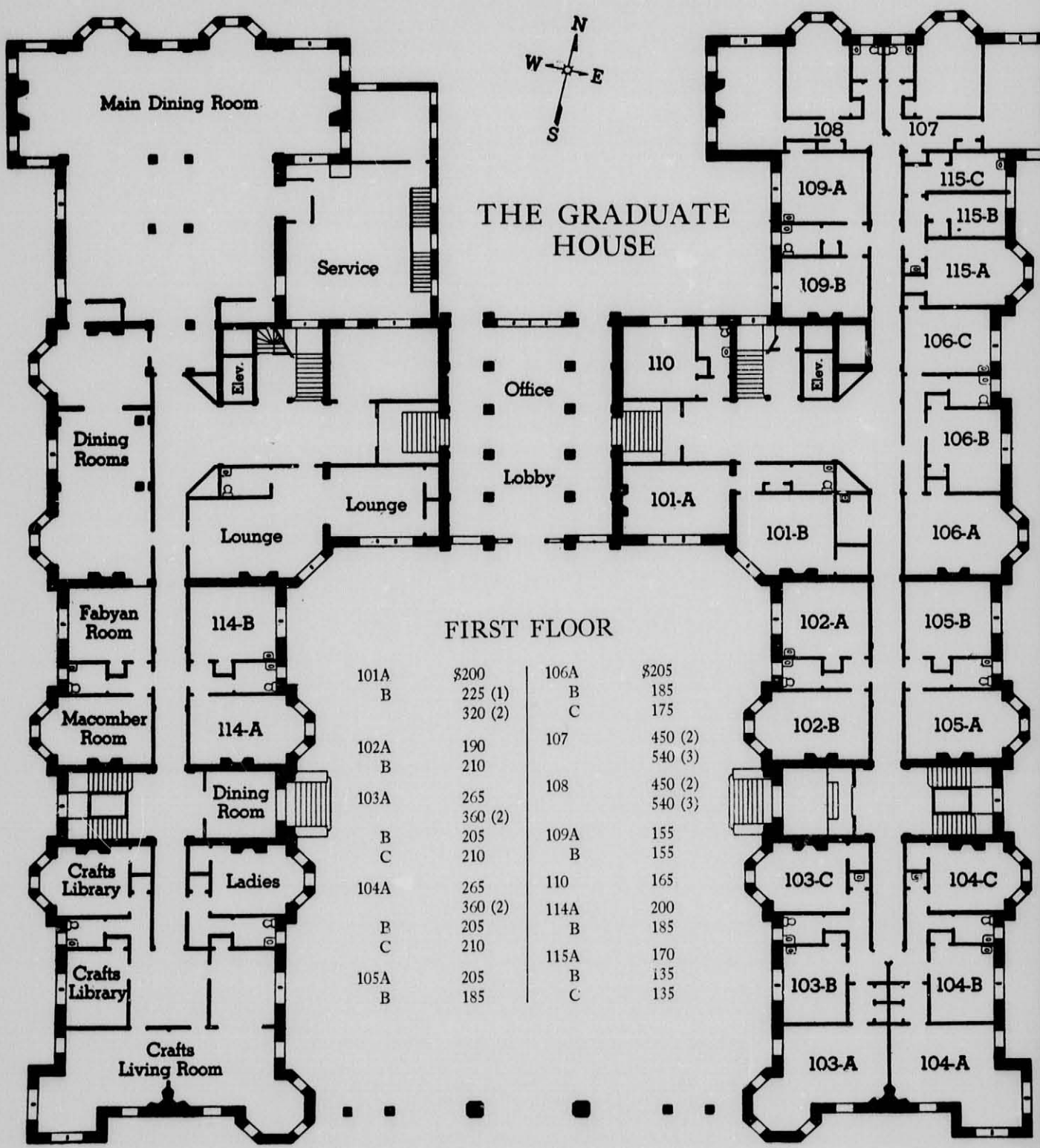
Laundry and Valet Service. The Institute operates a laundry and valet agency, and students are enabled to secure such service through the Dormitory Office at greatly reduced prices.

Storage and Parking. Ample facilities for storage are provided in the basement of the halls without charge. Trunks are not permitted in the rooms. Outdoor parking of properly registered automobiles is permitted on the Institute grounds at the risk of the owner.

Dining Service. Dining facilities are in the Walker Memorial, headquarters of student activities, adjacent to the Dormitories. Either cafeteria or table service is available. No board by the day or week is furnished, and no student is required to use this service. Because of the low cost and the excellent facilities, however, about 2,000 meals a day are served. During the academic year the student dining service operates seven days a week.

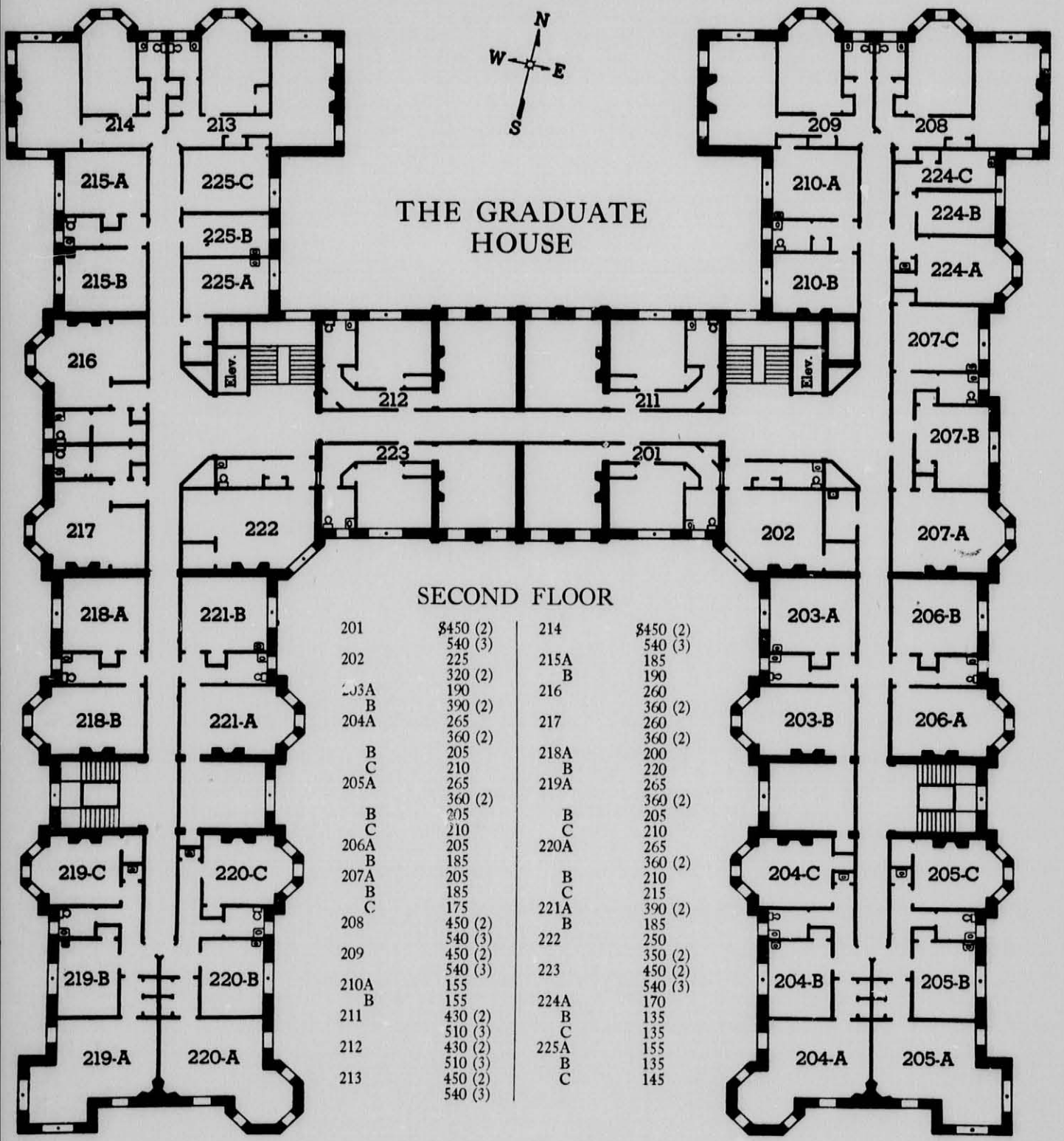
Building Service. The dormitory buildings are of first class construction and are fireproof. Rooms are cleaned by use of vacuum cleaners; mazda lamps are furnished; and each room is provided with extra electrical outlets. Steam heat is available throughout the Institute year, day and night. The house service is directly in charge of the manager of the dormitories and is maintained by experienced porters. A representative of the Institute is on the premises day and night.

