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VOLUME 62 NUMBER 6

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CATALOGUE

ACADEMIC YEAR 1927-28

INCLUDING SPECIAL COURSES ARRANGED FOR OFFICERS OF THE UNITED STATES ARMY AND FOR OFFICERS OF THE UNITED STATES NAVY

APRIL, 1927
THE TECHNOLOGY PRESS
CAMBRIDGE

CALENDAR FOR ACADEMIC YEAR 1927–1928

	1927
Entrance Examinations at Technology Begin	Sept. 14
College Year Begins (First Term Registration Day) . .	Sept. 26
Christmas Vacation	Dec. 23–Jan. 2
	1928
Last Exercise, First Term	Jan. 21
Midyear Examination Period	Jan. 23–Feb. 4
Second Term Begins (Registration Day)	Feb. 6
Spring Recess	April 18–22
Last Exercise, Fourth Year	May 23
Fourth Year Examinations Begin	May 25
Last Exercise, Second Term	May 26
Annual Examinations Begin	May 28
Commencement Day	June 5
Examinations, College Entrance Examination Board . .	June 18–23
Summer Session Begins	June 11

CALENDAR FOR ACADEMIC YEAR 1928–1929

	1928
Entrance Examinations at Technology Begin	Sept. 12
College Year Begins (First Term Registration Day) . . .	Sept. 24
Christmas Vacation	Dec. 22–Jan. 1
	1929
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Midyear Examination Period	Jan. 21–Feb. 2
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Associate Professor of Mathematics

George Rutledge, Ph.D.
Assistant Professor of Mathematics

Norbert Wiener, Ph.D.
Assistant Professor of Mathematics

Philip Franklin, Ph.D.
Assistant Professor of Mathematics

Special Lecturer

Dirk Jan Struik, Dr.Math.

Instructors

Raymond Donald Douglass, M.A.
Lepine Hall Rice, A.B.
Samuel Demitry Zeldin, Ph.D.
Charles Henry Verse, M.S.

MECHANICAL ENGINEERING

EDWARD FURBER MILLER, Sc.D.
Professor of Steam Engineering
In charge of the Department
Director of Engineering Laboratories
Head of Ordnance School of Application
Dean of Army Students

ALLYNE LITCHFIELD MERRILL, S.B.
Professor of Mechanism
Secretary of the Faculty

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

WILLIAM ATKINSON JOHNSTON, S.B.
Professor of Theoretical and Applied Mechanics

CHARLES FRANCIS PARK, S.B.
Professor of Mechanism
Director of the Mechanical Laboratories
Director of the Lowell Institute School

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

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

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

HARRISON WASHBURN HAYWARD, S.B.
Professor of Materials of Engineering
Assistant Director, Division of Industrial Coöperation and Research

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

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

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

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

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

ROBERT HENRY SMITH, M.S.
Associate Professor of Machine Construction

EARLE BUCKINGHAM
Associate Professor of Engineering Standards and Measurements

JESSE JENNINGS EAMES, S.B.
Associate Professor of Experimental Engineering

DEAN ABNER FALES, S.B.
Associate Professor of Automotive Engineering

THOMAS SMITH, B.S., M.E.
Assistant Professor of Mechanism

IRVING HENRY COWDREY, S.B.
Assistant Professor of Testing Materials

DEAN PEABODY, JR., S.B.
Assistant Professor of Applied Mechanics

WILLIAM HENRY JONES, S.B.
Assistant Professor of Experimental Engineering

MYRON WILKINSON DOLE, S.B.
Assistant Professor of Mechanism

Special Lecturers

ROBERT LOUIS BROWNE, B.S.
Thermit Welding

FRED DAVIS
Electric Arc Welding

GEORGE JAEGER
Oxy-Acetylene Welding

CLIFFORD LORING MUZZEY, S.B.
Production

WILLIAM TAYLOR OBER
Electric Butt and Spot Welding

LEWIS DANIEL SPENCE
Automatic Machinery

HAROLD LEMOYNE VAN KEUREN, B.S
Measuring with Light Waves

Instructors

James Richard Lambirth
Charles Everett Littlefield
Roy Gibson Burnham, S.B.
Jeremiah Francis O'Neill
Ralph Guy Adams, S.B.
Arthur Brown English
Claude Hugh Clark
Arthur Lawrence Townsend, S.B.
James Holt, S.B.
Carl Louis Svenson, S.B.
Igor Nicholas Zavarine, S.M.
Robert Butterfield Cheney
George Howard Hardy
Albert Benoni Alsos, S.B. (*Absent*)
Birthram Sheppard
Edward Robinson Schwarz, S.B.
John Harvey Zimmerman, S.M.
Herbert Carlton Moore, S.B.
David Dinkel Jacobus, M.E.
Archibald McKechnie, Jr.

Assistants

Nicholas Nicholas Alexandroff, M.E., M.S.
Felix Bardach, Dip.Ing.
Robert Gottlieb Eschmann
Ellsworth Spencer Gray, S.B.
Richard Cornelius Hodges
Andrew Wyles Lawson
Mark William Libbey
Neil Butler MacLaren, S.B.
Francis Winfield Perkins, *Constructor of Apparatus*
Herbert Dyer Swift, S.B.
Morton Carter Swift
Arthur Francis Underwood, S.B.

MILITARY SCIENCE AND TACTICS

Harold Edward Cloke
Colonel, Coast Artillery Corps
Professor of Military Science and Tactics
In charge of the Department

Sydney Smith Winslow, M.S.
Major, Coast Artillery Corps, D.O.L.
Assistant Professor of Military Science and Tactics
In charge of Coast Artillery Unit

Cleveland Hill Bandholtz
Major, Ordnance Department, D.O.L.
Assistant Professor of Military Science and Tactics
In charge of Ordnance Unit

Lewis Edward Goodier, Jr., B.S.
Major, U. S. A., Retired
Assistant Professor of Military Science and Tactics
Executive Officer

Thomas Phillips
Captain, Chemical Warfare Service, D.O.L.
Assistant Professor of Military Science and Tactics
In charge of Chemical Warfare Unit

Harold Lewis Milan
1st Lieutenant, Signal Corps, D.O.L.
Assistant Professor of Military Science and Tactics
In charge of Signal Corps Unit

Geoffrey Maurice O'Connell, A.B.
1st Lieutenant, Coast Artillery Corps, D.O.L.
Assistant Professor of Military Science and Tactics
With Coast Artillery Unit

Anderson Thomas William Moore
1st Lieutenant, Corps of Engineers, D.O.L.
Assistant Professor of Military Science and Tactics
In charge of Engineer Unit

Elmer Ellsworth Barnes
1st Lieutenant, Corps of Engineers, D.O.L.
Assistant Professor of Military Science and Tactics
With Engineer Unit

Mark Rhey Woodward
1st Lieutenant, Air Corps, D.O.L.
Assistant Professor of Military Science and Tactics
In charge of Air Corps Unit

Instructors

William Wilkinson Robertson
1st Sergeant, D.E.M.L.
Coast Artillery Corps

Alfred Floyd Truax
Technical Sergeant, D.E.M.L.
Signal Corps

Homer Joseph Duncan
Staff Sergeant, D.E.M.L.
Corps of Engineers

Alexander Holmes
Staff Sergeant, D.E.M.L.
Coast Artillery Corps

Samuel Leroy Frey
Sergeant, D.E.M.L.
Chemical Warfare Service

John Burke Fitzgerald
Armorer
Sergeant, D.E.M.L.
Coast Artillery Corps

MINING AND METALLURGY

William Spencer Hutchinson, S.B.
Professor of Mining
In charge of the Department

George Booker Waterhouse, Ph.D.
Professor of Metallurgy
In charge of the Option in Metallurgy

Charles E Locke, S.B.
Associate Professor of Mining Engineering and Ore Dressing

Carle Reed Hayward, S.B.
Associate Professor of Metallurgy

Edward Everett Bugbee, S.B.
Associate Professor of Mining Engineering and Metallurgy

Horace Tharp Mann, Sc.D.
Associate Professor of Petroleum Engineering

Instructor

Rufus Cook Reed, S.B.

Assistants

Franklin LeRoy Foster, S.B.

Benjamin Burrrows Tremere, Jr., S.B.

NAVAL ARCHITECTURE AND MARINE ENGINEERING

James Robertson Jack
Professor of Naval Architecture and Marine Engineering
In charge of the Department
Director of the Nautical Museum
Dean of Navy Students

William Hovgaard
Professor of Naval Design and Construction
In charge of Course XIII-A

Henry Hiram Wheaton Keith, S.B.
Associate Professor of Naval Architecture

George Owen, S.B.
Associate Professor of Naval Architecture

Lawrence Boylston Chapman, S.B.
Associate Professor of Ship Operation and Marine Engineering

Evers Burtner, S.B.
Assistant Professor of Naval Architecture and Marine Engineering

Instructor

Frederick Alexander Magoun, S.M.

PHYSICS
(Including Electrochemical Engineering)

Charles Ladd Norton, S.B.
Professor of Industrial Physics
In charge of the Department
Director of the Research Laboratory of Industrial Physics
Director of Division of Industrial Coöperation and Research

Harry Manley Goodwin, Ph.D.
Professor of Physics and Electrochemistry
In charge of the course in Electrochemical Engineering
Dean of Graduate Students

William Suddards Franklin, Sc.D.
Professor of Physics

William Johnson Drisko, S.B.
Professor of Physics

Newell Caldwell Page, S.B.
Professor of Electricity

Maurice deKay Thompson, Ph.D.
Associate Professor of Electrochemistry

Gordon Ball Wilkes, S.B.
Associate Professor of Industrial Physics

Arthur Cobb Hardy, M.A.
Assistant Professor of Optics and Photography

William Raymond Barss, Ph.D.
Assistant Professor of Physics

Max Knobel, Ph.D.
Assistant Professor of Physics

John Torrey Norton, S.B.
Assistant Professor of Physics

Manuel Sandoval Vallarta, Sc.D.
Assistant Professor of Physics

Louis Henry Young, S.B.
Assistant Professor of Physics

Instructors

Royal Merrill Frye, A.M.
Francis Weston Sears, S.M.
Robert Edgar Hodgdon, B.S.
Oscar Kenneth Bates, S.M.
Donald Charles Stockbarger, Sc.D.
Thomas Harry Frost, S.M.
Alexander Loxley Massey Dingee, S.B.
Russell Weaver Conant, S.B.
Nathaniel Herman Frank, S.B.
William Bates Greenough, Jr., S.B. (*Absent*)
John Kimball Phelan, B.S.
Bertram Eugene Warren, S.M. (*Absent*)
Fred Hiram Perrin, S.M.
George Parsons Swift, S.B.

Research Associates

Frederick Harwood Norton, S.B.
William Phelps Allis, Sc.D.
Hans Muller, Dip. Ing.
Cyril Stanley Smith, B.Sc., Sc.D.
Frederick William Cunningham, S.B.
Henry Guinness de Laszlo, Ph.D.

Assistants

Elof Benson
Curator of Apparatus
LeBaron Carleton Colt, S.B.
Homer Duggan, S.B.
Robert Burns Morrissey, S.B.
Carl Gustav Selig
Constructor of Apparatus
Elmer Chapman Warren, S.B.

Research Assistants

Charles Ladd Norton, Jr., S.B.
Arnold Flint Taylor, S.B.

ROMANCE LANGUAGES

Ernest Felix Langley, Ph.D.
Professor of French
In charge of the Department

Instructors

Marc Denkinger, A.M.
Jaques Henri Pillionnel, A.M.

COURSE IN MILITARY ENGINEERING

Committee in Charge of Course

Edward Furber Miller, Sc.D.
Colonel, O. R. C.
Professor of Steam Engineering
In charge of the Department of Mechanical Engineering
Director of Engineering Laboratories
Head of Ordnance School of Application
Dean of Army Students

Harold Edward Cloke
Colonel Coast Artillery Corps
Professor of Military Science and Tactics
In charge of the Department of Military Science

Vannevar Bush, M.S., Eng.D.
Lieutenant Commander, U. S. R.
Professor of Electric Power Transmission

DIVISION OF GENERAL STUDIES

Special Lecturers

James Libby Tryon, LL.B., Ph.D.
International Law
Stephen Sumner Townsend
Director of Choral Music
Hector H. Holmes
Business and Patent Law
Irving C. Whittemore
Psychology

DIVISION OF MUNICIPAL AND INDUSTRIAL RESEARCH

William Austin Bassett, S.B.
Professor of Municipal and Industrial Research
In charge of the Division

DIVISION OF INDUSTRIAL COÖPERATION AND RESEARCH

Charles Ladd Norton, S.B.
Director

Harrison Washburn Hayward, S.B.
Assistant Director

Earl Bowman Millard, Ph.D.
Assistant Director

Raymond Percy Miller, S.B.
Personnel Manager

STAFF OF THE SCHOOL OF CHEMICAL ENGINEERING PRACTICE

(For details see Department of Chemical Engineering, page 9)

R. T. Haslam
W. P. Ryan
H. C. Weber
F. W. Adams
W. T. Dixon
J. T. McCoy
C. W. Richards

STAFF OF THE RESEARCH LABORATORY OF APPLIED CHEMISTRY

(For details see Department of Chemical Engineering, page 9)

R. T. Haslam
G. L. Clark
R. P. Russell
G. H. B. Davis
H. O. Forrest
P. K. Frölich
R. H. Aborn
E. L. Chappell
H H. Lagerpusch
O. F. Neitzke
H. D. Wilde
W. C. Asbury
M. W. Boyer
H. J. MacMillan
J. H. Boyd, Jr.
E. W. Brugmann
C. M. Cooper
E. V. Fasce
K. R. Fitch
R. L. Hershey
T. J. N. Hubbuch
A. M. Kazazian
A. E. Kunberger
C. Lyng
G. R. McDaniel
I. L. Murray
D. C. Otis
J. K. Roberts
B. E. Roethelli
C. M. Smith, Jr.
V. C. Smith
E. Tauch
A. H. Waitt
T. E. Warren
A. White
P. J. Wiezevich

STAFF OF THE RESEARCH LABORATORY OF ELECTRICAL ENGINEERING

(For details see Department of Electrical Engineering, page 13)

D. C. Jackson
F. A. Laws
V. Bush
R. A. Hudson
F. G. Kear
H. Shore

STAFF OF RESEARCH LABORATORY OF INDUSTRIAL PHYSICS

(For details see Department of Physics, page 20)

C. L. Norton
W. J. Drisko
N. C. Page
G. B. Wilkes
W. R. Barss
J. T. Norton
L. H. Young
O. K. Bates

STAFF OF THE RESEARCH LABORATORY OF ORGANIC CHEMISTRY

(For details see Department of Chemistry, page 10)

J. F. Norris
S. P. Mulliken
T. L. Davis
A. A. Morton
A. A. Ashdown
H. S. Davis
Res. Fellow, Amer. Petroleum Inst.
J. Piccard

STAFF OF THE RESEARCH LABORATORY OF PHYSICAL CHEMISTRY

(For details see Department of Chemistry, page 10)

F. G. Keyes
W. R. Whitney (*Non-Resident*)
L. J. Gillespie
J. A. Beattie
G. Scatchard
L. B. Smith
E. Lurie
O. C. Bridgeman, *Nat. Res. Fellow*
J. K. Thornton
N. B. Carter
C. K. Lawrence
E. L. Skau, *Nat. Res. Fellow*

STAFF OF THE AERONAUTICAL RESEARCH LABORATORY

(For details see Course in Aeronautical Engineering, page 7)

E. P. Warner
W. G. Brown
S. Ober
W. F. Eade
J. R. Markham

STAFF OF THE RESEARCH LABORATORY FOR AIRCRAFT ENGINES

C. F. Taylor
L. M. Porter

GENERAL INFORMATION

Purpose of the Massachusetts Institute of Technology. — Its primary purpose is to afford to students such a combination of general, scientific and professional training as will fit them to take leading positions as engineers, scientific experts, and teachers and investigators of science. It is also one of its important functions to contribute to the existing store of scientific knowledge and to the promotion of industrial development through the prosecution in its laboratories of original researches in pure and applied science.