For further information address the Bursar, Massachusetts Institute of Technology, Cambridge, Mass.



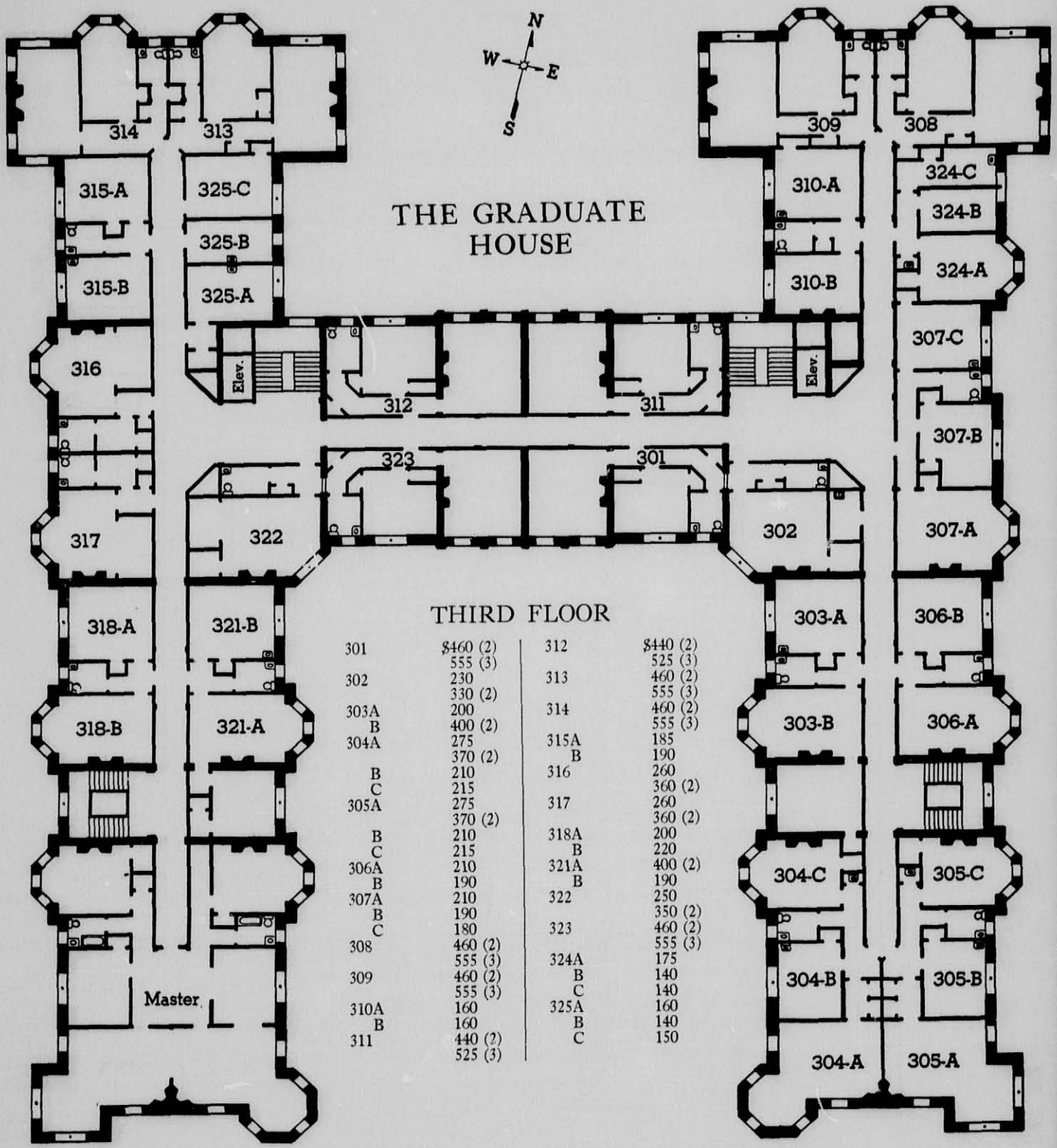
FIRST FLOOR

101A	$200	106A	$205
B	225 (1)	B	185
	320 (2)	C	175
102A	190	107	450 (2)
B	210		540 (3)
103A	265	108	450 (2)
	360 (2)		540 (3)
B	205	109A	155
C	210	B	155
104A	265	110	165
	360 (2)	114A	200
B	205	B	185
C	210	115A	170
105A	205	B	135
B	185	C	135



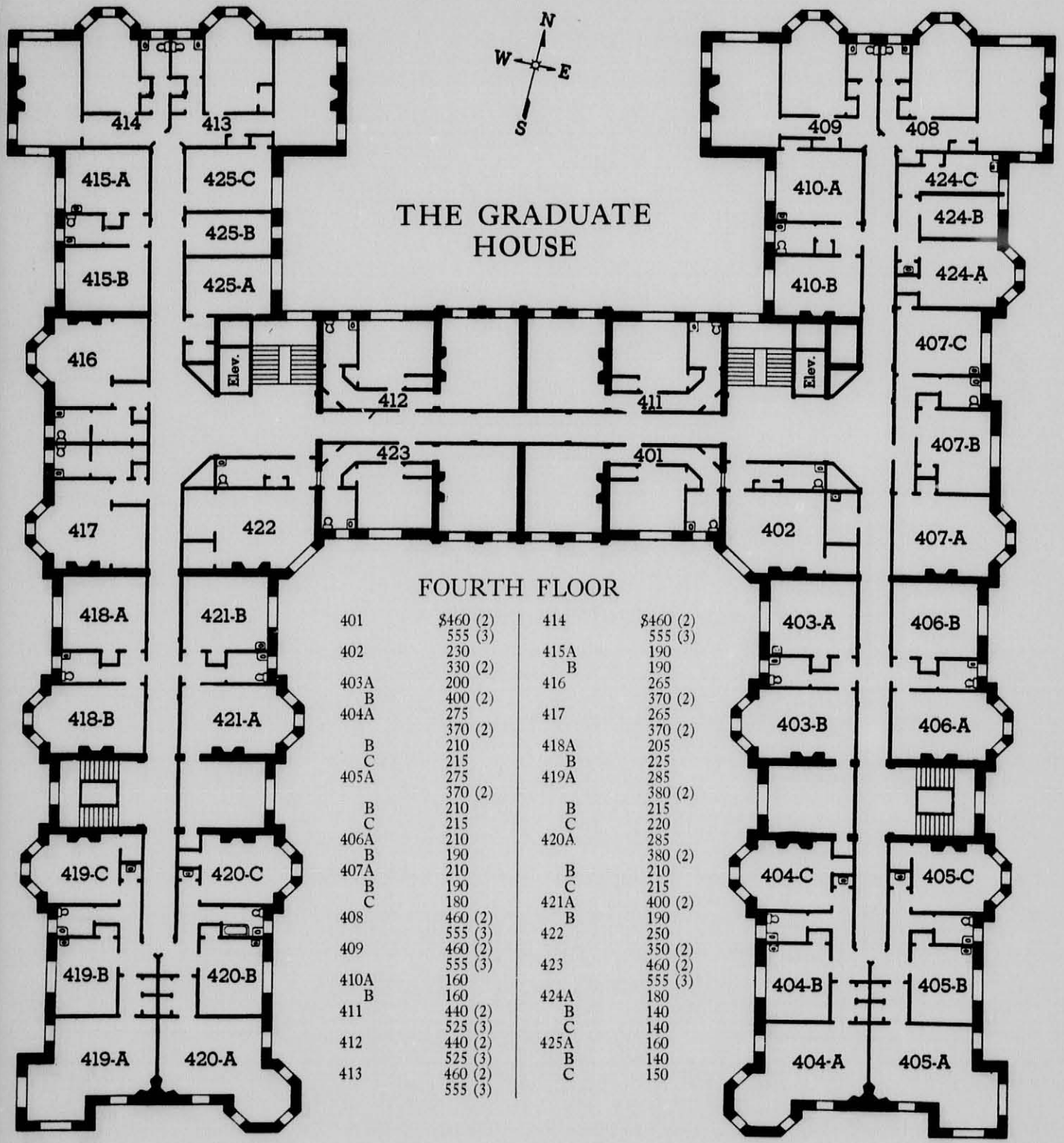
SECOND FLOOR

201	$450 (2)	214	$450 (2)
	540 (3)		540 (3)
202	225	215A	185
	320 (2)	B	190
203A	190	216	260
B	390 (2)		360 (2)
204A	265	217	260
	360 (2)		360 (2)
B	205	218A	200
C	210	B	220
205A	265	219A	265
	360 (2)		360 (2)
B	205	B	205
C	210	C	210
206A	205	220A	265
B	185		360 (2)
207A	205	B	210
B	185	C	215
C	175	221A	390 (2)
208	450 (2)	B	185
	540 (3)	222	250
209	450 (2)		350 (2)
	540 (3)	223	450 (2)
210A	155		540 (3)
B	155	224A	170
211	430 (2)	B	135
	510 (3)	C	135
212	430 (2)	225A	155
	510 (3)	B	135
213	450 (2)	C	145
	540 (3)		