The school consists of the Professional Departments of Civil and Sanitary Engineering, Mechanical Engineering, Mining and Metallurgy, Architecture, Chemistry, Electrical Engineering, Biology and Public Health, Physics, Chemical Engineering, Geology and Naval Architecture and Marine Engineering; and the Professional Courses in General Science and Engineering, Mathematics, Engineering Administration, Aeronautical Engineering, Building Construction, Military Engineering and Fuel and Gas Engineering. In addition to these are the Departments of English and History, Economics and Statistics, Mathematics, Military Science, German, Romance Languages, Hygiene and the Divisions of Drawing, General Studies, and Municipal and Sanitary Research.

The Institute offers to its students both undergraduate and graduate courses of study. The former lead to the degree of Bachelor of Science or Bachelor in Architecture; the latter, to the degrees of Master in Architecture, Master of Science, Doctor of Philosophy, Doctor of Science or Doctor of Public Health. It also affords to advanced students and to more experienced investigators excellent opportunities for the pursuit of original scientific investigations in its departmental special research laboratories.

The Institute also maintains Research Laboratories of Physical Chemistry, Applied Chemistry, Industrial Physics, Electrical Engineering and Aerodynamics.

Historical Sketch. The foundation of the Massachusetts Institute of Technology was laid in a "Memorial" prepared in 1859 by Professor William Barton Rogers, and presented, by a Committee, to the Legislature of the Commonwealth of Massachusetts of 1860. In this Memorial "reference is made to the expected early establishment of a comprehensive Polytechnic College, furnishing a complete system of industrial education supplementary to the general training of other institutions and fitted to equip its students with every scientific and technical principle applicable to the industrial pursuits of the age."

On April 10, 1861, an Act was passed by the General Court of Massachusetts to incorporate The Massachusetts Institute of Technology "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 application of science in connection with arts, agriculture, manufactures and commerce."

The first meeting of the Institute for organization was held April 8, 1862, but the Civil War led to the postponement of the opening of the School of Industrial Science. A preliminary session of the school was opened on February 20, 1865, fifteen students attending. The regular courses of instruction began October 2, 1865.

For fifty years the Institute developed on the original site granted by the State. During this time the number increased from fifteen students to nineteen hundred, the staff of instruction from ten to three hundred, and the number of courses of study leading to the degree of Bachelor of Science from six to fifteen.

Location. After occupying for fifty years its original location in Boston the Institute moved to a new site on the Charles River Basin. This site comprises a tract of approximately eighty acres extending along the esplanade on the Cambridge side of the river and affording an extensive panoramic view of the city of Boston. Here are located the Educational Buildings, the Walker Memorial, the Dormitories, the Athletic Field and the Power Plant. Many street car and subway lines afford easy access from all parts of Boston, Cambridge, the suburbs, and the railroad stations for trains from the north, south and west. The location of the Institute in proximity to the great collections and libraries of Boston and Cambridge, and in the neighborhood of a great manufacturing district is of great advantage to technological students.

The Department of Architecture is located in Boston and occupies the Rogers Building on the old site on Boylston Street.

EDUCATIONAL BUILDINGS

Libraries. The Library of the Institute contains about one hundred and seventy thousand volumes and sixty thousand pamphlets and maps, and receives regularly more than one thousand current periodicals. It includes the Central Library and a number of Departmental-Libraries and Reading Rooms.

The main collection of books is situated in the stack surrounding the Central Reading Room. This room affords a convenient place for reading and study. It is open on week days during term time from 9 a.m. to 10 p.m. except Saturdays when it is closed at four o'clock.

Laboratories. The most marked characteristic of the Institute from the material point of view consists of its numerous large and well equipped laboratories. Recognition of the value of laboratory instruction as a fundamental element in general education and of the proper function of such instruction is of comparatively recent origin, dating only from the latter half of the last century. Emphasis has been placed on such work from the beginning, the Institute having taken the initiative in the establishment of laboratory instruction in scientific and engineering subjects.

M.I.T. ANNUAL CATALOGUES AND BULLETINS
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The principal laboratories are listed below:

The Mechanical Engineering Laboratories, including the Laboratory of Steam and Compressed Air, the Hydraulic Laboratory, the Refrigeration Laboratory, the Testing Materials Laboratories, the Gas Engine Laboratory, the Power Measurement Laboratory, and the Laboratories of Mechanic Arts.

The Laboratories of Mining Engineering and Metallurgy.

The Laboratories of Chemistry.

The Laboratories of Chemical Engineering.

The Research Laboratories of Physical Chemistry.

The Research Laboratory of Applied Chemistry.

The Laboratories of Electrical Engineering.

The Research Laboratories of Electrical Engineering.

The Laboratories of Biology and Public Health.

The Laboratories of Physics, including Laboratories of General Physics and the special laboratories of Heat, Optics, Electricity, Electrochemistry and Industrial Physics (Research).

The Mineralogical and Geological Laboratories.

The Aerodynamic Laboratory.

The Institute laboratory work is effectively supplemented by visits to engineering and industrial establishments, and by excursions directed by members of the Faculty.

DORMITORIES

The first unit of the Institute Dormitories is located on Charles River, east of the Walker Memorial. It is built along the north and east sides of the lot that contains the President's house.

The unit consists of six halls named Ware, Atkinson, Runkle, Holman, Nichols and Crafts, in honor of professors at the Institute in its earlier years. Each hall has a separate entrance, and is four stories high, except in the case of Runkle, which has rooms on six floors. The unit has accommodations for two hundred fifteen men.

The first section of a second Dormitory unit was constructed during the winter of 1923–24, and was made possible by the gift of $100,000 from the Class of '93, at its thirtieth reunion. It is located on the Institute campus near Walker Memorial.

This hall, named Ninety-Three, will accommodate eighty men, is five stories high and will eventually join with other sections contemplated, in forming a quadrangle.

A circular giving details in regard to application for and allotment of rooms, equipment, rentals, payments, occupancy, government of the dormitories, and other information may be had on application to Horace S. Ford, Bursar of the Institute.

As the exercises of the school begin at nine o'clock in the morning, and end by five o'clock in the afternoon, students may conveniently live in any of the nearer cities or towns on the lines of the various railroads, if they prefer to do so.

The Technology Christian Association keeps a list of desirable rooms available for students.

EXPENSES

An estimate of expenses for the school year, a period of 38 weeks, is given below:

For a Period of 38 Weeks

Tuition	$300	
Average Fees	20	$330.00
Undergraduate Dues	10	
Board		380.00
Room		240.00
Books and Materials		90.00
		$1,040.00

To assist students in securing employment, either during the school year or the summer, an Undergraduate Employment Office 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, without danger of permanent impairment of health. 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 language and business customs of a strange country.

RECREATIONAL FACILITIES

The Walker Memorial, built in memory of the late president, General Francis A. 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 of the building is the gymnasium with lockers and dressing rooms. There are offices for the various student activities, squash courts and rooms for hand ball. There are recreation and reading rooms, an excellent and growing library and on the first floor a large dining hall with cafeteria service at low prices. In the grill room a *table d'hote* lunch is served and other dining rooms are provided for class dinners and dinners of any Technology organization. In the basement are found bowling alleys and a billiard room. A matron is in attendance and excellent opportunities are afforded for the entertainment of guests. Adjacent to this building are twelve tennis courts; a regulation football field, which is also used for soccer; and a baseball diamond; a quarter-mile cinder track with a 220-yard straightaway; and accommodations for the field events.

In order to take care of the needs of the track men for the winter an out-door board track with a 70-yard straightaway is provided. There is near the athletic field, another gymnasium with a regulation basket ball court. Bleachers which will accommodate approximately 400 are built along one side. In addition there is a movable boxing ring 24 feet square;

wrestling mats and indoor jumping pits. Also connected with this building are eight squash courts.

A boathouse on the Charles River is fully equipped with indoor rowing apparatus, showers, lockers, etc. A number of singles and wherries are 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.

UNDERGRADUATE ACTIVITIES

Massachusetts Institute of Technology Undergraduate Association. The student government of the undergraduates at Technology is in the hands of the Institute Committee, a body representing every important student activity.

The Technology Christian Association. The Technology Christian Association aims to be of practical service to every student at the Institute, and to help Technology realize its highest ideals. Its purpose is " to foster among the members of the Institute the best ideals of Christian living and to enlist them in active Christian service."

All students and members of the Institute who are in sympathy with the objects of the Association and wish to coöperate in promoting them are eligible to membership.

There are no membership dues, but the Association depends for support upon the voluntary contributions of the students. The general secretary is a college graduate, and gives full time to the direction of the work. The expenses of the secretarial office are collected from the alumni and other friends of the Institute, and are expended under the direction of an advisory board.

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

No attempt is made to concentrate on the few men composing a single varsity team, but coaching and instruction is given to all men reporting for a given sport. As a corollary to this, the success of a given athletic activity is gauged by the number of men it attracts. Varsity and class teams are maintained in a wide variety of athletic exercise. Among the activities may be named: track and field sports, cross country, rowing, basket ball, boxing, fencing, golf, gymnastics, hockey, rifle shooting, soccer, swimming, tennis, wrestling, while class teams only are developed in football and baseball. Squads range from the twenty to thirty men who report for fencing to the two hundred to three hundred men who are interested in track or in rowing. A coaching system is being gradually developed for most of these activities.

The physical equipment for the conduct of these various sports is being steadily improved.

Tech Show. The Tech Show, which is produced each year during Junior Week, is a musical comedy written, staged, acted, and orchestrated entirely by undergraduates.

Combined Musical Clubs. The Combined Musical Clubs of the Institute consist of the Glee, Mandolin and Banjo Clubs. The Musical Clubs are among the oldest activities in the school, the Glee Club having been founded in the fall of 1880.

Undergraduate Publications. *The Tech*, the newspaper of Technology, established in 1881, is published three times a week throughout the academic year.

Technique is the yearbook of the Institute and forms a permanent record of all the notable undergraduate activities. It also contains a photograph of each member of the Senior Class.

Voo Doo is Technology's monthly humorous publication.

The Tech Engineering News is the professional journal of the undergraduates, and is published monthly throughout the school year. Its purpose is to disseminate news of scientific and industrial interest by publishing articles written by prominent alumni and engineers, the results of original investigations conducted in the Institute laboratories, news of scientific interest, and articles on topics of timely importance.

GENERAL REGULATIONS

Academic Year. Exercises of the Institute begin on the last Monday in September and end early in June. The calendar appears on page 2. The exercises of the Institute are omitted on Massachusetts legal holidays, which are January 1, February 22, April 19, May 30, July 4, Labor Day, October 12, Thanksgiving Day and December 25.

Summer Session. Subjects are offered which correspond to most of those given during the regular school year. Professional summer schools in Civil Engineering, Mining Engineering, Metallurgy, Chemistry, and Geology and Mineralogy are carried on either regularly or at intervals. Some of this work is supplementary to and different in character from that given during the regular terms. Certain entrance subjects are also given at the Institute in the summer. The passing of any one of these subjects will excuse an applicant from taking the regular entrance examination in that subject.

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

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

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

Entrance conditions shall be made up before the beginning of the second year except as extension of time or other alternative may for special reasons be allowed by the Faculty.

Attendance. After approval of his registration the student must attend all exercises, including the final examination in the subjects for which he is registered. Irregular attendance, habitual tardiness or inattentiveness may lead to probation. With the exception of an interval of one hour in the middle of the day, students are, in general, expected to devote themselves to the work of the school between the hours of 9 a.m. and 5 p.m. There are no exercises on Saturday after 1 p.m., and the rooms are closed. Students who withdraw during the term should immediately notify 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 to the Dean of adequate evidence of sickness or other valid reason for the absence, the Faculty 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 at the end of the second term; 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 such 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.

Health of Students. The Department of Hygiene is organized to protect and improve the health of students and to take care of those who become sick or injured. A clinic is held by a doctor every morning and afternoon for the care of the sick and injured, and gymnastic facilities are available for all students. Students in the first year are required to take physical exercise, and have their option of taking routine gymnastic work in the gymnasium or substituting one of the competitive sports.

Every student who enters the Institute is given a physical examination, and if any defects are found an effort is made to correct them. With a view to correcting certain defects a course in gymnastics is given by an Instructor especially trained in this work. Students who are found to be markedly underweight may, if they desire, enter a special class which has been organized to ascertain and remove the cause of this condition. Accurate measurements are taken at the first of the year of all the men entering physical training.

At the end of each year bronze medals, the gift of the late Samuel Cabot, '70, are given to the five students who make the greatest improvement in strength, measurements, and general gymnastic efficiency, as indicated by the physical examinations and as shown in regular class work. Five more students are given Honorable Mention.

Seniors are given a physical examination during their fourth year in order to determine the effect of the four years' study on their health, and the effects of the physical training on their development.

Military Science. All male students, except aliens, who are under twenty-eight years of age and who are rated as first or second-year students, are required to attend exercises in military science and drill. The military exercises include not only military drill but also lectures upon military subjects.

Physically defective students who would be injured by drill will be furnished written excuse from drill only by the Medical Director.

Several units of the Reserve Officers' Training Corps, such as Artillery, Engineer Corps, Ordnance, Signal Corps, Air Service and Chemical Warfare are arranged, whereby students may prepare themselves to become reserve officers in these various branches of the Army. Members of this R.O.T.C. continue their military work through the third and fourth year in conjunction with their professional courses and receive pay for taking this additional military training.

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. In case of injury to any building, or to any of the 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 caused 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. In case the offense be a less serious one, the student may be placed upon probation.

It is the aim of the Faculty so to administer the discipline of the school as to maintain a high standard of integrity and a scrupulous regard for truth. 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 make appeal for special consideration of his individual case. All petitions must be submitted on printed blanks furnished for the purpose, which may be obtained at the Information Office, Room 10–100.

Advisers. The Dean is the general consulting officer for students, and coöperates with the President in matters touching discipline and general student relations. In coöperation with the Technology Christian Association a number of upper classmen are selected to act as advisers to incoming students. These men are assigned to students who have taken entrance examinations, and they will help new men in matters of registration, in the selection of rooms, etc.

On request to the Dean, advisers from the instructing staff will also 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.

FEES, DEPOSITS, PAYMENTS, ETC.

Tuition Fees. The tuition fee for all students pursuing regular courses in 1927–28 is $300 per year and must be paid *in advance* as follows: $150 before the opening of each term, the date and hour to be specified in the Registration Instructions issued prior to the opening of each term.

The tuition fees for students taking Course VI-A after the second year or X-A are $100 per term (3 terms).

Beginning September 1928, the tuition fee will be $400 per year for all students, which amount will include laboratory fees and undergraduate dues.

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 to the Bursar, Room 10–180, before the last examination or may be remitted in advance.

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 Laboratory Fees, Breakage, etc. To cover laboratory fees, etc., all students (except men taking Course IV, Option 1, and officers detailed by United States Army or Navy Department) will be required to make a deposit, from which the fees covering laboratory courses, chemical and mining breakage, etc., are to be deducted.

If the total of the fees, breakage, etc., 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.

These deposits are due and payable with the first term's tuition.

1.	*All First-Year Men* (Except Course IV)	$25.00
2.	*All Upper Classmen*	50.00
	With exceptions as follows:	
	Civil Engineering, Course I	25.00
	Architecture, Course IV	none
	Architectural Engineering, Course IV-A	15.00
	Engineering Administration, Course XV, Option 1	15.00
	Engineering Administration, Course XV, Option 2	25.00
3.	*All Special and Unclassified Students*	50.00

Students will not be permitted to enter upon their work in the various laboratories without making the above deposits.

See detailed list of laboratory fees.

For students taking Military Drill, a deposit of $25 is required. Amounts are returned for each unit of the equipment which the student returns to the Military Department, in condition commensurate with its use, at the end of the school year or upon his withdrawal.

Graduate and Undergraduate Dues. Dues of $10.00 per year are levied on all male students who pay, or have paid on their behalf, more than half the regular tuition fees for the year and the corresponding tax for students who pay one-half the regular tuition fee or less is $5.00 per year.

These dues are payable in two equal parts, $5.00 each term, upon the same dates as the tuition fee and are levied on all students, including special students and unclassified students.

In the case of female students the dues are $5.00 per year.