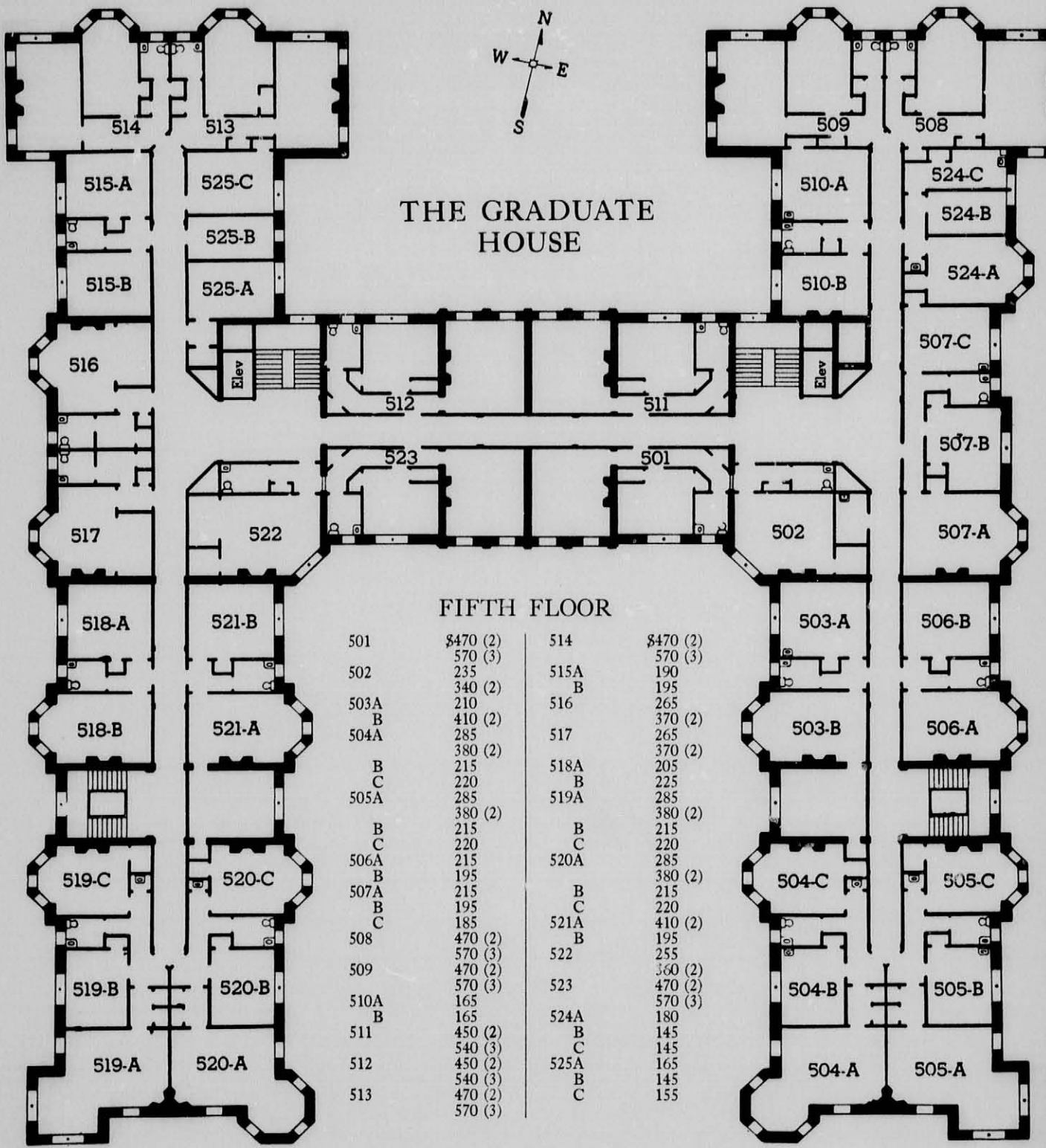


THIRD FLOOR

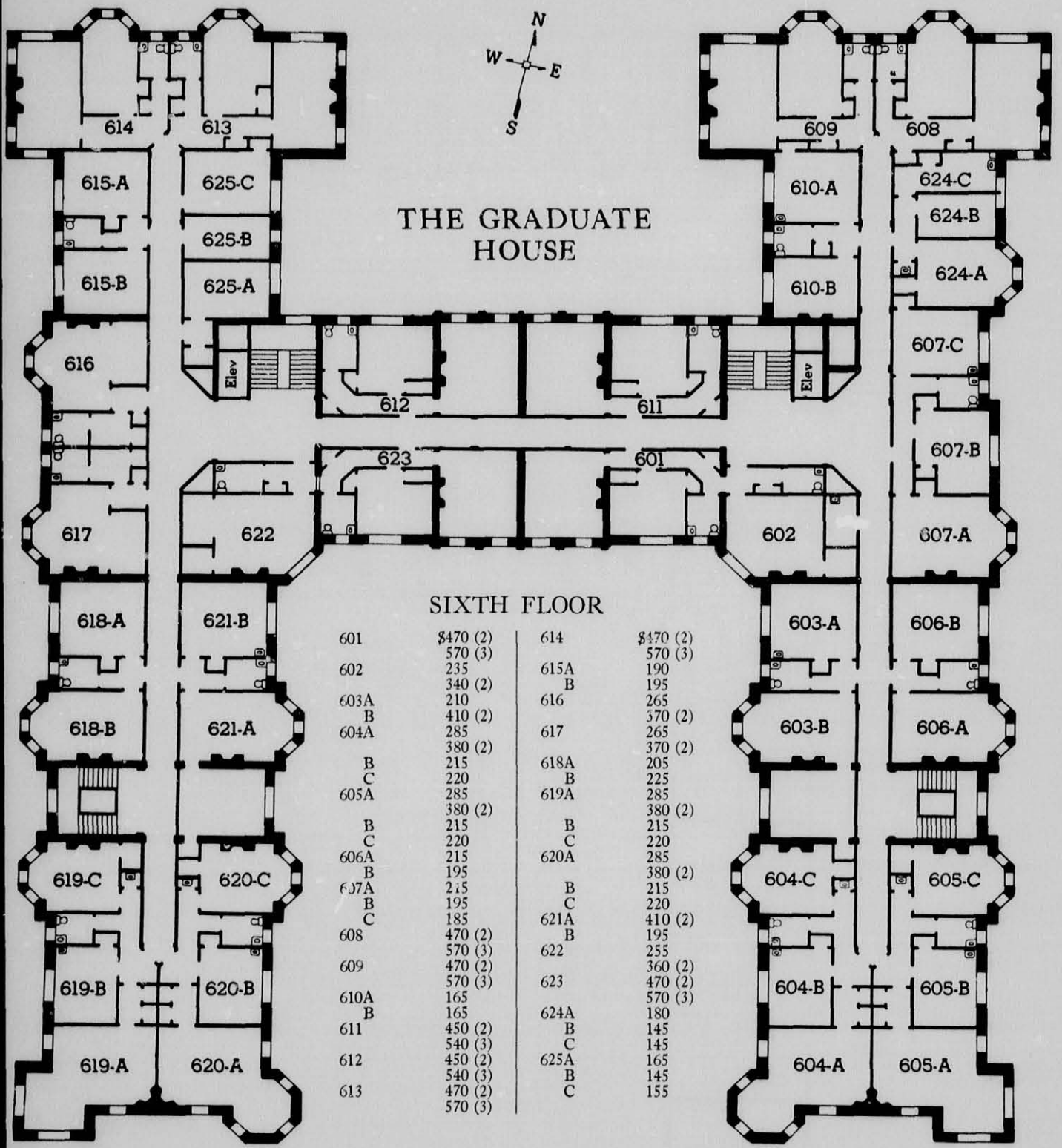
301	$460 (2)	312	$440 (2)
	555 (3)		525 (3)
302	230	313	460 (2)
	330 (2)		555 (3)
303A	200	314	460 (2)
B	400 (2)		555 (3)
304A	275	315A	185
	370 (2)	B	190
B	210	316	260
C	215		360 (2)
305A	275	317	260
	370 (2)		360 (2)
B	210	318A	200
C	215	B	220
306A	210	321A	400 (2)
B	190	B	190
307A	210	322	250
B	190		350 (2)
C	180	323	460 (2)
308	460 (2)		555 (3)
	555 (3)	324A	175
309	460 (2)	B	140
	555 (3)	C	140
310A	160	325A	160
B	160	B	140
311	440 (2)	C	150
	525 (3)		



401	$460 (2)		414	$460 (2)	
	555 (3)			555 (3)	
402	230		415A	190	
	330 (2)		B	190	
403A	200		416	265	
B	400 (2)			370 (2)	
404A	275		417	265	
	370 (2)			370 (2)	
B	210		418A	205	
C	215		B	225	
405A	275		419A	285	
	370 (2)			380 (2)	
B	210		B	215	
C	215		C	220	
406A	210		420A	285	
B	190			380 (2)	
407A	210		B	210	
B	190		C	215	
C	180		421A	400 (2)	
408	460 (2)		B	190	
	555 (3)		422	250	
409	460 (2)			350 (2)	
	555 (3)		423	460 (2)	
410A	160			555 (3)	
B	160		424A	180	
411	440 (2)		B	140	
	525 (3)		C	140	
412	440 (2)		425A	160	
	525 (3)		B	140	
413	460 (2)		C	150	
	555 (3)				



501	$470 (2)		514	$470 (2)	
	570 (3)			570 (3)	
502	235		515A	190	
	340 (2)		B	195	
503A	210		516	265	
B	410 (2)			370 (2)	
504A	285		517	265	
	380 (2)			370 (2)	
B	215		518A	205	
C	220		B	225	
505A	285		519A	285	
	380 (2)			380 (2)	
B	215		B	215	
C	220		C	220	
506A	215		520A	285	
B	195			380 (2)	
507A	215		B	215	
B	195		C	220	
C	185		521A	410 (2)	
508	470 (2)		B	195	
	570 (3)		522	255	
509	470 (2)			360 (2)	
	570 (3)		523	470 (2)	
510A	165			570 (3)	
B	165		524A	180	
511	450 (2)		B	145	
	540 (3)		C	145	
512	450 (2)		525A	165	
	540 (3)		B	145	
513	470 (2)		C	155	
	570 (3)				