Dues will be remitted and the corresponding amount supplied from funds applicable to such purposes in the case of all students who are granted scholarships on the basis of financial need and of others who may be exempted from the payment of dues by a committee appointed to deal with such matters.

The proceeds of the dues will be devoted to the promotion of student life at the Institute with special reference to the physical and social welfare of the students. No part shall 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	.36
Class Dues	.44
Athletics	6.80
Walker Memorial	1.00
Department of Hygiene	1.00
Reserve and Contingent Fund	.40

Payments. *No bills are sent.* All payments should be made to Horace S. Ford, Bursar, Massachusetts Institute of Technology, Cambridge, Mass. *Students are strongly advised to make payments by mail, as they will find it greatly to their convenience to do so.*

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.

Payment is required also for apparatus injured or destroyed in the laboratories, and for the cost of repair of damage by students to any other property of the Institute.

SCHOLARSHIPS, FELLOWSHIPS AND PRIZES

UNDERGRADUATE SCHOLARSHIPS

The Institute holds funds bequeathed or given to it from which undergraduate scholarships are awarded and for several years, the amount annually available for this purpose has averaged about $60,000.

It is the policy of the Faculty Committee on Undergraduate Scholarships to apply the available scholarship funds to the assistance of as many well qualified, needy students as possible by assigning, in general, amounts less than full tuition. Awards are made, except in a few special instances, only to students who have completed at least a year of satisfactory work at the Institute. All students receiving scholarship aid are exempt from payment of Undergraduate Dues, such dues being paid in their behalf from other Institute funds.

The facts considered in making assignments are the needs of the student and his ability as indicated by his scholastic record. Awards are divided between the terms of the year and the amount assigned to the second term may be cancelled if the recipient's record for the first term is unsatisfactory.

Applications for undergraduate scholarship aid should be made not later than February 15 on blanks to be obtained at Room 3-108. Applications by entering students for the Cambridge Scholarships should be filed before July 1, of the year in which they plan to enter the Institute.

The scholarships described below are arranged in the alphabetical order of their names, the figures in parenthesis being the dates of establishment:

Elisha Atkins Scholarship Fund (1894). Founded by Mrs. Mary E. Atkins of Boston with a gift of $5,000.

Edward Austin Fund (1899). By the will of Edward Austin, the Institute received a bequest of $400,000, the income of which is available for "needy, meritorious students and teachers to assist them in payment of their studies."

Thomas Wendall Bailey Fund (1914). By the will of Thomas Wendall Bailey, the Institute received a bequest, the income of which is used "in rendering assistance to needy students in the Department of Architecture."

Charles Tidd Baker Fund (1922). By the will of Charles Tidd Baker, the Institute received a bequest of $20,000, one half of the net income of which is "applied each year to the assistance of poor and worthy students."

Billings Student Fund (1900). By the will of Robert C. Billings, the Institute received a bequest of $50,000 "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 Fund (1915). By the will of Frank W. Boles, the Institute received a bequest of $10,000 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 Scholarship Fund (1915). By the will of Hannah B. Abbe, the Institute received a bequest of $10,000 to constitute a fund "known as the Jonathan Bourne Scholarship Fund, the income only to be used in aid of deserving students."

Harriet L. Brown Scholarship Fund (1922). By the will of Harriet L. Brown, the Institute received a bequest "to be held in trust as a scholar ship . . . 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."

Cambridge Scholarships (1916). A limited number of scholarships are granted to students entering the first year class at the Institute who are graduates of schools in Cambridge and children of legal residents of that city. These scholarships are for full tuition and are awarded by competition on the results of the regular entrance examinations. They are confined to students who make application furnishing evidence of need, and who obtain clear entrance records. They may be continued in the second, third and fourth years upon application, providing the holder maintains a satisfactory scholastic record and continues to furnish evidence of need. Forms of application for these scholarships, including complete regulations concerning them, may be obtained at Room 3-108. Applications by entering students should be filed before July 1, of the year in which they plan to enter the Institute.

Camp Devens Scholarship (1926). This scholarship was established by the Institute and is awarded to the member of the Citizens Military Training Camp at Camp Devens, Massachusetts, selected from the "Whites" or the "Blues," based on the reports and records transmitted to the First Corps Area Headquarters of the United States Army. Applicants must be men who have not sufficient funds to pay all expenses while at Technology, and must either pass, or have passed, the entrance examinations to the Institute. The scholarship will be awarded for the freshman year and will be renewed for the second and succeeding years upon application, providing the holder maintains a satisfactory scholastic record and continues to furnish evidence of need.

Mabel Blake Case Fund (1920). By the will of Caroline S. Freeman, the Institute received a bequest of $25,000 to constitute "a fund known as Mabel Blake Case Fund, income to be used to aid deserving students (preferably women) who are in need of assistance."

Nino Tesher Catlin Scholarship Fund (1926). From Maria T. Catlin, the Institute received a gift 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 . . . if possible . . . to a member of the Lambda Phi Fraternity."

Lucius Clapp Scholarship Fund (1905). From Lucius Clapp, the Institute received a gift to form a fund of which the net income is used "to aid worthy students who may not be able to complete their studies without help."

Class of '96 Scholarship Fund (1923). This fund was received from the M.I.T. 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 repayed by the recipients when and if able.

Lucretia Crocker Scholarship Fund (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 Scholarship Fund (1903). By the will of James H. Danforth, the Institute received a bequest of $5,000 for scholarship purposes as a memorial to his brother, Isaac Warren Danforth.

Ann White Dickinson Scholarship Fund (1898). By the will of Ann White Dickinson, the Institute received a bequest of $40,000 "to establish free scholarships in M.I.T. . . .such persons enjoying benefit. . .shall be worthy young men of American origin."

Farnsworth Scholarship (1889). Founded by Mrs. Mary E. Atkins of Boston with a gift of $5,000.

Charles Lewis Flint Scholarship Fund (1889). By the will of Charles L. Flint, the Institute received a bequest of $5,000, the income of which was designated for the "support of some worthy student, preference to be given to some graduate of the English High School, Boston."

Sarah S. Forbes Scholarship Fund (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 by them in 1913 to the Institute. The income is available "for the maintenance and education of a scholar in M.I.T."

Norman H. George Fund (1919). By the will of Norman H. George, the Institute received a bequest "to be used for the assistance of needy and worthy students in obtaining an education in M.I.T."

George Hollingsworth Scholarship Fund (1916). By the will of Rose Hollingsworth, the Institute received a bequest of $5,000 to found a scholarship to be known as the George Hollingsworth Scholarship.

T. Sterry Hunt Scholarship Fund (1894). By the will of T. Sterry Hunt, for seven years Professor of Geology at Technology, the Institute received a bequest of $3,000 to found a scholarship in his name. This scholarship is restricted to students of Chemistry and preference is given to those in the higher years.

William F. Huntington Scholarship Fund (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."

Joy Scholarship (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 Scholarship Fund (1910). By the will of William Litchfield, the Institute received a bequest of $5,000 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."

Lloyd's Scholarship Fund (1922). This scholarship was founded by Lloyd's Registry of American and Foreign Shipping. The stipend is $500 per annum and the scholarship is tenable for three years, being awarded on the applicant's freshman record. Beneficiaries are required to pursue the Institute's course in Naval Architecture and Marine Engineering.

Elisha T. Loring Scholarship Fund (1890). By the will of Elisha Thacker Loring, the Institute received a bequest of $5,000, the income of which is available for "the assistance of needy and deserving pupils."

Lowell Institute Scholarship Fund (1923). This fund was received as a gift from the alumni of the Lowell Institute School to found an M.I.T. scholarship for graduates of that school.

George H. May Scholarship Fund (1914). From George H. May of the Class of 1892, the Institute received a gift of $5,000 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 Masters of the Newton High Schools." Beneficiaries under this fund are expected to issue a note agreeing to repay the face value, without interest, of amounts received.

Milton High School Scholarship Fund (1885). Founded by the Institute in recognition of contributions from residents of Milton. This scholarship is conferred upon such former pupil 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.

James H. Mirrlees Scholarship Fund (1886). From James Buchanan Mirrlees of Glasgow, Scotland, the Institute received a gift of $2,500 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 Scholarship (1895). By the will of Mrs. Betsy F. W. Nichols, the Institute received a bequest of $5,000 to constitute a scholarship called 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 in the award is given to students in the course in Chemistry.

Charles C. Nichols Scholarship (1904). By the will of Charles C. Nichols, the Institute received a bequest of $5,000 to constitute a scholarship.

John Felt Osgood Scholarship Fund (1909). By the will of Eliza B. Osgood, the Institute received a bequest of $5,000 "to establish and maintain a scholarship in Electricity in memory of my husband, John Felt Osgood."

George L. Parmelee Scholarship Fund (1921). By the will of George L. Parmelee, he bequeathed to the Institute "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 Scholarship Fund (1887). By the will of Richard Perkins, the Institute received $100,000, the income from half of which is available for the "support of free scholarships in said Institute."

Alumni Regional Scholarships (1926). As a means of obtaining the coöperation of 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 have been established. These awards are open to American citizens of good character and health whose standing in their preparatory school studies has been high. An applicant must have passed his entrance examinations with a good record and have fulfilled all other requirements for admission. Grants are renewable upon application for the second and succeeding years providing the recipient maintains a satisfactory scholastic record and continues to furnish evidence of financial need.

William Barton Rogers Scholarship (1904). In commemoration of the early association of President William Barton Rogers with William and Mary College of Virginia, the Institute established a scholarship with the value of $300 a year, to be known as the William Barton Rogers Scholarship. It is granted to a student nominated by the Faculty of William and Mary College.

John P. Schenkl Scholarship Fund (1922). By the will of Johanna Pauline Schenkl, the Institute received a bequest of $20,000 "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 Scholarship Fund (1871). Founded with a gift of $5,000 from the English High School Association in memory of Thomas Sherwin. Holders of this scholarship must be graduates of the English High School of Boston and must be pursuing a regular course at the Institute.

Samuel E. Tinkham Fund (1924). By a gift from the Boston Society of Civil Engineers, this fund was established to aid a worthy student in Civil Engineering. The Institute is required to advise the Society annually of the disposition of this income.

F. B. Tough Scholarship (1924). This fund is established "for the purpose of extending financial assistance to worthy students." Preference is given to students in Mining or Oil Production.

Susan Upham Scholarship Fund (1892). From Susan Upham the Institute received a gift of $1,000, the income to be used "to assist students deserving financial aid."

Vermont Scholarship (1924). From Redfield Proctor of the Class of 1902, the Institute received a gift of $6,000 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 "some worthy student. . .preferably from Vermont, who shall meet regular scholastic and other requirements."

Ann White Vose Scholarship Fund (1896). By the will of Ann White Vose, the Institute received a bequest of $25,000 "plus one-half of the remainder of my estate. . .to establish free scholarships in M.I.T. . . . such persons enjoying benefit. . . shall be worthy young men of American origin."

Arthur M. Waitt Mechanical Engineering Scholarship Fund (1925). By the will of Arthur M. Waitt, the Institute received a bequest of $10,000, the income of which is used in "assisting needy and deserving students in the second, third and fourth year classes of the Mechanical Engineering Course of said Institute."

Louis Weissbein Scholarship Fund (1915). By the will of Louis Weissbein, the Institute received a bequest of $4,000 "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 Jewish students in the Department of Architecture.

Frances Erving Weston Scholarship Fund (1912). By the will of Frances Erving Weston, the Institute received a bequest, the income of which is available "to aid a native born American Protestant girl of Massachusetts."

Samuel Martin Weston Scholarship Fund (1912). By the will of

Frances Erving Weston, the Institute also received a bequest to found a scholarship in memory of her husband, Samuel Martin Weston. The income from this fund is available "to aid a native born American Protestant boy, preference to be given one from Roxbury."

Jonathan Whitney Fund (1912). By the will of Mrs. Francis B. Greene, the Institute received a bequest, the income of which is "applied to assist poor and deserving young men and women obtaining an education at M.I.T."

Morrill Wyman Fund (1915). By the will of Morrill Wyman, the Institute received a bequest, 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."

The Youth's Companion Scholarship (1926). Through its department known as the Y. C. Lab, a junior national scientific society composed of boys interested in engineering, technical and scientific pursuits, the ***Youth's Companion*** established a four-year scholarship carrying full tuition and laboratory fees. The award is made by the Governors of the Y.C. Lab to an applicant who has passed the entrance requirements of the Institute. Continuance of the scholarship during the second and succeeding years depends upon the recipient maintaining a satisfactory scholastic standing.

FELLOWSHIPS AND GRADUATE SCHOLARSHIPS

Graduate scholarships amounting to approximately forty thousand dollars will be available in 1927–28 to assist students in pursuing graduate work leading to the Master's and Doctor's degrees.

Applications for financial aid should be filed with the Secretary of the Committee on Graduate Courses and Scholarships not later than the first of March. This rule applies both to original applications and to renewals of previous grants. If funds are available, applications for grants will be considered during the school year.

An application for scholarship aid must be accompanied by an application for a course of advanced study and an official transcript of the applicant's college record, if these papers have not been filed previously. Both applications must be made on forms which may be obtained from the Dean of graduate students or the Secretary of the Committee on Graduate Courses and Scholarships.

In the award of graduate scholarships the committee will consider first, the ability of the candidate to pursue advanced study and research; second, his pecuniary need. Scholarship awards become available in two installments, namely at the beginning of each of the two regular terms. Grants are not made unreservedly, but their continuance from term to term is dependent on the recipient maintaining a satisfactory standard of scholarship. If a satisfactory standard of scholarship is not maintained, the grant may be declared as forfeited at the beginning of the term.

The awards made to students proceeding towards the Master's degree will in general be in sums sufficient to cover the tuition, that is, $300. The same is true of awards made to students proceeding towards the doctorate, who have not previously been in residence at the Institute for at least one term.

Foreign traveling scholarships may be awarded to applicants who are Institute graduates or who have served on the instructing staff of the Institute.

The recipient of a scholarship grant is expected to complete the period of study for which he has received the grant. In case he discontinues his work before the end of such period he will be expected to refund the entire amount of the grant received, unless released therefrom for satisfactory reasons, by the Committee on Graduate Courses and Scholarships.

ENDOWMENT FUNDS APPLICABLE TO GRADUATE SCHOLARSHIPS 1927–1928

Austin Fund. Founded by a bequest of Edward Austin, to assist meritorious students and teachers in the pursuit of their studies. From this fund approximately $24,000 will be available for graduate scholarships to meet the tuition fees of full time students and of members of the Instructing Staff who are working towards the Master's or Doctor's degrees.

Austin Research Fellowships. Two fellowships, each carrying an award of $500 in addition to remission of tuition fees, are open to candidates for the degree of Doctor of Science or Doctor of Philosophy who have shown exceptional ability in the field of research.

Jonathan Whitney Fund. The income from this fund, established by Francis B. Greene, is available for the purpose of aiding students who need financial assistance in obtaining an education at the Institute. $2,000 available for tuition.

Malcolm Cotton Brown Fund. Established by Charles A. Brown and Caroline C. Brown in memory of their son, Lieut. Malcolm Cotton Brown, '19, for the purpose of stimulating advanced study and research in Physics. The income is available annually to a senior in high standing in the Course in Physics. Only in exceptional cases where the recipient has greatly distinguished himself is the award made for a second year to the same student. Stipend $1,000.

Henry Saltonstall Scholarship Fund. Founded by the bequest of Henry Saltonstall. The income to be used to aid students, whether undergraduates or graduates, pursuing advanced courses. Stipend $550.

James Savage Fund. Founded by the late James Savage, the income to be awarded to 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 $600.

Susan H. Swett Fund. The income to be awarded to a graduate student of the Institute, or of some similar institution of equal standing, who, by his character, capacity, training, and attainments, shall give evidence of special fitness to pursue advanced study in some branch or branches of knowledge taught in the Institute. Stipend $500.

Louis Francisco Verges Fund. The income to be awarded to a meritorious student, either graduate doing research in the field of the sugar industry, or if there be no such candidate, an undergraduate in the Department of Civil Engineering. Stipend $500.

Dalton Fund. Founded by Charles H. Dalton, the income to be used 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 $300.

Moore Scholarship Fund. The income from a fund, the gift of Mrs. F. Jewett Moore, is available 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 $350.

Ellen H. Richards Memorial Research Fund. The income of this fund will be devoted to the promotion of research in sanitary chemistry, the branch of science to the development of which Mrs. Richards so greatly contributed. The income will be utilized by the Institute for the award of fellowships to advanced students competent to pursue this line of research, for the employment of research assistants, and in such other ways as will best promote investigation in the field in question.

Richard Lee Russel Fund. Founded by Theodore E. Russel in memory of his brother Richard Lee Russel. The income to be devoted to assisting some worthy student of high standing in the department of Civil Engineering to continue his studies at the Institute as a post-graduate or undergraduate. Stipend $110.

Willard B. Perkins Fund. Founded by a bequest of Willard B. Perkins, of the Class of '72. The income, amounting to one thousand dollars, was available in 1919–1920 and every fourth year for a traveling scholarship in Architecture.

Rebecca R. Joslin Graduate Scholarship Fund. The income from this fund is available as a loan to students pursuing advanced work in Chemical Engineering. Any student receiving benefit from this fund is expected to abstain from smoking and the use of tobacco in any form.

Collamore Fund. The income from the bequest of Helen Collamore to be applied primarily to the aid of women students in graduate courses. $650 available.

Henry Bromfield Rogers Fund. The income from this fund is used for fellowships or scholarships for women, graduates of the Institute, or other colleges whose graduate work is carried on at the Institute. $1,200 available.

SPECIAL GRADUATE SCHOLARSHIPS, 1927–28

Swope Fellowships. Two fellowships, one of $1,000 and one of $500, have been established to enable students in the Honors Group in the Department of Electrical Engineering to proceed with graduate study, and one fellowship of $1,000 has been established for a similar purpose in the Department of Physics.

du Pont Fellowship. Donated by the du Pont de Nemours Company, available 1927–28 for graduate students in Chemistry and Chemical Engineering. Stipend $750.

Graduate Scholarship in Fuel and Gas Engineering. Offered jointly by the Massachusetts Gas Company and the Boston Consolidated Gas Company. Stipend $700.

Traveling Fellowship in Architecture. Fifteen hundred dollars to be devoted to travel and study abroad under the direction of the Department of Architecture. This fellowship is open to regular and special students who have passed at least two consecutive years in the school, one of which must have been in the graduate year.

Technology Plan Research. In connection with the Division of Industrial Coöperation and Research, a fund of several thousand dollars is available for the study of problems in pure science. With the aid of this fund, problems in Physics and Chemistry are now being studied.

Textile Research Fellowship. Established by the Arkwright Club to encourage properly qualified students to pursue graduate study and research in the field of textiles. Stipend $2,000.

Research Fellowships in Automotive Engineering. Several fellowships, each carrying a stipend of 11,000, are available to graduate students properly qualified to undertake fundamental research in the field of Automotive Engineering.

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 grant 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.

Holders of Institute Traveling Fellowships are expected to present to the Secretary of the Committee on Graduate Courses and Scholarships on or before the first of April and the first of October of each year a full report of the progress of their work. This report should include not only a statement of all 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.

Fellows who have studied abroad under Institute grants may be requested to give at the Institute one or more lectures embodying the result of their advanced study and research at some time subsequent to the conclusion of their graduate work, the subject, number of lectures, and time at which they are to be given to be arranged in consultation with the professor in charge of the department of study in which the fellowship was awarded.

PRIZES

The following annual prizes are offered to the students of the Department of Architecture, and are awarded through competitions in Design.

The Boston Society of Architects' Prize. The gift of the Society. A prize of one hundred and fifty dollars for the best design submitted by a present or former student of Harvard, Technology or the Boston Architectural Club on one of the regular conjunctive programs.

The Chamberlin Prize. The gift of Mr. W. E. Chamberlin, Class of 1877. Twenty-five dollars awarded to a student in the graduate class in design.

The F. W. Chandler Prizes. The gift of the alumni of the Department and of Professor Chandler's friends. Five prizes of ten dollars each awarded for sketch problems in the third, fourth and graduate years.

The "Class of 1904" Prize. The gift of the Class of 1904. A prize of fifteen dollars awarded to a student in the junior class in design.

James Means Prize Fund. An annual prize is to be given for an essay on an aeronautical subject.

Rotch Prizes. The gift of Mr. Arthur Rotch. Two prizes of two hundred dollars awarded at the end of the senior year to the regular and the special student having the best general records. The special student must have spent at least two years in residence to be eligible.

Student Medal of the American Institute of Architects. This medal is awarded on the recommendation of the Department to the member of the graduating class whose record for the course is the best.

Department of Architecture Medals. At the end of each academic year the bronze medal of the Department is given to the winner of each prize.

Summer Sketching Prizes. A prize of twenty-five dollars for the best set of outdoor summer sketches in pencil or pen and ink, and a prize of equal amount for the best set of outdoor summer sketches in water colors or wash.

William R. Ware Prizes. In memory of the founder of the department. Fifty and twenty-five dollars for first and second prizes 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 Prize. The American Bureau of Shipping awards a prize of one hundred dollars in gold annually to the student graduating in Naval Architecture and Marine Engineering who attains the highest average in scholarship throughout for the last two years of the course. The prize is awarded to American citizens only.

COURSES OF STUDY OFFERED

The Institute gives instruction in English, History and Political Science, and in other general studies which are essential to a liberal education. It also gives a thorough training in the fundamental sciences of chemistry, physics and mathematics, and in the important application of the principles of these sciences to the various branches of engineering and applied science. It lays far more stress on the development of the power to deal effectively with new engineering or scientific problems than on the acquirement of an extensive knowledge of details. In order to attain these results, much of its classroom instruction is given to small sections of students, and in its laboratories and drawing-rooms students receive a large amount of personal attention. The independent solution of assigned problems forms a large part of nearly all its courses. A large proportion of liberal studies of a literary and general scientific character are insisted upon and courses upon technological methods and other highly specialized subjects are largely excluded; for, while the latter are sometimes important in special industries, they are not essential to a broadly trained engineer, who can readily acquire later the necessary technical knowledge. The system of instruction differs from the university plan of education in that cultural studies are closely correlated and interwoven with the professional work, while under the latter plan the two groups of studies are ordinarily pursued successively, in separate undergraduate and graduate schools. The Institute lays, moreover, especial emphasis on training in science and scientific methods, not only as an essential to professional success, but as an important element in culture and in life. Its courses differ from those of many colleges, in that electives are introduced to a much less extent, in the belief that better results are obtained by prescribing, after the student has selected the profession for which he desires to prepare himself, the principal studies which he is to pursue. He is given, however, the choice among groups of elective studies relating to different branches of his profession and between a variety of electives in the group of general studies.

The sum of the time assigned to exercises and of that estimated as being normally necessary for the outside preparation for them in all courses is from forty-eight to fifty hours each week.

Following the first, second or third year, certain of the professional courses require attendance at summer classes.

In addition to the prescribed subjects, all students in most regular courses are required to devote a specified amount of time to elective work in General Studies.

Courses of study leading to the Bachelor's degree are offered in the several branches of science and engineering named below. (See pages 60 to 126 for course schedules.)

Special attention is, however, called to the fact that admission to the Institute does not guarantee subsequent admission to any particular professional course nor to certain special courses, which may be open only to the extent of professional equipment and may be restricted to citizens of the United States or to minors whose parents are citizens of the United States.

Aeronautical Engineering. Course XVI.
Architecture, Course IV.
Architectural Engineering. Course IV-A.
Biology and Public Health, Course VII, with options in Biology and Public Health and Industrial Biology.
Building Construction, Course XVII.
Chemical Engineering, Course X, with School of Chemical Engineering Practice, X-B.
Chemistry, Course V.
Civil Engineering, Course I, with options. (1) General; (2) Transportation Engineering and (3) Hydro-electric Engineering.
Electrical Engineering, Course VI, with electives in professional subjects in the fourth year. Also option in Communication Engineering, VI-C and Coöperative Course in Electrical Engineering, VI-A.
Electrochemical Engineering, Course XIV.
Engineering Administration, Course XV, with options in Civil, Mechanical and Electrical, and Chemical Engineering.
General Science, Course IX-A.
General Engineering, Course IX-B.
Geology, Course XII.
Mathematics, Course IX-C.
Mechanical Engineering, Course II, with electives in professional subjects in the fourth year.
Mining Engineering and Metallurgy (including Petroleum Production), Course III, with options in Mining Engineering, Metallurgy and Petroleum Production.
Military Engineering.
Naval Architecture and Marine Engineering, Course XIII, with an option in Ship Operation.
Physics, Course VIII.
Sanitary and Municipal Engineering, Course XI.

In most of these courses distinct options or electives in professional subjects, as shown above, are offered which enable the student to concentrate more of his attention upon some one side of his profession. In no case, however, is the specialization carried so far as to preclude a thorough training in all the fundamental branches of the subject.

It will be observed that in addition to the courses in the various branches of engineering, the Institute offers courses in the other important branches of applied science. Thus the courses in industrial chemistry, metallurgy, public health and industrial biology serve to prepare students as scientific experts and for professional positions in manufacturing establishments and government laboratories. Thorough courses in pure science, namely, in chemistry, physics, biology, geology, and general science, are also offered. These give the training required for teaching positions in technological institutions, colleges, and preparatory schools, and for research positions in the departments of the Government, the industries, and in private laboratories. The course in Biology and Public Health furnishes too, an exceptional training for the subsequent study of medicine in medical schools of the graduate type. Special opportunities leading to the Certificate in Public Health and in Public Health Education are also offered.

The course in Architecture, with its two options in Architecture and Architectural Engineering, is a course of an artistic as well as a scientific character, involving a large amount of instruction and training in the fine arts.

The course in Engineering Administration provides a training for men who expect to enter upon administrative work in enterprises which demand a knowledge of scientific and engineering principles.

Choice of Professional Course. All these courses except Architecture, Option 1, and Building Construction are identical, in the first year. The student therefore may change his course of study at any time before the beginning of the second year. In making the choice, of course, the primary consideration should be the student's tastes and aptitudes, as shown by the results of his previous work at the Institute and in his preparatory school, rather than any supposed pecuniary or other advantages attaching to special professions.

General Studies. The object of these studies is to promote breadth of intellectual interest. Most of the student's time beyond the second year is necessarily devoted directly or indirectly to increasing his future professional efficiency and even in the earlier years this has been the underlying purpose of most of the work. Without attempting any discrimination between general and professional, or liberal and technical studies, the Faculty has aimed to include in the list of general studies subjects so far removed from the professional field that the student shall acquire in some measure new points of view and a wider mental horizon. Even subjects which have an implied relationship to the professional fields are presented with such emphasis on their broader general aspects as to serve the purpose indicated.

PROFESSIONAL SUMMER SCHOOLS

To bring the students into closer relations with the practical side of their professions, professional summer schools are held in the departments of Civil Engineering and Mining and Metallurgy and Geology. The students accompanied by instructors, give their time to field-work, 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, compass, transit and level, the entire field-work in surveying and railroad engineering is given at Camp Technology on the shore of Gardner's Lake near the village of East Machias, Maine. This locality is well adapted for the carrying out of all the operations involved in the various problems of plane surveying; for performing the field-work necessary for the making of large and small scale topographic maps; and for the making of railroad location surveys. Gardner's Lake is specially favorable for carrying on the field-work necessary to hydrographic surveying. The Machias and East Machias rivers are available for stream gaging by means of floats and by the various types of meters. Some of the smaller streams afford opportunity for weir measurements.

The camp property comprises about eight hundred and fifty acres of rolling land in the form of a strip varying in width from one-fourth to one mile with a shore line of five miles on the lake. The main group of buildings consists of an administration building connected by covered passages with buildings on either side and in the rear. This group of buildings contains three recitation rooms accommodating some one hundred and thirty students, a drafting-room with space for seventy-two students, a dining-room seating one hundred and sixty, office accommodations for an instructing force of twenty-four, a large lounge room, three sleeping rooms, a camp store and post office, an instrument room, kitchen, icehouse, toilet room and lavatories, and a dormitory for the service staff. Sleeping quarters for students are provided in eight wooden barracks, each containing six double rooms; tents on raised platforms are also available for twenty students. An additional barracks building is used by members of the faculty in residence at the camp, and another large wooden building furnishes sleeping accommodations for other members of the instructing staff. The latter building also provides drafting space for twenty-four. The camp is equipped with excellent sanitary facilities, a wholesome water supply from driven wells and an electric light plant. An infirmary which serves as an emergency hospital contains the quarters of the physician who is in constant attendance throughout the camp session.

The camp is intended primarily for students of Courses I, XI, and XV, Option 1, who are required to attend during the months of August and September following their sophomore year. A limited number of students from other courses having the requisite preparation may be admitted by petition.

The tuition fee is $100 for 1·05, 1·06, 1·20 and 1·60 combined. The cost of operating the camp during the session is shared equally by those in attendance.

Summer School of Surveying for Miners and Geologists. Surveying, 1·10, which is given at the Summer Mining Camp at the Replogle Mine, near Dover, N. J., includes topographic surveying, levelling and mine surveying. It is required for students in Course III, Options 1 and 3, between their second and third year; and for students in Course XII, between their third and fourth year. The camp, which is about two hours' distance from New York City, on the Lackawanna Line, has been selected because of its unequalled situation with reference to mines, famous geological exposures and topography. The fee is $100. Deposit for board and incidental expenses is $85.

Summer School in Mining Practice. Mining Practice, 3·08, required of all students in Course III, Options 1 and 3, either between the second and third or between the third and fourth years, is given at the Summer Mining Camp. The fee is $10; deposit for board and incidental expenses, $20.

Summer Metallurgical School. Plant Visits 3·60, required of all students in Course III, Option 2, and any others planning to register for

Metallurgy 3·41, 3·411, 3·43 or 3·431. A number of Metallurgical plants in eastern Pennsylvania and New Jersey are visited. There is no registration fee, but each student will pay his own expenses, estimated at $75 round trip from Boston.

Summer School of Surveying. Students in Course III, Option 2, and Course VI are required to take the Course in Surveying and Plotting, 1·02, in the early part of the summer following their second year. The instruction is given in Cambridge and vicinity. The fee for this course is $30.

REQUIREMENTS FOR ADMISSION

Admission to the First Year. To be admitted as a first-year student the applicant must have attained the age of seventeen years and must meet the entrance requirements as follows: (Numbers in parentheses indicate the ordinary "unit" rating. They are given for purposes of comparison and require no attention from candidates for admission to the Institute.)

1. Must pass **examinations** in:
   - Algebra (2)
   - Plane Geometry (1)
   - Solid Geometry (½)
   - Trigonometry (½)
   - Physics (1)
   - English (3)
   - Foreign Language — **ONE** of the following combinations (a, b or c)
     - (a) French, elementary (2) and French, intermediate (1)
     - (b) German, elementary (2) and German, intermediate (1)
     - (c) French, elementary (2) and German, elementary (2)
2. Must pass **examination** or present school **record of certificate grade** in:
   - History (1)
3. Must pass **examination** or present school **record of passing grade** in:
   - Chemistry
4. Must pass **examination** or present school **record of passing grade** for:
   - Electives
     - **Two** if language group (a) or (b) is offered
     - **One** if language group (c) is offered

Electives may be offered from the following list: Others will be considered. (Application for the acceptance of other subjects may be addressed to the Committee on Admissions.)

- Biology (1)
- Botany (1)
- Zoölogy (1)
- English, additional (1)
- French, intermediate* (1)
- German, intermediate* (1)
- History, additional (1)
- Latin (2) (Not less than two units accepted)
- Spanish (1)

*If offered in excess of the requirement under c.

Time and Place of Entrance Examinations. June examinations for admission to the first year class are held under the direction of the College Entrance Examination Board in all the principal cities of the United States, in Canada, London, Paris and Geneva. Information in regard to these examinations may be obtained by writing to the Secretary of the

College Entrance Examination Board, 431 West 117th Street, New York, N. Y.