SIXTH FLOOR

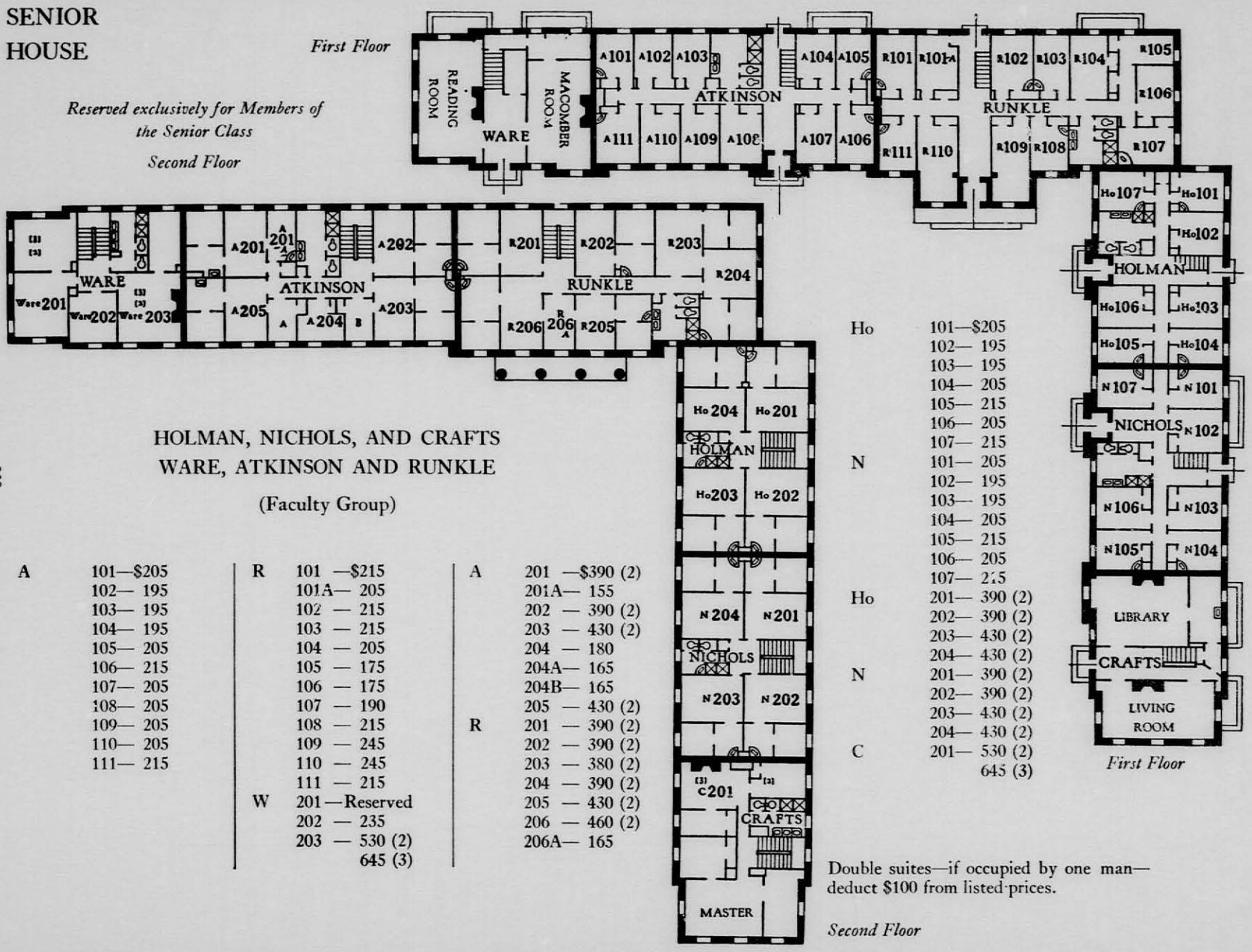
601	$470 (2)	614	$470 (2)
	570 (3)		570 (3)
602	235	615A	190
	340 (2)	B	195
603A	210	616	265
B	410 (2)		370 (2)
604A	285	617	265
	380 (2)		370 (2)
B	215	618A	205
C	220	B	225
605A	285	619A	285
	380 (2)		380 (2)
B	215	B	215
C	220	C	220
606A	215	620A	285
B	195		380 (2)
607A	215	B	215
B	195	C	220
C	185	621A	410 (2)
608	470 (2)	B	195
	570 (3)	622	255
609	470 (2)		360 (2)
	570 (3)	623	470 (2)
610A	165		570 (3)
B	165	624A	180
611	450 (2)	B	145
	540 (3)	C	145
612	450 (2)	625A	165
	540 (3)	B	145
613	470 (2)	C	155
	570 (3)		

SENIOR HOUSE

First Floor

Reserved exclusively for Members of the Senior Class

Second Floor



HOLMAN, NICHOLS, AND CRAFTS WARE, ATKINSON AND RUNKLE

(Faculty Group)

A	101—$205	
	102— 195	
	103— 195	
	104— 195	
	105— 205	
	106— 215	
	107— 205	
	108— 205	
	109— 205	
	110— 205	
	111— 215	
R	101 —$215	
	101A— 205	
	102 — 215	
	103 — 215	
	104 — 205	
	105 — 175	
	106 — 175	
	107 — 190	
	108 — 215	
	109 — 245	
	110 — 245	
	111 — 215	
W	201—Reserved	
	202 — 235	
	203 — 530 (2)	
	645 (3)	
A	201 —$390 (2)	
	201A— 155	
	202 — 390 (2)	
	203 — 430 (2)	
	204 — 180	
	204A— 165	
	204B— 165	
	205 — 430 (2)	
R	201 — 390 (2)	
	202 — 390 (2)	
	203 — 380 (2)	
	204 — 390 (2)	
	205 — 430 (2)	
	206 — 460 (2)	
	206A— 165	
Ho	101—$205	
	102— 195	
	103— 195	
	104— 205	
	105— 215	
	106— 205	
	107— 215	
N	101— 205	
	102— 195	
	103— 195	
	104— 205	
	105— 215	
	106— 205	
	107— 215	
Ho	201— 390 (2)	
	202— 390 (2)	
	203— 430 (2)	
	204— 430 (2)	
N	201— 390 (2)	
	202— 390 (2)	
	203— 430 (2)	
	204— 430 (2)	
C	201— 530 (2)	
	645 (3)	

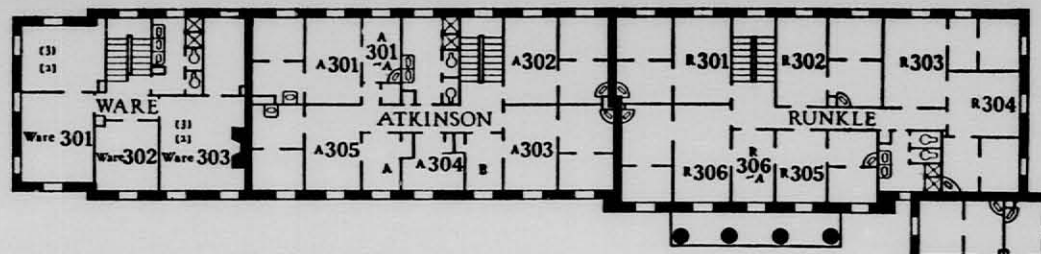
Double suites—if occupied by one man—deduct $100 from listed prices.

Second Floor

First Floor

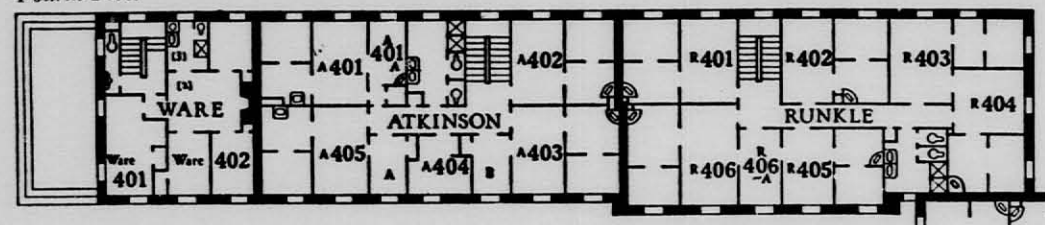
Third Floor

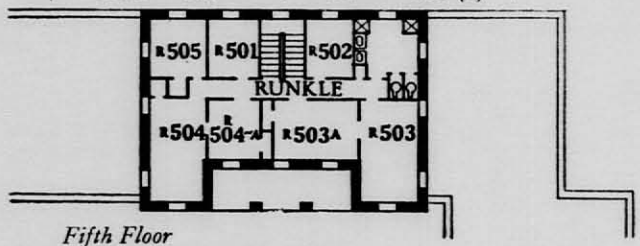
W301—$530 (2)	A301 —$390 (2)	R301 —$390 (2)
645 (3)	301A— 155	302 — 390 (2)
W302— 235	302 — 390 (2)	303 — 380 (2)
W303— 530 (2)	303 — 430 (2)	304 — 390 (2)
645 (3)	304 — 180	305 — 430 (2)
	304A— 165	306 — 460 (2)
	304B— 165	306A— 165
	305 — 430 (2)	