In September the Institute conducts its own examinations which are held in Cambridge only. Correspondence in regard to these examinations and other questions relating to admission to the Institute or its courses of study should be addressed to the Committee on Admissions.

Candidates are advised to attend the June examinations in order that any deficiencies may be made up during the summer.

C. E. E. B. Examinations-June 20-25, 1927. The application for examination must be addressed to the College Entrance Examination Board, 431 West 117th Street, New York City. It must be made on a form to be obtained from the Secretary of the Board. If the application is received sufficiently early, the examination fee will be $10 whether the candidate is examined in the United States, Canada or elsewhere. A list of the places at which these examinations are to be held in June, 1927, will be published by the Board about March 1.

Table of Equivalents. The following table shows for which subjects records of the College Entrance Examination Board are accepted as covering requirements for admission to the Institute.

M. I. T. Subjects	*C. E. E. B. Subjects*
Algebra	Mathematics A, or A1 and A2
Chemistry	Chemistry
English	English Cp or 1 and 2 or 1-2
French (Elementary)	French Cp 2
French (Intermediate)	French B
Geometry, Plane	Mathematics C or (cd)
Geometry, Solid	Mathematics D
German (Elementary)	German Cp 2
German (Intermediate)	German B
History	History A to D inclusive
Physics	Physics
Plane Trigonometry	Mathematics E
Electives	History A to D inclusive: Latin Cp 2; French B or Cp 3; French Cp 4; German B or Cp 3; German Cp 4; Spanish; Botany; Zoölogy; Biology.

Records of 60 or above will be accepted, except as noted below.

Candidates are expected to take the separate examinations in Geometry, C and D, but a record in Geometry CD will be accepted. If the single examination in Geometry, CD., is taken, a record of at least 70 is required.

A record of 70 in Trigonometry is required in view of the importance of the subject for Institute candidates and the fact that the College Board ratings in this subject are relatively high in comparison with those in Algebra and Geometry.

Candidates are expected to take, if practicable, the divided examinations in both French and German, but if the single examination, Cp 3, is taken, a record of 60 or above will be accepted as covering both elementary and intermediate.

Schedule of Examinations to be Held at Institute in September 1927 and 1928

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

1927		1928
September 14	**Wednesday**	**September 12**
9.00 a.m. to 12.00 m.	. . . .	Algebra
2.00 p.m. to 4.00 p.m.	. . . .	Physics
September 15	**Thursday**	**September 13**
9.00 a.m. to 11.00 a.m.	. . . .	English
11.15 a.m. to 1.00 p.m.	. . . .	Plane Geometry
2.00 p.m. to 4.00 p.m.	. . . .	French (Elementary)
September 16	**Friday**	**September 14**
9.00 a.m. to 10.45 a.m.	. . . .	Solid Geometry
11.00 a.m. to 1.00 p.m.	. . . .	German (Elementary)
2.00 p.m. to 4.00 p.m.	. . . .	Trigonometry
September 17	**Saturday**	**September 15**
9.00 a.m. to 11.00 a.m.	. . . .	French (Intermediate)
11.00 a.m. to 1.00 p.m.	. . . .	German (Intermediate)
2.00 p.m. to 4.00 p.m.	. . . .	History (U. S. or Ancient)

Entrance Examination Fee. (See Page 33.)

Division of Entrance Examinations. Candidates are allowed to spread their entrance examinations over three consecutive periods (a period meaning June and September of the same year).

A preliminary candidate is one who is taking examinations a year or more in advance of his anticipated admission. He may take examinations either in June or September, but is not allowed to repeat in September any examinations in which he has failed in June. The examinations in Physics and Trigonometry should be taken not more than one year before admission and the study of Mathematics and English should have been continued during the year immediately preceding admission.

Application for Admission. Candidates should write to the Committee on Admissions for blank forms on which to make application

Conditions. A candidate for admission in September of any year must take at that time examinations in all subjects not already passed.

Summer Courses in Entrance Subjects. The Institute offers summer courses corresponding to entrance requirements in Algebra, Solid Geometry, Trigonometry, Physics, Chemistry, English, French and German. An applicant passing any of these subjects will be excused from taking the corresponding entrance examination.

General Preparation. The student intending to enter the Institute should bear in mind that the broader his intellectual training and the more extensive his general acquirements, the greater will be the advantages he may expect to gain. Thorough preparation in the subjects set for examination is important, for the character and the amount of instruction given in the Institute leave little opportunity to make up deficiencies. The training given in the best high and preparatory schools will, in general, afford suitable preparation.

In entrance mathematics, importance will be attached to accuracy in the numerical work of the papers and to satisfactory freehand sketches in geometry and trigonometry. Familiarity with the metric system is required.

The attention of teachers and applicants is particularly called 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. A considerable portion of the mathematics should be given during the final years of preparation.

The requirements of age and scholarship specified herewith are regarded as a minimum in all ordinary cases, and only exceptional circumstances will justify any relaxation.

Registration in advance for admission to the first year is at present unnecessary, as admission depends only upon the satisfactory completion of the entrance requirements.

DEFINITIONS OF REQUIRED SUBJECTS

Mathematics. The present formulation of the requirements was adopted in 1923 on the recommendation of a commission appointed by the College Entrance Examination Board.

The requirements conform in substance to the recommendations of the National Committee on Mathematical Requirements appointed in 1918 by the Mathematical Association of America.

Elementary Algebra. This requirement consists of the College Board Mathematics A1 and Mathematics A2 combined. The corresponding examination at the Institute (in September only) covers both parts of the Elementary Algebra.

Algebra to Quadratics (Mathematics A1). (1) The meaning, use, evaluation, and necessary transformations of simple formulas, and the derivation of such formulas from rules expressed in words. (2) The graph, and graphical representation in general. The construction and interpretation of graphs. (3) Negative numbers; their meaning and use. (4) Linear equations in one unknown quantity, and simultaneous linear equations involving two unknown quantities, with verification of results. Problems. (5) Ratio, as a case of simple fractions; proportion, as a case of an equation between two ratios; variation. Problems. (6) The essentials of algebraic technique. (7) Exponents and radicals; simple cases. (8) Numerical trigonometry.

Quadratics and Beyond (Mathematics A2). (1) Numerical and literal quadratic equations in one unknown quantity. Problems. (2) The binomial theorem for positive integral exponents, with applications. (3) Arithmetic and geometric series. (4) Simultaneous linear equations in three unknown quantities. (5) Simultaneous equations, consisting of one quadratic and one linear equation, or of two quadratic equations of certain types. Graphs. (6) Exponents and radicals. (7) Logarithms.

A summer course (M1) is given in Algebra, covering the above subjects.

Plane Geometry. The usual theorems and constructions given in good text-books, including the general properties of plane rectilinear figures; the circle and the measurement of angles; similar polygons; areas; regular polygons and the measurement of the circle.

The solution of numerous original exercises, including loci problems.

Applications to the mensuration of lines and plane surfaces.

The scope of the requirement in Plane Geometry is indicated by a syllabus published by the College Entrance Examination Board. The examination will consist partly of book propositions and partly of originals. In the former type of question the candidate will be asked to give proofs of standard theorems which are assumed to have been presented to him in his course of study, or to reproduce standard constructions. In the latter type are included the demonstration of theorems which are not assumed to be familiar to the candidate, problems of measurement and calculation, and problems in the working out of unfamiliar constructions and the identification of unfamiliar loci. Questions calling for simple geometrical knowledge and understanding may fall under either type.

The originals on the examination will in general depend for their solution on propositions mentioned in the syllabus, but occasionally the original will be so framed that a solution will occur more readily to the candidate who is familiar with such important geometrical facts as the properties of the 30° and the 45° right triangles.

With regard to constructions, the candidate is expected to be able to perform and to describe accurately those listed at the end of the syllabus published by the College Entrance Examination Board, and also, as originals, others based on these. He is not required to give proofs of constructions unless a proof is specifically called for by the question, and such proofs will not be regarded as constituting a part of the book-work requirement, but will have the status of originals. The candidate is expected to be provided with ruler and compasses.

Solid Geometry. The usual theorems and constructions of good text-books, including the relations of planes and lines in space; the properties and measurement of prisms, pyramids, cylinders, and cones; the sphere and the spherical triangle.

The solution of numerous original exercises, including loci problems.

Applications to the mensuration of surfaces and solids.

The scope of the requirement in Solid Geometry is indicated in a syllabus published by the College Entrance Examination Board. The examination will consist partly of questions on book propositions and partly of originals.

A summer course (M3) is given in this subject.

Plane Trigonometry. In this requirement are included the following topics: (1) Definition of the six trigonometric functions of angles of any magnitude, as ratios. The computation of five of these ratios from any given one. Functions of 0°, 30°, 45°, 60°, 90°, and of angles differing from these by multiples of 90°. (2) Determination, by means of a diagram of such functions as sin $(A+90°)$ in terms of the trigonometric functions of A. (3) Circular measure of angles; length of an arc in terms of the central angle in radians. (4) Proofs of the fundamental formulas, and of simple identities derived from them. (5) Solution of simple trigonometric equations. (6) Theory and use of logarithms, without the introduction of work involving infinite series. Use of trigonometric tables, with interpolation. (7) Derivation of the Law of Sines and the Law of Cosines. (8) Solution of right and oblique triangles (both with and without logarithms) with special reference to the applications. Value will be attached to the systematic arrangement of the work.

A summer course (M4) is given in this subject.

Chemistry. Applicants must present evidence of familiarity with the rudiments of chemistry. More importance is attached to aptitude in manipulation and in critical observation, and to a practical knowledge of the composition, methods of preparation, and reactions of the common chemical substances, than to a knowledge of theoretical conceptions, such as the determination of atomic and molecular weights, molecular structure, valence, etc. A certificate in Chemistry must indicate a passing grade and must show 150 hours of work.

A summer course (600) is given in this subject.

Physics. The candidate will be expected to be familiar with the fundamental principles of physics. It is especially desirable that he should have a good knowledge of general mechanics and of the mechanics of solids, liquids, and gases. A knowledge of physical hypotheses is comparatively unimportant. Textbook instruction should be supplemented by classroom experiments. A sufficiently extended treatment of the subject will be found in any of the principal textbooks now in use in secondary schools. Ability to solve simple problems will be expected.

It is furthermore expected that the student will receive training in laboratory work. Deficiency in laboratory work will not necessarily lead to rejection, provided the school from which the student comes is unable to furnish such instruction. In this case, however, a certificate of such inability will be required from the principal of the school.

The laboratory work required for entrance should consist of at least twenty-five well selected experiments, chosen with the view of illustrating and teaching fundamental laws and principles rather than methods of physical measurement. This work should preferably come during the school year immediately preceding the student's entrance. A satisfactory selection may be made from Experiments 1 to 51 of the College Entrance Examination Board.

A summer course (800) is given in this subject.

English. The examination in English is intended as a test of the candidate's ability to express himself clearly and simply, and of his capacity for using his past experience and reading in expressing elementary processes of thought.

In preparation for the examination the candidate should have done a considerable amount of reading, chosen from authors of recognized worth. The books adopted by the National Conference on Uniform Entrance Requirements are taught in most secondary schools, and the candidate may, if necessary, use these in his preparation. In any case it is expected that the aim of preparatory study will be, first, to develop in the pupil a consciousness that words, if understood, convey definite ideas; and, secondly, to form in him the habit of comparing these ideas with his own experience and his own views.

The candidate will be required to write upon subjects familiar to him, or to comment on a literary treatment of some such subject. When questions of a literary sort are asked, they are intended rather as a test of the candidate's power to read intelligently than of his knowledge of specific books.

The composition should be correct in spelling, punctuation, grammar, idiom, and the formation of paragraphs, and should be plain and natural in style. The candidate will be judged by how well he writes rather than by how much he writes.

A summer course (E1) is given in this subject.

French (Elementary). The requirement for Elementary French is a systematic course of four or five periods a week extending over at least two school years, each year representing not less than 120 full sixty-minute periods or the equivalent. Training in pronunciation and in the understanding of easy spoken French is regarded as an essential part of this requirement.

The examination in Elementary French covers the following:

(*a*) Ability to read simple prose at sight and to translate it into clear and idiomatic English.

(*b*) Proficiency in elementary grammar, to be tested by the translation of easy English into French and by questions on the following topics: inflection of nouns and adjectives for gender and number; pronominal adjectives; the forms and positions of pronouns, especially the personals; the partitive construction; the forms and use of numerals; the use of the subjunctive, except unusual cases; the conjugation of the regular and of the more common irregular verbs. Special attention will be given to the verbs.

A summer course (L51 and L52) is given in this subject.

French (Intermediate). This course should consist of recitations partly conducted in French. It should comprise a continuation of the study of grammar, the study of a book on composition, translation into French of connected passages, dictation, reading and translation of some standard modern authors.

At the end of the course the student should be able to pronounce French reasonably well, to understand easy spoken French, express simple ideas in French, especially those dealing with travel, and read works of ordinary difficulty with considerable ease.

A summer course (L61 and L62) is given in this subject.

German (Elementary). The requirement for Elementary German is a systematic course of four or five periods a week extending over at least two school years, each year representing not less than 120 full sixty-minute periods or the equivalent.

Training in pronunciation and in the understanding of easy spoken German is regarded as an essential part of this requirement.

The examination in Elementary German covers the following:

(*a*) Ability to read simple prose at sight and to translate it into clear and idiomatic English.

(*b*) Proficiency in elementary grammar, to be tested by the translation of easy English into German, and by questions on the following topics: the conjugation and synopsis of the regular and of the more usual irregular verbs; declension of readily classified nouns, of adjectives, articles, pronouns; comparison of adjectives and adverbs; use of the more common prepositions; the simpler uses of the modal auxiliaries; simple cases of indirect discourse, and the rules for the order of words.

A summer course (L11 and L12) is given in this subject.

German (Intermediate). This course should include a systematic review of grammar. The reading, scientific as well as literary, should

Note. It is expected that the translations from French and German will be written in correct and expressive English; and these papers may at any time be examined as additional evidence in determining the student's proficiency in composition.

become more difficult, and the syntax, idiom and synonyms of the language should be carefully studied in a series of composition exercises.

By the end of the course the student 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 with a good pronunciation.

A summer course (L21 and L22) is given in this subject.

History. The History requirement may be met by presenting a record of certificate grade or by passing the examination in any of the following subjects: Ancient, European, English or American History. The Institute offers only examinations in Ancient and United States History. In United States History a thorough acquaintance with the history of the Thirteen Colonies and of the United States to the present time is required, together with an elementary knowledge of the government of the United States. In Ancient History the requirement covers the history of Greece and Rome to the fall of the Roman Empire in the West.

Each of the above subjects is intended to represent one year of historical work, wherein the study is given five times a week, or two years of historical work, wherein the study is given three times a week.

The examination in History will be so framed as to require comparison and the exercise of judgment on the pupil's part, rather than of mere memorizing. The examinations will presuppose the use of good textbooks, collateral reading and practice in written work. Geographical knowledge may also be tested.

Candidates expecting to take the Course in Architecture are advised to prepare in Ancient History.

DEFINITIONS OF ELECTIVE SUBJECTS

The object of the elective requirements is to secure and to recognize greater breadth of preparatory training. The time allotment for each unit of elective should be equivalent to four or five periods per week for a school year of approximately forty weeks.

These requirements are to be met by the presentation of certificates made out on forms supplied by the Institute.

Excuse from the elective requirement, or the acceptance of an equivalent, may be allowed in the case of applicants considerably above the usual age, or those coming from foreign countries. In general it is desired that electives should not be chosen with reference to anticipation of subjects in the Institute curriculum. Applicants desiring advance credit for such work will be expected to pass the usual examinations for advanced standing.

Elective Biological Subjects. Applicants may offer either (*a*) an extended course in botany, zoölogy or in general biology and elementary physiology; or (*b*) briefer courses in any two of the same subjects. In the latter case evidence should be given of knowledge of general principles and of some laboratory and field work.

Elective English. The work of secondary schools varies so much in this subject that no definite requirement is formulated at present. Any applicant who has carried work in English materially beyond the entrance requirements may present for approval as his elective a statement of the amount and kind of work done. Elective additional English, however, cannot be accepted unless the required English has been passed.

Elective Latin. Satisfactory evidence should be presented that the applicant has acquired the elements of Latin Grammar, that he has had an elementary course in Latin Composition and has read four books of Caesar or the equivalent. As a smaller amount of Latin would be of no practical advantage, this is the minimum amount that can be accepted.

The study of Latin is recommended to persons who purpose to enter the Institute and who can give the subject adequate attention while preparing for the regular requirements for admission.

Elective Spanish (Elementary). — Elementary grammar, including the common irregular verbs; reading, translation from Spanish into English and from English into Spanish.

ADMISSION WITH ADVANCED STANDING

The Institute offers to both graduates and undergraduates of other colleges opportunities for transfer on as favorable a basis as is compatible with the requirements of its professional courses and standards. As most of these requirements are, however, prescribed, it is important that the applicant's previous work should have been planned with due reference to them.

In general, an applicant from another college who has attended one full year or more, obtained satisfactory grades (the lowest passing grade is not a satisfactory grade on which to base credit) and received honorable dismissal, may expect excuse from entrance examinations and provisional credit for entrance subjects and those given at the Institute in so far as he has covered these subjects. Students who present but a single year of college work and offer chemistry are not credited with first-year chemistry except on the basis of an examination taken in that subject at the Institute in September. Students presenting but one year's work in English without History must take English and History E12, unless they pass an examination covering History of E11 and E12 in September or January. Students who intend to take any of these examinations should notify the Registrar and send for an examination schedule. In case a student has not been credited with all required entrance subjects he will, unless especially excused, be expected to make up the remainder by taking entrance examinations.

A candidate for admission with advanced standing should send early in June, and in any case not later than July 15, his application blank indicating his choice of course, accompanied by an official record from the college or university which he has attended, showing the subjects credited at entrance and those which he has taken in college, with his grades; also a statement of honorable dismissal (or its equivalent) or a certificate of graduation. He should send sheets detached from his college catalogue describing the subjects which he has pursued. On these sheets he should write his name and (in the margin) check the subjects that he has taken. By preparing a tabulation of his subjects and credits on the application form for admission with advanced standing and underlining the Course Schedule to show the subjects in which he expects to receive credit, he may be able to estimate the terms of his admission and his probable deficiencies. This tabulation will also be helpful to the Committee on Admissions in determining his rating. As soon as his rating is determined, a report will be sent him in the form of a certified Course Schedule which will show with what Institute subjects he is credited.

A student who plans to enter the third or fourth year at the Institute should, if possible, send his credentials not later than May 15, including a certificate of the subjects completed together with a statement of those which he expects to complete before entrance. Students desiring credit in Electrical Engineering Laboratory should present their reports as well as their college records in that subject. The candidate should forward in June a record of the additional subjects completed at that time. Candidates having deficiencies are advised to make them up by attending the Summer Session at the Institute.

Questions about credits in professional subjects given in the *third* or *fourth* year will, in general, await adjustment in personal interview. In such cases the student is expected to consult the department concerned before the opening of the term so that he may complete his registration in season. Representatives of the departments will be on duty during the week preceding the opening of the school for consultation.

Students applying for admission with advanced standing to Course IV, will be graded in design in accordance with their performance in their first problem.

For information concerning opportunities for graduate work and research applicants are referred to the Bulletin "Graduate Study and Research."

Admission of Special Students. An applicant considerably above the usual age, pursuing special work, may be classed as a special student. He should present a plan for study approved by the Department with which his work will be taken. He may be excused from the usual entrance examinations in case he has presented to the Department evidence of such professional or other experience as will justify the expectation that he can profitably undertake the work desired. In all other cases, special students will be expected to take those examinations on which the work they desire depends, or to present college records in corresponding subjects.

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 take in their first year of residence courses in English, graphics (descriptive geometry), shades and shadows, perspective, and architectural history, unless these subjects have been passed at the September examinations for advanced standing, or excuse has been obtained on the basis of equivalent work accomplished elsewhere. They will register for theory of architecture, freehand drawing, design, and other professional courses. Satisfactory records must be obtained in order to continue architectural subjects. All special students must also register for freehand drawing. 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. Special students who desire to take the course in architectural engineering must pass or offer equivalents for the entrance examinations in mathematics and physics.

REQUIREMENTS FOR THE DEGREE OF BACHELOR OF SCIENCE

To receive the Degree of Bachelor of Science the student must have attended the Institute not less than one academic year, which must in general be that next preceding his graduation. He must have completed the 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.

GRADUATE COURSES

(For complete information regarding graduate work, see the bulletin on Graduate Study and Research.)

The Institute offers opportunities for graduate study and research in all professional departments. The degrees awarded are those of Master of Science, Master in Architecture, Doctor of Science, Doctor of Philosophy, and Doctor of Public Health.

Applicants, except in cases of unusual attainments, must have taken their first degree from a scientific school, college or university of good standing.

A degree of Master of Science is awarded upon the satisfactory completion of advanced study and research approved by the Faculty and extending over not less than one year.

The degrees of Doctor of Science, Doctor of Philosophy and Doctor of Public Health are awarded on the completion of a program of advanced study and the performance of an investigation of high grade. As a rule the study and research must be pursued under the direction of the Faculty for three years. Graduates of the Institute of unusual ability or those who have had exceptional preparation may be able to complete the requirements in two years.

Coöperation with Harvard University. The following agreement is at present in effect between Harvard University and the Massachusetts Institute of Technology.

"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."

Graduate students desiring to take advantage of this privilege must present a note of approval from the chairman of their committee to the Dean of Graduate Students in order to obtain a letter of recommendation to Harvard University.

COURSES FOR OFFICERS OF THE UNITED STATES ARMY AND UNITED STATES NAVY

The Institute offers courses in Ordnance Design, Torpedo Design and Naval Construction leading to the Degree of Master of Science, to officers of the United States Navy; a course in Chemical Warfare leading to the degree of Master of Science, and a course in Military Engineering leading to the degree of Bachelor of Science, to officers of the United States Army. A special course in Army Ordnance is also given for officers of the United States Army.

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, Air Service and Chemical Warfare. For information and course schedules, see pages 127–141.

UNDERGRADUATE COURSE SCHEDULES FOR 1926-1927

THE NUMBERING SYSTEM

Subjects are grouped and numbered according to the professional course or department under which the instruction is given.

For description of subjects see pages 142 to 252.

Course or Department	Numbers	
Civil Engineering	1.00 to 1.99	(I)
Mechanical Engineering	2.00 to 2.99	(II)
Mining and Metallurgy	3.00 to 3.99	(III)
Architecture and Architectural Engineering	4.00 to 4.99	(IV, IV-A)
Chemistry	5.00 to 5.99	(V)
Electrical Engineering	6.00 to 6.99	(VI)
Biology and Public Health	7.00 to 7.99	(VII)
Physics	8.00 to 8.99	(VIII)
Chemical Engineering	10.00 to 10.99	(X)
Geology	12.00 to 12.99	(XII)
Naval Architecture and Marine Engineering	13.00 to 13.99	(XIII)
Aeronautical Engineering	16.00 to 16.99	(XVI)
Building Construction	17.00 to 17.99	(XVII)
Drawing	D1 to D99	
Economics	Ec1 to Ec99	
English and History	E1 to E99	
Fuel and Gas Engineering	F1 to F99	
General Studies	G1 to G99	
Languages	L1 to L99	
Mathematics	M1 to M99	
Military Science and Tactics	MS1 to MS99	
Hygiene	PT1 to PT2	

First number in a column indicates the number of class room hours per term; the second number indicates the number of preparatory hours per term for the average student.

FIRST YEAR. For all Courses (Except IV and XVII)

	First Term 15 Weeks	Second Term 15 Weeks
Chemistry 5·01, 5·02	120 — 75	120 — 75
Descriptive Geometry D21, D22	45 — 10	45 — 10
English and History E11, E12	45 — 75	45 — 75
Mathematics M11, M12	45 — 90	45 — 90
Mechanical Drawing D11	45 — 0	.. ..
Military Science MS11, MS12	45 — 0	45 — 0
Physical Training PT1, PT2	20 — 0	20 — 0
Physics 8·01, 8·02	60 — 75	60 — 75
Working Drawings D12	.. ..	45 — 0
Hours of exercise and preparation:	750 = 425 + 325	750 = 425 + 325

FIRST YEAR. COURSE IV

	First Term	Second Term
Architectural History 4·411, 4·412	30 — 60	30 — 60
Design I 4·712	.. ..	180 — 0
English E11, E12	45 — 75	45 — 75
French L63, L64	45 — 90	45 — 90
Graphics 4·06	90 — 0	.. ..
Mathematics M11, M12	45 — 90	45 — 90
Military Science MS11, MS12	45 — 0	45 — 0
Perspective 4·12	45 — 0	.. ..
Physical Training PT1, PT2	20 — 0	20 — 0
Shades and Shadows 4·11	45 — 0	.. ..
Theory of Architecture 4·311, 4·312	15 — 0	15 — 0
Hours of exercise and preparation:	740 = 425 + 315	740 = 425 + 315

FIRST YEAR. COURSE XVII

	First Term 15 Weeks	Second Term 15 Weeks
Architectural Drawing 4·10	.. ..	45 — 0
Chemistry 5·01, 5·02	120 — 75	120 — 75
Descriptive Geometry D21	45 — 10	.. ..
English and History E11, E12	45 — 75	45 — 75
Graphics 4·061	.. ..	55 — 0
Mathematics M11, M12	45 — 90	45 — 90
Mechanical Drawing D11	45 — 0	.. ..
Military Science MS11, MS12	45 — 0	45 — 0
Physical Training PT1, PT2	20 — 0	20 — 0
Physics 8·01, 8·02	60 — 75	60 — 75
Hours of exercise and preparation:	750 = 425 + 325	750 = 435 + 315

CIVIL ENGINEERING — COURSE I

The course in Civil Engineering is designed to give the student sound training, both theoretical and practical, in the sciences upon which professional practice is based. Particular care is taken to enforce the application of the principles taught, and the student is made familiar with the use of engineering instruments and with the usual problems of practice.

Civil engineering is the broadest in scope of the engineering professions, being the parent stem from which have diverged most of the other branches of engineering. The field of civil engineering, nevertheless, still remains so large that no one can become expert in its whole extent. It covers topographical engineering, including the making of geodetic and geological surveys, and surveys for engineering construction; transportation engineering, consisting of the building of railroads, highways, canals, docks, harbors, and other works serving the purpose of commerce and transportation; municipal engineering, including the construction of sewers, waterworks, roads, and streets; structural engineering, consisting of the construction of bridges, buildings, retaining walls, foundations and all fixed structures; hydraulic engineering, including the development of water power and public water supplies, the improvement of rivers and the reclamation of land by irrigation. All of these branches of engineering rest upon a relatively compact body of principles, and in these principles the students are trained by practice in the classroom, the drafting-room, the field and the testing laboratory.

In the comparatively advanced work of the upper years the student is offered a choice of three options or groups of study, namely: a general option in civil engineering, including the study of hydraulic and sanitary engineering in considerable detail, an option in transportation engineering in which more than usual attention is paid to railway and highway engineering, and an option in hydro-electric engineering in which special consideration is given to the subject of water power development. The special work of the hydro-electric option begins in the third year, and that of the other options in the fourth year.

Civil Engineering — COURSE I — *Continued*

First Year, Page 60

SECOND YEAR ALL OPTIONS

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·15	.. ..	45 — 90
Astronomy and Spherical Trigonometry 1·12	45 — 60	.. ..
Descriptive Geometry D31	60 — 45	.. ..
English and History E21, E22	45 — 75	45 — 75
Graphic Statics 1·39	.. ..	45 — 15
Map Reading and Topographical Drawing 1·18	30 — 0	.. ..
Mathematics M21, M22	45 — 90	45 — 90
Mechanism 2·01	.. ..	30 — 60
Military Science MS21, MS22	45 — 0	45 — 0
Physics 8·03, 8·04	60 — 75	60 — 75
Surveying and Plotting 1·00, 1·01	30 — 45	30 — 0
Hours of exercise and preparation:	750 = 360 + 390	750 = 345 + 405

REQUIRED SUMMER COURSES AT CAMP TECHNOLOGY

Geodetic and Topographic Surveying 1·06	95 — 5
Hydrographic Surveying 1·60	75 — 0
Plane Surveying 1·05	90 — 10
Railway Fieldwork 1·20	80 — 0

THIRD YEAR

Option 1. General
Option 2. Transportation Engineering

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·20	45 — 90	.. ..
Electrical Engineering, Elements 6·40	60 — 90	.. ..
Electrical Engineering Laboratory 6·89	.. ..	30 — 30
Foundations 1·48	15 — 15	.. ..
Geodesy 1·13	30 — 30	.. ..
Geology 12·321, 12·322	30 — 15	45 — 45
Hydraulics 1·62	.. ..	45 — 75
Materials 1·43	.. ..	15 — 30
Political Economy Ec31, Ec32	45 — 45	45 — 45
Railway and Highway Engineering 1·21, 1·22	30 — 60	30 — 30
Railway Drafting 1·23, 1·24	60 — 0	45 — 0
Structures 1·40	.. ..	45 — 75
Testing Materials Laboratory 2·37	.. ..	20 — 10
General Study	30 — 30	30 — 30
Hours of exercise and preparation:	720 = 345 + 375	720 = 350 + 370

THIRD YEAR

Option 3. Hydro-electric Engineering

	First Term 15 Weeks	Second Term 15 Weeks
Accounting Ec50	45 — 45	.. ..
Applied Mechanics 2·20	45 — 90	.. ..
Electrical Engineering, Elements 6·40	60 — 90	.. ..
Electrical Engineering Laboratory 6·89	.. ..	30 — 30
Foundations 1·48	15 — 15	.. ..
Geodesy 1·13	30 — 30	.. ..
Geology 12·321, 12·322	30 — 15	45 — 45
Hydraulics 1·62,	.. ..	45 — 75
Materials 1·43	.. ..	15 — 30
Political Economy Ec31, Ec32	45 — 45	45 — 45
Railway and Highway Engineering 1·211, 1·22	20 — 40	30 — 30
Report Writing E33	.. ..	30 — 30
Structures 1·40	.. ..	45 — 75
Testing Materials Laboratory 2·37	.. ..	20 — 10
General Study	30 — 30	30 — 30
Hours of exercise and preparation:	720 = 320 + 400	735 = 335 + 400

Civil Engineering — COURSE I — *Continued*

FOURTH YEAR

Option 1. General

	First Term 15 Weeks	Second Term 15 Weeks
Bridge Design 1·501, 1·502	105— 0	75 — 0
Engineering and Hydraulic Laboratory 2·63	.. ..	30 — 30
Field Geology 12·37	15 — 15	.. ..
Heat Engineering 2·46, 2·47	60—105	30 — 45
Hydraulic and Sanitary Design 1·79	.. ..	30 — 0
Hydraulic and Sanitary Engineering 1·75, 1·76	60 — 75	60 — 75
Roads and Pavements 1·35	20 — 25	.. ..
Structures 1·41, 1·42	60 —120	60 —120
Thesis	.. ..	105
General Study	30 — 30	30 — 30
Hours of exercise and preparation: 720 =	350 + 370	720

FOURTH YEAR

Option 2. (a and b) Transportation Engineering

	First Term 15 Weeks	Second Term 15 Weeks
Bridge Design 1·501, 1·502	105 — 0	75 — 0
(*b*) Chemistry of Road Materials 5·37	60 — 0	.. ..
Engineering and Hydraulic Laboratory 2·63	.. ..	30 — 30
Engineering Construction and Estimates 1·25	30 — 45	.. ..
Field Geology 12·37	15 — 15	.. ..
(*b*) Highway Design 1·38	.. ..	45 — 0
Heat Engineering 2·46, 2·47	60—105	30 — 45
(*b*) Highway Transportation 1·37	.. ..	30 — 60
(*a*) Railway Design 1·28	.. ..	75 — 0
(*a*) Railway Engineering 1·26, 1·27	30 — 30	30 — 60
Roads and Pavements 1·35	20 — 25	.. ..
Structures 1·41, 1·42	60—120	60—120
(*b*) Testing Highway Materials 1·36	.. ..	15 — 15
Thesis	.. ..	105
General Study	30 — 30	30 — 30
Hours of exercise and preparation: (2*a*) 720 =	350 + 370	720
(2*b*) 720 =	380 + 340	720

FOURTH YEAR

Option 3. Hydro-electric Engineering

	First Term 15 Weeks	Second Term 15 Weeks
Bridge Design 1·511, 1·512	60 — 0	90 — 0
Central Stations 6·47	.. ..	30 — 60
Electric Transmission and Distribution of Energy 6·44	30 — 60	.. ..
Engineering and Hydraulic Laboratory 2·631	.. ..	45 — 45
Field Geology 12·37	15 — 15	.. ..
Heat Engineering 2·46, 2·47	60—105	30 — 45
Structures 1·41, 1·421	60—120	30 — 60
Water Power Engineering 1.70, 1·71	45 — 90	90 — 45
Thesis	.. ..	90
General Study	30 — 30	30 — 30
Hours of exercise and preparation: 720 =	300 + 420	720

MECHANICAL ENGINEERING — COURSE II

As Civil Engineering is the oldest and earliest developed branch of the profession, so Mechanical Engineering ranks next in point of time and development as the foundation of all industrial progress. It is essentially the engineering of design and production in industry.