Fourth Floor

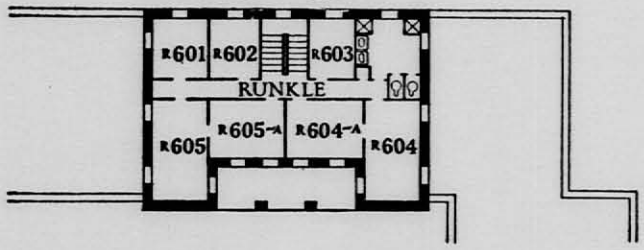
W 401—$265	A401A—$155	A404B—$165	R404 —$390 (2)
402— 630 (2)	402 — 390 (2)	405 — 430 (2)	405 — 430 (2)
735 (3)	403 — 430 (2)	R401 — 390 (2)	406 — 460 (2)
A 401— 390 (2)	404 — 180	402 — 390 (2)	406A— 165
	404A— 165	403 — 380 (2)	





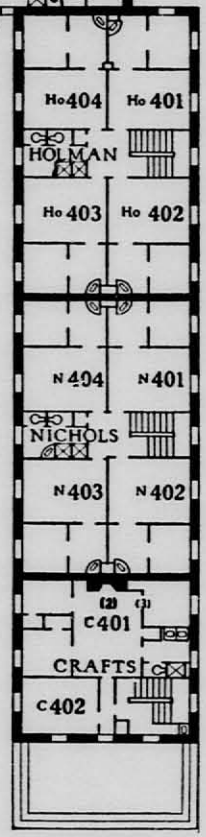
Fifth Floor

R	501—$155	R	503A—$230
	502— 150		504 — 235
	503— 230		504A— 200
			505 — 165



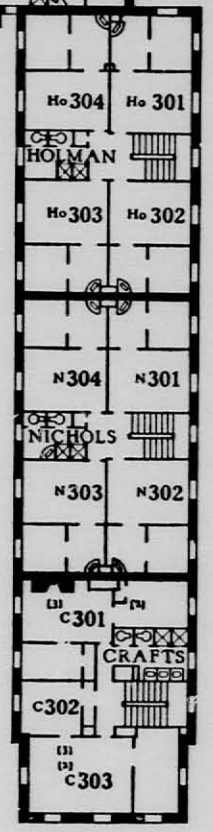
Sixth Floor

R	601—$155	R	604 —$200
	602— 150		604A— 200
	603— 145		605 — 200
			605A— 200



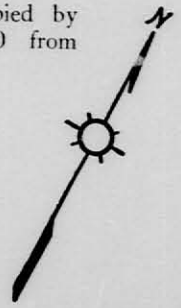
Fourth Floor

Ho	301—$390 (2)	
	302— 390 (2)	
	303— 430 (2)	
	304— 430 (2)	
N	301— 390 (2)	
	302— 390 (2)	
	303— 430 (2)	
	304— 430 (2)	
C	301— 530 (2)	
	645 (3)	
	302— 245	
	303— 530 (2)	
	645 (3)	
Ho	401— 390 (2)	
	402— 390 (2)	
	403— 430 (2)	
	404— 430 (2)	
N	401— 390 (2)	
	402— 390 (2)	
	403— 430 (2)	
	404— 430 (2)	
C	401— 630 (2)	
	735 (3)	
	402— 255	



Third Floor

Double suites—if occupied by one man—deduct $100 from listed prices.



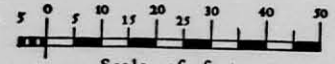
UNDERGRADUATE HOUSES

MUNROE, HAYDEN AND WOOD HALLS (Alumni Group)

Reserved for Undergraduates

MUNROE

201—$220
202— 220
203— 220
204— 230
205— 220
206— 540 (2), 705 (3)
207— 230
208— 225
209— 225
210— 225
211—$225
212— 225
213— 225



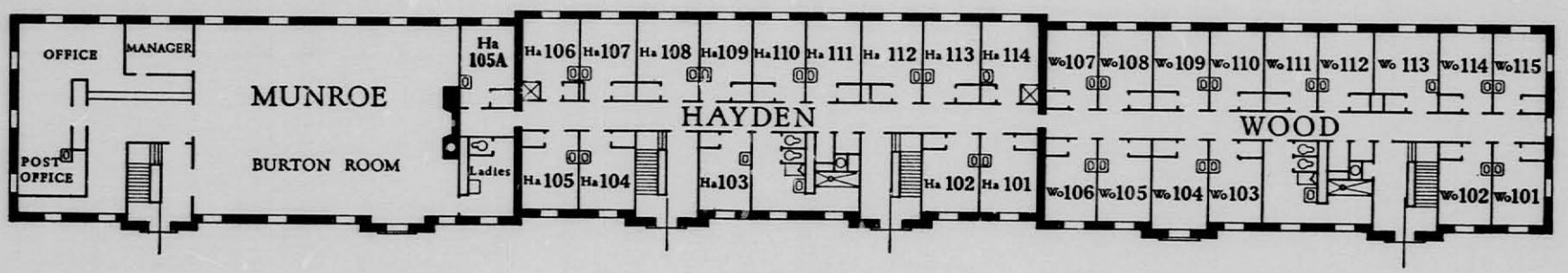
HAYDEN

101 —$210
102 — 210
103 — 210
104 — 210
105 — 210
105A— 220
106 — 220
107 — 220
108 — 220
109 — 215
110 — 215
111 — 215
112 — 220
113 — 220
114 — 220
201—$220
202— 220
203— 220
204— 220
205— 220
206— 230
207— 230
208— 230
209— 225
210— 225
211— 225
212— 230
213— 230
214— 230

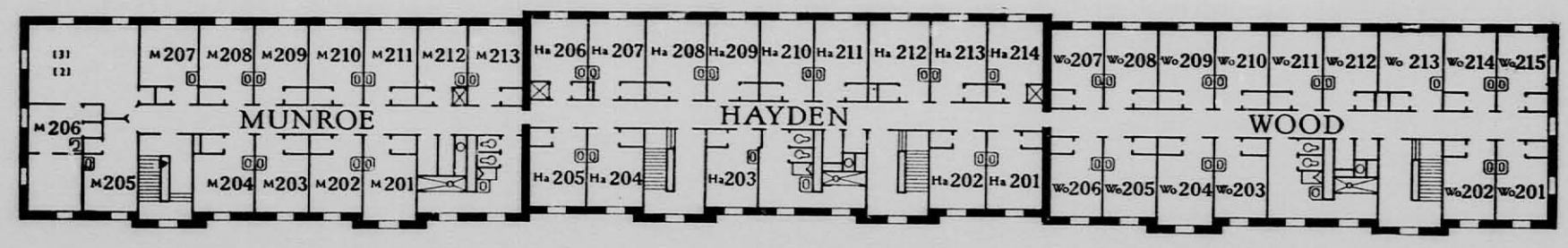
WOOD

101—$220
102— 205
103— 205
104— 210
105— 205
106— 205
107— 215
108— 215
109— 215
110— 215
111— 215
112— 215
113— 220
114— 215
115— 230
201—$230
202— 215
203— 215
204— 215
205— 215
206— 215
207— 225
208— 225
209— 225
210— 225
211— 225
212— 225
213— 230
214— 225
215— 240