The course in Mechanical Engineering prepares the student to enter any one of the various branches of that profession, *i.e.*, engine design, automotive design, locomotive construction, steam turbine engineering, mill engineering, refrigeration, heating and ventilation, power plant design, hydraulic engineering, factory construction, production methods and industrial management.

Sufficient training is given in Electrical Engineering subjects to enable one to handle the ordinary problems which come to a mechanical engineer,

Much time is spent during the first two years on such fundamental subjects as chemistry, physics, mathematics, mechanism, applied mechanics and drawing, as a thorough knowledge of these subjects is essential to an engineer.

The student is given a training in the mechanic arts sufficient to make him familiar with the use of modern machine tools, foundry practice, forging and pattern work, such knowledge being a requirement for a successful designer of machinery.

Lectures on Heat Engineering, including theoretical thermodynamics, on heat transmission, on heat treatment of metals, on the theory of elasticity, and on materials of engineering, together with the laboratory work which is arranged to parallel these lectures, fill the time given to professional work in the third year.

In the fourth year the student is offered the choice of several professional electives; also the choice of one of the following options: Automotive Engineering, Engine Design, Textile Engineering, Refrigeration, Ordnance Engineering.

To subjects of general cultural value, like English, history, political economy and general studies, nine hundred hours have been allotted, this being a little less than one-seventh of the total time.

Mechanical Engineering — COURSE II — *Continued*

First Year, Page 60

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·15	.. ..	45 — 90
English and History E21, E22	45 — 75	45 — 75
Forging 2·90	.. ..	45 — 0
Foundry 2·91	60 — 0	.. ..
Machine Drawing 2·13	.. ..	90 — 0
Mathematics M21, M22	45 — 90	45 — 90
Mechanical Engineering Drawing 2·10	90 — 0	.. ..
Mechanical Engineering Equipment 2·04	.. ..	15 — 0
Mechanism 2·00	45 — 90	.. ..
Military Science MS21, MS22	45 — 0	45 — 0
Pattern Making 2·92	.. ..	30 — 0
Physics 8·03, 8·04	60 — 75	60 — 75
Surveying 1·03	30 — 0	.. ..
Hours of exercise and preparation:	750 = 420 + 330	750 = 420 + 330

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·20, 2·21	45 — 90	45 — 75
Electrical Engineering, Elements 6·40	.. ..	60 — 90
Heat Engineering 2·40, 2·42	45 — 90	45 — 75
Heat Engineering 2·41	30 — 30	.. ..
Machine Design 2·70	.. ..	60 — 0
Machine Tool Laboratory 2·951, 2·952	90 — 0	60 — 0
Materials of Engineering 2·30	.. ..	30 — 30
Mechanism of Machines 2·05	60 — 30	.. ..
Political Economy Ec31, Ec32	45 — 45	45 — 45
Physical Chemistry 5·82	30 — 30	.. ..
General Study	30 — 30	30 — 30
Hours of exercise and preparation:	720 = 375 + 345	720 = 375 + 345

FOURTH YEAR. (General Course)

	First Term 15 Weeks	Second Term 15 Weeks
Dynamics of Machines 2·251	30 — 60	.. ..
Electrical Engineering Laboratory 6·89	30 — 30	.. ..
Engineering Laboratory 2·601, 2·602	60 — 60	60 — 60
Heat Engineering 2·43	30 — 60	.. ..
Hydraulics 1·64	45 — 90	.. ..
Industrial Plants 2·781	.. ..	45 — 45
Industrial Plants 2·782	.. ..	60 — 0
Machine Design 2·71	90 — 0	.. ..
Mechanics of Engineering 2·26	.. ..	45 — 90
Power Plant Design 2·58	.. ..	60 — 0
Production Methods 2·98	.. ..	15 — 15
Testing Materials Laboratory 2·35	60 — 30	.. ..
General Study	30 — 30	30 — 30
Thesis	.. ..	105
Elective	.. ..	60
Hours of exercise and preparation:	735 = 375 + 360	720

In the second term of the fourth year an elective from the following list is to be taken by each student:

ELECTIVES

	First Term	Second Term
Aeronautics 16·76	.. ..	30 — 30
Application of X-Ray and Photo-Elasticity 8·44	.. ..	60 — 0
Automatic Machinery 2·850	.. ..	30 — 30
Engineering Chemistry 5·34	.. ..	60 — 0
Fire Protection Engineering 2·851	.. ..	30 — 30
Heat Treatment 2·856	.. ..	60 — 0
Locomotive Engineering 2·853	.. ..	30 — 30
Mechanical Equipment of Buildings 2·854	.. ..	30 — 30
Steam Turbine Engineering 2·855	.. ..	30 — 30

Mechanical Engineering — COURSE II — *Continued*

FOURTH YEAR

Option 1. Automotive

	First Term 15 Weeks	Second Term 15 Weeks
Automobile Laboratory 2·66	.. ..	30 — 30
Dynamics of Machines 2·251	30 — 60	.. ..
Electrical Engineering Laboratory 6·89	30 — 30	.. ..
Engineering Laboratory 2·601, 2·603	60 — 60	30 — 30
Gasoline Automobile 2·79	.. ..	45 — 45
Heat Engineering 2·43	30 — 60	.. ..
Heat Treatment 2·84	30 — 0	.. ..
Hydraulics 1·64	45 — 90	.. ..
Industrial Plants 2·781	.. ..	45 — 45
Machine Design 2·711, 2·712	60 — 0	30 — 0
Mechanics of Engineering 2·26	.. ..	45 — 90
Power Plant Design 2·58	.. ..	60 — 0
Production Methods 2·98	.. ..	15 — 15
Testing Materials Laboratory 2·35	60 — 30	.. ..
General Study	30 — 30	30 — 30
Thesis	.. ..	105
Hours of exercise and preparation: 735 =	375 + 360	720

FOURTH YEAR

Option 2. Engine Design

	First Term 15 Weeks	Second Term 15 Weeks
Dynamics of Machines 2·251	30 — 60	.. ..
Electrical Engineering Laboratory 6·89	30 — 30	.. ..
Engine Design 2·77	.. ..	90 — 45
Engineering Laboratory 2·601, 2·602	60 — 60	60 — 60
Heat Engineering 2·43	30 — 60	.. ..
Heat Treatment 2·84	30 — 0	.. ..
Hydraulics 1·64	45 — 90	.. ..
Industrial Plants 2·781	.. ..	45 — 45
Machine Design 2·711	60 — 0	.. ..
Mechanics of Engineering 2·26	.. ..	45 — 90
Power Plant Design 2·58	.. ..	60 — 0
Production Methods 2·98	.. ..	15 — 15
Testing Materials Laboratory 2·35	60 — 30	.. ..
General Study	30 — 30	30 — 30
Thesis	.. ..	105
Hours of exercise and preparation: 735 =	375 + 360	735

FOURTH YEAR

Option 3. Textile

	First Term 15 Weeks	Second Term 15 Weeks
Dynamics of Machines 2·251	30 — 60	.. ..
Electrical Engineering Laboratory 6·89	30 — 30	.. ..
Engineering Laboratory 2·601, 2·603	60 — 60	30 — 30
Fire Protection Engineering 2·851	.. ..	30 — 30
Heat Engineering 2·43	30 — 60	.. ..
Hydraulics 1·64	45 — 90	.. ..
Industrial Plants 2·781	.. ..	45 — 45
Machine Design 2·71	90 — 0	.. ..
Mechanics of Engineering 2·26	.. ..	45 — 90
Power Plant Design 2·58	.. ..	60 — 0
Production Methods 2·98	.. ..	15 — 15
Testing Materials Laboratory 2·35	60 — 30	.. ..
Textile Engineering 2·87	.. ..	90 — 30
General Study	30 — 30	30 — 30
Thesis	.. ..	105
Hours of exercise and preparation: 735 =	375 + 360	720

Mechanical Engineering — Course II — *Continued*

FOURTH YEAR

OPTION 4. Refrigeration

	First Term 15 Weeks	Second Term 15 Weeks
Dynamics of Machines 2·251	30 — 60	.. ..
Electrical Engineering Laboratory 6·89	30 — 30	.. ..
Engineering Laboratory 2·601, 2·603	60 — 60	30 — 30
Heat Engineering 2·43	30 — 60	.. ..
Hydraulics 1·64	45 — 90	.. ..
Industrial Plants 2·781	.. ..	45 — 45
Machine Design 2·71	90 — 0	.. ..
Mechanics of Engineering 2·26	.. ..	45 — 90
Power Plant Design 2·58	.. ..	60 — 0
Production Methods 2·98	.. ..	15 — 15
Refrigeration 2·49	.. ..	45 — 75
Refrigeration Laboratory 2·64	.. ..	30 — 30
Testing Materials Laboratory 2·35	60 — 30	.. ..
General Study	30 — 30	30 — 30
Thesis	.. ..	105
Hours of exercise and preparation: 735 =	375 + 360	720

ARMY ORDNANCE

This work begins with a summer session. Subjects covered: Differential Equations, M72, a course of one hundred and ninety-five hours; Mechanics 2·891, this course extending through a period of two hundred and thirty-five hours, Chemistry 5·04S extending through a period of 90 hours.

Schedule for the Year

	Summer Term	First Term 15 Weeks	Second Term 15 Weeks
Chemistry 5·04S	90 — 0	.. ..	.. ..
Chemistry of Powder and Explosives 5·57	.. ..	.. ..	30 — 30
Chemistry Laboratory 5·81	.. ..	.. ..	105 — 0
Differential Equations M72	195	.. ..	.. ..
Electrical Engineering, Elements 6·42	.. ..	75 — 75	.. ..
Electrical Engineering Laboratory 6·88	.. ..	.. ..	60 — 90
Heat Engineering 2·461, 2·471	.. ..	45 — 75	45 — 60
Mechanics 2·891	235	.. ..	.. ..
Mechanisms 2·03	.. ..	90 — 30	.. ..
Ordnance Problems 2·892	.. ..	.. ..	120 — 0
Organic Chemistry 5·51, 5·52	.. ..	60 — 45	60 — 30
Organic Chemical Laboratory 5·61	.. ..	135 — 0	.. ..
Power Laboratory 2·65	.. ..	.. ..	30 — 30
Theory of Elasticity 2·271, 2·272	.. ..	60—120	30 — 60
Theory of Gyroscope M571	.. ..	.. ..	15 — 15
	520	810	810

Mechanical Engineering — COURSE II — *Continued*

AUTOMOTIVE ENGINEERING — GRADUATE

	First Term 15 Weeks	Second Term 15 Weeks
Automotive Design 2·811, 2·812	120 — 0	150 — 0
Automotive Engineering 2·801, 2·802	45 — 90	45 — 90
Automotive Fuels 10·931	45 — 75	.. ..
Dynamics of Engines 2·254	30 — 60	.. ..
Engine Testing 2·671	60 — 30	.. ..
Heat Treatment 2·842	45 — 0	.. ..
Heat Treatment and Metallography 2·86	.. ..	60 — 20
Maintenance and Operation of Automotive Equipment 2·661	30 — 20	.. ..
Manufacturing Processes 2·981	45 — 15	.. ..
Motor Vehicle Testing 2·672	.. ..	75 — 45
Research	45	285
Hours of exercise and preparation:	755	770

TORPEDO DESIGN, UNITED STATES NAVY — GRADUATE

	First Term 15 Weeks	Second Term 15 Weeks
Aero Engine Laboratory 2·691	.. ..	30 — 0
Application of X-Ray and Photelasticity 8·44	.. ..	60 — 0
Automatic Machinery 2·07	45 — 45	.. ..
Automatic Machinery 2·08	.. ..	60 — 60
Dynamics of Machines 2·251	30 — 60	.. ..
Engineering Laboratory 2·601	60 — 60	.. ..
Heat Engineering 2·40, 2·42	45 — 90	45 — 75
Heat Treatment 2·841	45 — 0	.. ..
Machine Design 2·761, 2·762	90 — 30	90 — 30
Materials of Engineering 2·301	30 — 30	.. ..
Mechanism of Machines 2·06	30 — 30	.. ..
Physical Metallurgy 2·331, 2·332	30 — 30	120 — 30
Theory of the Gyroscope M57	.. ..	15 — 30
Thermodynamics 5·78	.. ..	30 — 30
Torpedoes 2·51	.. ..	30 — 60
Hours of exercise and preparation:	780 = 405 + 375	795 = 480 + 315

Research of 300 hours between June 15 and December 15 of following year.

ORDNANCE DESIGN, UNITED STATES NAVY — GRADUATE

	First Term 15 Weeks	Second Term 15 Weeks
Advanced Mechanics and Theory of Elasticity 2·281, 2·282	45—120	45—120
Aircraft Armament 16·48	.. ..	45— 75
Dynamics of Machines 2·251	30 — 60	.. ..
Electrical Engineering Laboratory 6·89	30 — 30	.. ..
Exterior Ballistics M75	30 — 60	.. ..
Heat Treatment 2·841	45 — 0	.. ..
Industrial Applications of Electric Power 6·46	.. ..	45 — 30
Interior Ballistics 2·29	.. ..	30 — 45
Machine Design 2·71	90 — 0	.. ..
Machine Design Advanced 2·75	.. ..	150 — 0
Mechanism of Machines 2·06	30 — 30	.. ..
Physical Metallurgy 2·331, 2·332	30 — 30	120 — 30
Structures 1·45	45 — 90	.. ..
Structural Design 1·461	.. ..	45 — 0
Theory of the Gyroscope M57	.. ..	15 — 30
Hours of exercise and preparation:	795 = 375 + 420	825 = 495 + 330

Research of 300 hours between June 15 and December 15 of following year.

MINING ENGINEERING AND METALLURGY
Including Petroleum Production
COURSE III

The demands made upon engineers in mining engineering, metallurgy, 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, metallurgy and petroleum engineering, as well as in related branches of mechanical, civil and electrical engineering. 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, metallurgy 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 and metallurgical plants.

Three optional courses are open to students.

Option 1. Mining Engineering. This covers the field of mining engineering and includes courses of 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. Metallurgy. This division is for those interested chiefly in metallurgy. Prominence is given to the metallurgical processes; the production, properties, and treatment of metals and alloys; and to metallography. Opportunity is given to specialize in iron and steel, copper and non-ferrous metallurgy, in gold and silver or in metallography. Trips followed by conferences and reports are made to mills, foundries and shops in the vicinity.

Option 3. Petroleum Production. This option covers the field of prospecting, development, production, transportation and storage of petroleum. Prominence is given to methods of finding and developing petroleum resources; to methods of drilling wells and extracting oil and gas from natural reservoirs; to the maintenance of oil and gas wells and fields; to methods of transportation of crude oil and gas and the storage of oil. Emphasis is placed on the statistics which are of importance in the study of petroleum economics from a world viewpoint.