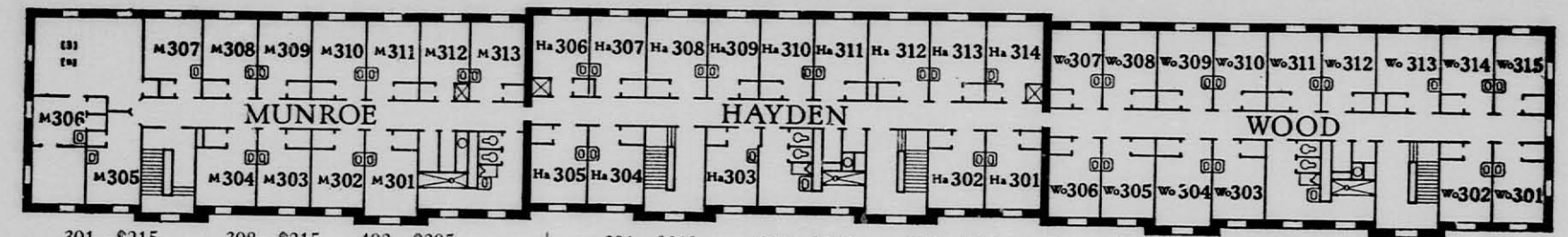
First Floor



Second Floor



Third Floor

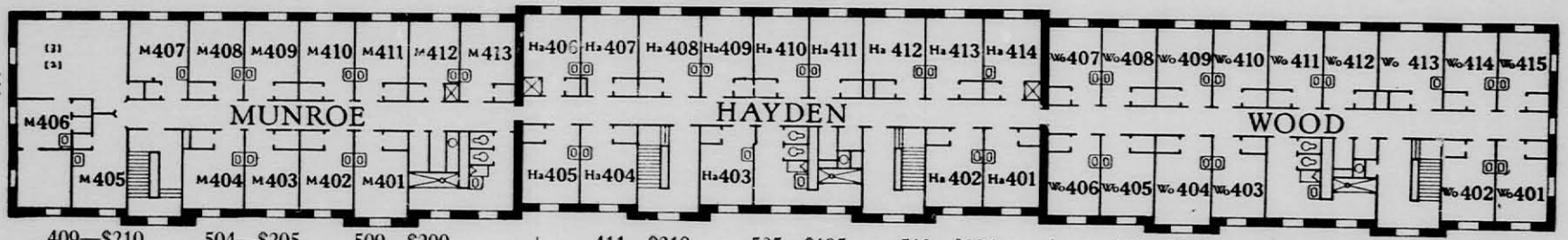


301—$215
302— 210
303— 210
304— 220
305— 210
306— 520 (2)
690 (3)
307— 220
308—$215
309— 215
310— 215
311— 215
312— 215
313— 215
401— 205
402—$205
403— 205
404— 215
405— 205
406— 560 (2)
660 (3)
407— 215
408— 210

301—$210
302— 210
303— 210
304— 210
305— 210
306— 220
307— 220
308— 220
309—$215
310— 215
311— 215
312— 220
313— 220
314— 220
401— 205
402— 205
403—$205
404— 205
405— 205
406— 215
407— 215
408— 215
409— 210
410— 210

301—$220
302— 205
303— 205
304— 210
305— 205
306— 205
307— 215
308— 215
309— 215
310—$215
311— 215
312— 215
313— 220
314— 215
315— 230
401— 215
402— 200
403— 200
404—$200
405— 200
406— 200
407— 210
408— 210
409— 210
410— 210
411— 210
412— 210

Fourth Floor

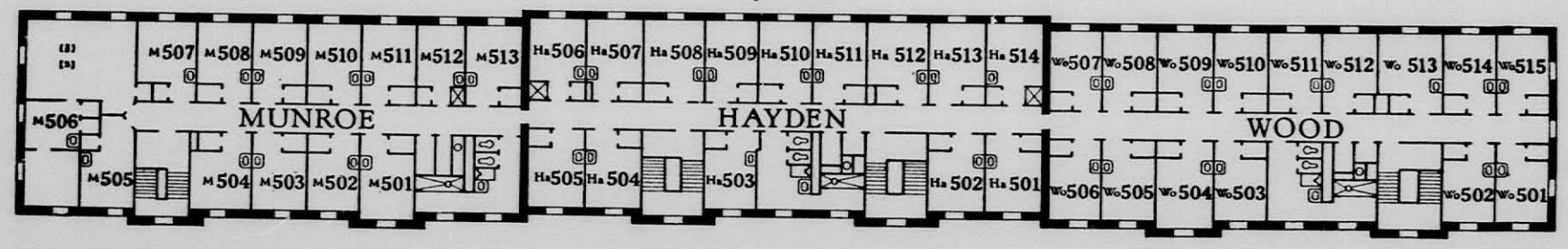


409—$210
410— 210
411— 210
412— 210
413— 210
501— 195
502— 195
503— 195
504—$205
505— 195
506— 480 (2)
630 (3)
507— 205
508— 200
509—$200
510— 200
511— 200
512— 200
513— 200

411—$210
412— 215
413— 215
414— 215
501— 195
502— 195
503— 195
504— 195
505—$195
506— 205
507— 205
508— 205
509— 200
510— 200
511— 200
512—$205
513— 205
514— 205

413—$215
414— 210
415— 225
501— 205
502— 190
503— 190
504— 190
505— 190
506—$190
507— 200
508— 200
509— 200
510— 200
511— 200
512— 200
513—$205
514— 200
515— 215

Fifth Floor



UNDERGRADUATE HOUSES

GOODALE, BEMIS AND WALCOTT HALLS (Alumni Group)

Reserved for Undergraduates

GOODALE

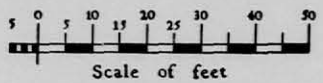
101—$215	201—$225
102— 205	202— 215
103— 205	203— 215
104— 215	204— 225
105— 205	205— 215
106— 205	206— 215
107— 215	207— 225
108— 225	208— 235
109— 215	209— 225
110— 215	210— 225
111— 225	211— 235
112— 215	212— 225
113— 215	213— 225
114— 225	214— 235

BEMIS

101—$175	201—$185
102— 200	202— 215
103— 175	203— 185
104— 175	204— 185
105— 175	205— 185
106— 175	206— 185
107— 200	207— 215
108— 175	208— 185
109— 185	209— 195
110— 210	210— 225
111— 185	211— 195
112— 270 (2)	212— 280 (2)
113— 185	213— 195
114— 210	214— 225
115— 185	215— 195

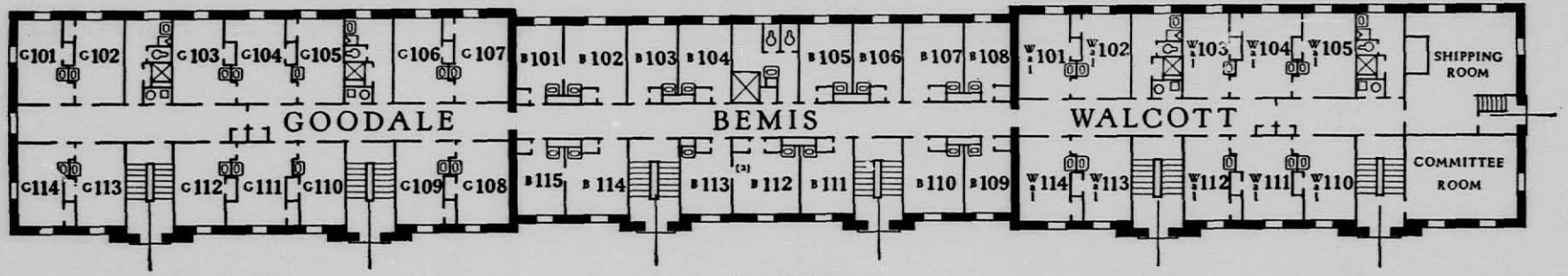
WALCOTT

101—$215	201—$225
102— 205	202— 215
103— 205	203— 215
104— 215	204— 225
105— 205	205— 215
110— 215	206— 215
111— 225	207— 235
112— 215	208— 235
113— 215	209— 225
114— 225	210— 225
	211— 235
	212— 225
	213— 225
	214— 235

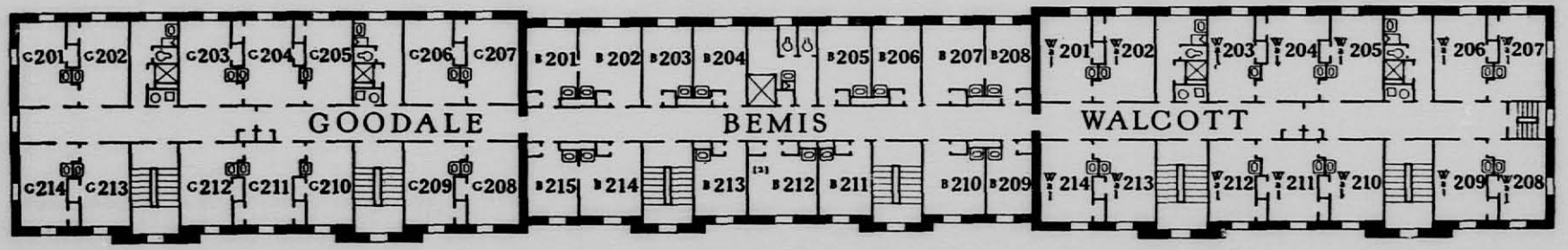


Scale of feet

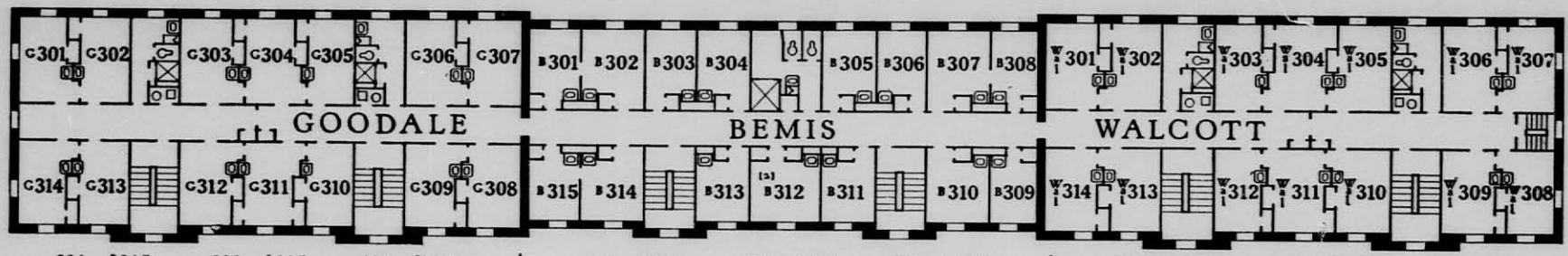
First Floor



Second Floor



Third Floor

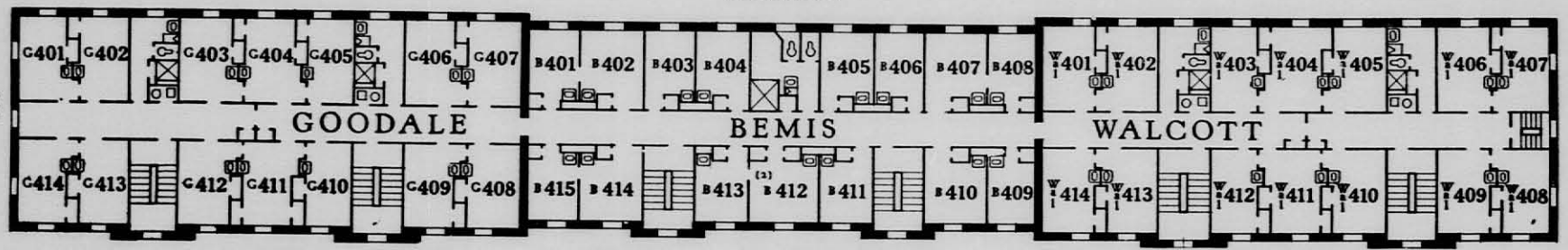


GOODALE		
301—$215	308—$225	401—$210
302— 205	309— 215	402— 200
303— 205	310— 215	403— 200
304— 215	311— 225	404— 210
305— 205	312— 215	405— 200
306— 205	313— 215	406— 200
307— 215	314— 225	407— 210

BEMIS		
301—$175	309—$185	401—$170
302— 200	310— 210	402— 195
303— 175	311— 185	403— 170
304— 175	312— 270 (2)	404— 170
305— 175	313— 185	405— 170
306— 175	314— 210	406— 170
307— 200	315— 185	407— 195
308— 175		408— 170

WALCOTT		
301—$215	308—$230	401—$210
302— 205	309— 215	402— 200
303— 205	310— 215	403— 200
304— 215	311— 225	404— 210
305— 205	312— 215	405— 200
306— 205	313— 215	406— 200
307— 230	314— 225	407— 225

Fourth Floor

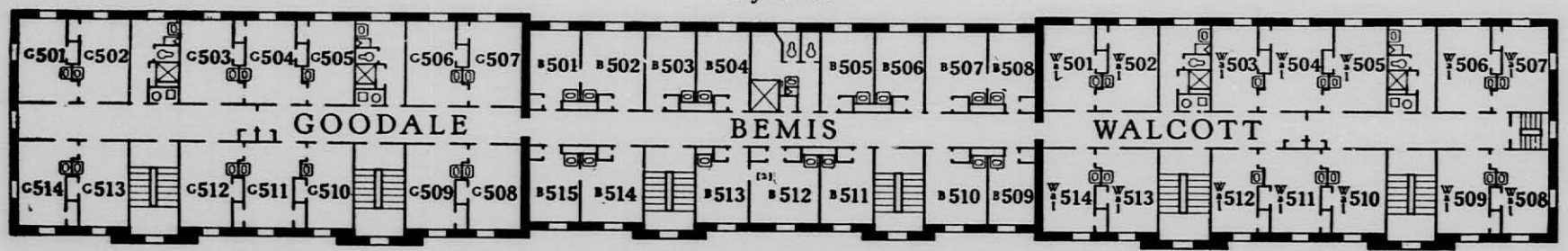


GOODALE		
408—$220	501—$200	508—$210
409— 210	502— 190	509— 200
410— 210	503— 190	510— 200
411— 220	504— 200	511— 210
412— 210	505— 190	512— 200
413— 210	506— 190	513— 200
414— 220	507— 200	514— 210

BEMIS		
409—$180	501—$160	508—$160
410— 205	502— 185	509— 170
411— 180	503— 160	510— 195
412— 260 (2)	504— 160	511— 170
413— 180	505— 160	612— 250 (2)
414— 205	506— 160	513— 170
415— 180	507— 185	514— 195
		515— 170

WALCOTT		
408—$225	501—$200	508—$210
409— 210	502— 190	509— 200
410— 210	503— 190	510— 200
411— 220	504— 200	511— 210
412— 210	505— 190	512— 200
413— 210	506— 190	513— 200
414— 220	507— 210	514— 210

Fifth Floor



ALPHABETICAL LIST OF SUBJECTS OF INSTRUCTION

(With reference to pages containing description)

ALPHABETICAL INDEX