Mining Engineering and Metallurgy—COURSE III—*Continued*

Option 1. Mining Engineering

First Year, Page 60

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
English and History E21, E22	45 — 75	45 — 75
Forging 2·901	30 — 0	.. ..
Geology 12·30	.. ..	45 — 45
Mathematics M21, M22	45 — 90	45 — 90
Mechanism 2·01	.. ..	30 — 60
Military Science MS21, MS22	45 — 0	45 — 0
Mineralogy 12·01	120 — 30	.. ..
Physics 8·03, 8·04	60 — 75	60 — 75
Qualitative Analysis 5·11	105 — 30	.. ..
Quantitative Analysis 5·12	.. ..	105 — 30
Hours of exercise and preparation:	750 = 450 + 300	750 = 375 + 375

REQUIRED COURSES AT SUMMER MINING CAMP

Surveying 1·10	345 — 15
Mining Practice 3·08	45 — 0

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·15, 2·20	45 — 90	45 — 90
Economic Geology 12·40	.. ..	75 — 45
Fire Assaying 3·31	90 — 30	.. ..
Geology 12·31	75 — 45	.. ..
Mining Methods 3·01, 3·02	75 — 45	60 — 45
Ore Dressing 3·21	.. ..	45 — 30
Ore Dressing Laboratory 3·22	.. ..	75 — 30
Political Economy Ec31, Ec32	45 — 45	45 — 45
Quantitative Analysis 5·13	105 — 30	.. ..
Testing Materials Laboratory 2·37	.. ..	20 — 10
General Study	.. ..	30 — 30
Hours of exercise and preparation:	720 = 435 + 285	720 = 395 + 325

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Economics of Mining 3·03	60 — 45	.. ..
Electrical Engineering Laboratory 6·85	.. ..	30 — 45
Electrical Engineering, Elements 6·40	60 — 90	.. ..
Engineering Laboratory 2·611	.. ..	30 — 15
Field Geology 12·33	45 — 15	.. ..
Heat Engineering 2·44, 2·45	45 — 75	45 — 75
Hydraulics 1·63	30 — 45	.. ..
Metallurgy, Copper, Lead, etc. 3·412	75 — 45	.. ..
Metallurgy, Gold and Silver 3·42	.. ..	75 — 30
Metallurgy, Iron and Steel 3·432	30 — 15	.. ..
Principles of Mining 3·04	.. ..	45 — 60
Stationary Structures 1·44	.. ..	30 — 45
General Study	30 — 30	30 — 30
Thesis	.. ..	150
Hours of exercise and preparation:	735 = 375 + 360	735

Mining Engineering and Metallurgy—COURSE III—*Continued*

Option 2. Metallurgy

First Year, Page 60

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
English and History E21, E22	45 — 75	45 — 75
Forging 2·901	30 — 0	.. ..
Foundry 2·91	.. ..	60 — 0
Gas Analysis 5·31	.. ..	15 — 15
Mathematics M21, M22	45 — 90	45 — 90
Mechanism 2·01	.. ..	30 — 60
Military Science MS21, MS22	45 — 0	45 — 0
Mineralogy 12·01	120 — 30	.. ..
Physics 8·03, 8·04	60 — 75	60 — 75
Qualitative Analysis 5·11	105 — 30	.. ..
Quantitative Analysis 5·12	.. ..	105 — 30
Hours of exercise and preparation:	750 = 450 + 300	750 = 405 + 345

REQUIRED SUMMER COURSES

Machine Drawing 2·14	60 — 0
Surveying and Plotting 1·02	70 — 5

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Accounting Ec50	.. ..	45 — 45
Applied Mechanics 2·15, 2·20	45 — 90	45 — 90
Engineering Laboratory 2·611	.. ..	30 — 15
Fire Assaying 3·31	90 — 30	.. ..
Heat Engineering 2·44, 2·45	45 — 75	45 — 75
Heat Measurements 8·12	45 — 15	.. ..
Metallography 3·61	.. ..	75 — 15
Ore Dressing 3·23	.. ..	45 — 30
Political Economy Ec31, Ec32	45 — 45	45 — 45
Quantitative Analysis 5·13	105 — 30	.. ..
Testing Materials Laboratory 2·37	.. ..	20 — 10
General Study	30 — 30	30 — 30
Hours of exercise and preparation:	720 = 405 + 315	735 = 380 + 355

REQUIRED SUMMER COURSE

Metallurgical Plant Visits 3·60	30 — 30

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Electrical Engineering, Elements 6·40	60 — 90	.. ..
Electrical Engineering Laboratory 6·85	.. ..	30 — 45
Electrochemistry, Elements 8·90	.. ..	60 — 30
Elements of Mining 3·05	30 — 30	.. ..
Hydraulics 1·63	30 — 45	.. ..
Metallurgy, Gold and Silver 3·42	.. ..	75 — 30
Metallurgy, General: Zinc and Minor Metals 3·44	.. ..	60 — 45
Metallurgy and Heat Treatment of Steel 3·45	.. ..	30 — 15
(*a*) Metallurgy { Iron and Steel 3·43	105 — 45	.. ..
(*a*) Metallurgy { Copper, Lead, etc. 3·411	90 — 45	.. ..
or		
(*b*) Metallurgy { Iron and Steel 3·431	45 — 45	.. ..
(*b*) Metallurgy { Copper, Lead, etc. 3·41	150 — 45	.. ..
Thermochemistry and Chemical Equilibrium 5·68	30 — 60	.. ..
General Study	30 — 30	30 — 30
Thesis	.. ..	180
Elective	.. ..	60
Hours of exercise and preparation:	720 = 375 + 345	720

Mining Engineering and Metallurgy—COURSE III—*Continued*

Option 3. Petroleum Production

First Year, Page 60

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
English and History E21, E22	45 — 75	45 — 75
Forging 2·901	30 — 0	.. ..
Geology 12·30	.. ..	45 — 45
Mathematics M21, M22	45 — 90	45 — 90
Mechanism 2·01	.. ..	30 — 60
Military Science MS21, MS22	45 — 0	45 — 0
Mineralogy 12·01	120 — 30	.. ..
Physics 8·03, 8·04	60 — 75	60 — 75
Qualitative Analysis 5·11	105 — 30	.. ..
Quantitative Analysis 5·12	.. ..	105 — 30
Hours of exercise and preparation:	750=450+300	750=375+375

REQUIRED COURSES AT SUMMER MINING CAMP

Surveying 1·10	345 — 15
Mining Practice 3·08	45 — 0
Oil Field Visits 3·89	50 — 0

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·15, 2·20	45 — 90	45 — 90
Economic Geology 12·40	.. ..	75 — 45
Geology 12·31	75 — 45	.. ..
Lubricating and Fuel Oil Testing 5·38	45 — 15	.. ..
Mining Methods 3·01, 3·02	75 — 45	60 — 45
Ore Dressing 3·23	.. ..	45 — 30
Petroleum Engineering, Elements 3·81, 3·82	90 — 45	60 — 45
Political Economy Ec31, Ec32	45 — 45	45 — 45
Testing Materials Laboratory 2·37	.. ..	20 — 10
General Study	30 — 30	30 — 30
Hours of exercise and preparation:	720 = 405 + 315	720 = 380 + 340

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Economics of Mining 3·03	60 — 45	.. ..
Electrical Engineering Laboratory 6·85	.. ..	30 — 45
Electrical Engineering, Elements 6·40	60 — 90	.. ..
Engineering Laboratory 2·611	.. ..	30 — 15
Field Geology 12·33	45 — 15	.. ..
Geology of Coal and Petroleum 12·80	60 — 45	.. ..
Heat Engineering 2·44, 2·45	45 — 75	45 — 75
Hydraulics 1·63	30 — 45	.. ..
Petroleum Production and Utilization 3·85, 3·86	75 — 30	75 — 30
Principles of Mining 3·04	.. ..	45 — 60
Stationary Structures 1·44	.. ..	30 — 45
General Study	.. ..	30 — 30
Thesis	.. ..	135
Hours of exercise and preparation:	720 = 375 + 345	720

ARCHITECTURE — COURSE IV

The architect of today requires training in the creative, the constructive, and the executive aspects of his profession. Rarely is an individual so endowed that he may achieve a mastery of all three fields, though an understanding of each in its relation to the other is essential to a thorough realization of the opportunities that lie before the architectural student. At the present time the Department offers courses covering two aspects of the general field, the creative and the constructive. A description of the latter (Course IV-A, Architectural Engineering) will be found on page 77; a description of the former (Course IV, Architecture) follows herewith.

The Department of Architecture of the Massachusetts Institute of Technology is the oldest school of architecture in the country. Its record of distinguished performance in the field of architectural education is unexcelled. That this enviable accomplishment may be perpetuated and that the graduates of the Department may have the best possible preparation for their years of practice, a five-year course has been established, leading to the degree of Bachelor in Architecture.

This new course affords the high school graduate the opportunity to acquire the essentials of a general education while pursuing his technical studies. For students with a college background, and likewise for those whose training has been largely in offices, this course offers an opportunity to supplement the deficiencies in their educational preparation to the best possible advantage. The former will receive credit for satisfactory work equivalent to the requirements of our schedule that has been performed elsewhere. The latter will correspondingly find that as a rule their experience as draughtsmen will qualify them to take the more advanced professional courses in design, freehand drawing or color (see requirements for special students on page 57). Thus in both instances as much time as possible will be gained toward the completion of the required schedule.

The method of teaching followed in the Department is founded upon personal criticism. Instructors in all professional subjects devote their efforts toward the development of individual initiative. This applies particularly to the courses in design, modelling, color and freehand drawing where individual criticism at the draughting board is accompanied by careful direction in the use of our exceptional library material.

Lest constant criticism should tend to make the student depend upon his instructors for ideas, and thus defeat the whole purpose of our teaching, students in the advanced grades are thrown increasingly upon their own resources, only receiving criticism when satisfactory progress has been made since the instructor's last visit. This policy, together with the custom of advancing students in design by points rather than by years, ensures to the capable performer such rapid advancement as his qualities justify.

Frequent opportunities for the comparison of our student work with that of students from other institutions are provided by the conjunctive problems shared with the Harvard School of Architecture and the Boston Architectural Club. These opportunities are further supplemented by sending selected drawings from all grades to the judgments of the Beaux Arts Institute of Design in New York City.

That deserving students in need of financial aid may not have to forego the opportunities that we offer, scholarship aid is available for both men and women. This assistance is supplemented by many cash prizes given throughout the year, and conspicuous ability is rewarded by Fontainebleau Scholarships and a Traveling Fellowship entitling the student to a year's travel in Europe.

All drawings and designs made during the course become the property of the Department to be retained, published, exhibited, or returned at the discretion of the Department.

Architecture — COURSE IV

FOUR YEAR COURSE

FIRST YEAR (Discontinued June 1927)

SECOND YEAR (Discontinued after 1928)

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·17, 2·18	45 — 75	45 — 75
Architectural History 4·421, 4·422	15 — 30	15 — 30
Design II 4·721, 4·722	180 — 0	225 — 0
English and History E21, E22	45 — 75	45 — 75
Freehand Drawing 4·021, 4·022	60 — 0	60 — 0
French L65	45 — 75	.. ..
Military Science MS21, MS22	45 — 0	45 — 0
Office Practice 4·20	.. ..	75 — 0
Theory of Architecture 4·321, 4·322	15 — 15	15 — 15
Hours of exercise and preparation:	720 = 450 + 270	720 = 525 + 195

REQUIRED SUMMER COURSE

Office Practice 4·21 100 — 0

THIRD YEAR (Discontinued after 1929)

	First Term 15 Weeks	Second Term 15 Weeks
Building Construction 4·80	15 — 15	.. ..
Color, Theory and Exercises 4·081, 4·082	15 — 45	15 — 45
Constructive Design 4·811, 4·812	90 — 0	105 — 0
Design III 4·731, 4·732	210 — 0	225 — 0
European Civilization and Art 4·461, 4·462	45 — 60	45 — 60
Freehand Drawing 4·031, 4·032	60 — 0	60 — 0
Modelling 4·071, 4·072	45 — 0	45 — 0
Political Economy Ec31, Ec32	45 — 45	45 — 45
Theory of Architecture 4·331, 4·332	15 — 15	15 — 15
Hours of exercise and preparation:	720 = 540 + 180	720 = 555 + 165

Architecture — COURSE IV — *Continued*

Four Year Course — *Continued*

FOURTH YEAR (Discontinued after 1930)

	First Term 15 Weeks	Second Term 15 Weeks
Color, Design and Application 4·091, 4·092	15 — 60	15 — 60
Design IV 4·741, 4·742	345 — 0	375 — 0
European Civilization and Art 4·471, 4·472	45 — 60	45 — 60
Freehand Drawing 4·041, 4·042	90 — 0	90 — 0
History of Renaissance Art 4·49	.. ..	15 — 15
Town Planning 4·61	30 — 45	.. ..
Philosophy of Architecture 4·52	.. ..	15 — 0
Professional Relations 4·241, 4·242	15 — 15	15 — 15
Hours of exercise and preparation:	720 = 540 + 180	720 = 570 + 150

FIVE YEAR COURSE — Beginning September 1927

FIRST YEAR (In effect 1927-28)

	First Term	Second Term
Architectural History 4·411, 4·412	30 — 60	30 — 60
Design I 4·712	.. ..	180 — 0
English E11, E12	45 — 75	45 — 75
French L63, L64	45 — 90	45 — 90
Graphics 4·06	90 — 0	.. ..
Mathematics M11, M12	45 — 90	45 — 90
Military Science MS11, MS12	45 — 0	45 — 0
Perspective 4·12	45 — 0	.. ..
Physical Training PT1, PT2	20 — 0	20 — 0
Shades and Shadows 4·11	45 — 0	.. ..
Theory of Architecture 4·311, 4·312	15 — 0	15 — 0
Hours of exercise and preparation:	740 = 425 + 315	740 = 425 + 315

SECOND YEAR (In effect 1928–29)

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·17, 2·18	45 — 75	45 — 75
Architectural History 4·421, 4·422	15 — 30	15 — 30
Design II 4·721, 4·722	180 — 0	180 — 0
English E21, E22	45 — 75	45 — 75
Freehand Drawing 4·021, 4·022	60 — 0	60 — 0
French L65, L66	30 — 45	30 — 45
Military Science MS21, MS22	45 — 0	45 — 0
Office Practice 4·211, 4·212	45 — 0	45 — 0
Theory of Architecture 4·321, 4·322	15 — 15	15 — 15
Hours of exercise and preparation:	720 = 480 + 240	720 = 480 + 240

REQUIRED SUMMER COURSE (Following Second Year)

Office Practice 4·20 100 hrs.

Architecture — COURSE IV — *Continued*

Five Year Course — (*Continued*)

THIRD YEAR (In effect 1929–30)

	First Term 15 Weeks	Second Term 15 Weeks
Building Construction 4·80	15 — 15	.. ..
Constructive Design 4·811, 4·812	105 — 0	105 — 0
Design III 4·731, 4·732	195 — 0	225 — 0
European Civilization and Art 4·461, 4·462	45 — 60	45 — 60
Freehand Drawing 4·031, 4·032	60 — 0	60 — 0
Modelling 4·071, 4·072	45 — 0	45 — 0
Political Economy Ec31, Ec32	45 — 45	45 — 45
Public Speaking	30 — 30	30 — 30
Theory of Architecture 4·331, 4·332	30 — 0	30 — 0
Hours of exercise and preparation:	720=570+150	720=585+135

FOURTH YEAR (In effect 1930-31)

	First Term 15 Weeks	Second Term 15 Weeks
Acoustics, Illumination and Color 8·06	15 — 30	.. ..
Color, Theory and Exercises	15 — 45	15 — 45
Design IV 4·741, 4·742	315 — 0	330 — 0
European Civilization and Art 4·471, 4·472	45 — 60	45 — 60
Freehand Drawing 4·041, 4·042	60 — 0	60 — 0
Geology of Materials 12·49	15 — 30	.. ..
Mechanical Equipment of Buildings	.. ..	60 — 45
Professional Relations	.. ..	15 — 15
Report Writing	30 — 30	.. ..
Theory of Architecture 4·341, 4·342	30 — 0	30 — 0
Hours of exercise and preparation:	720=525+195	720=555+165

FIFTH YEAR (In effect 1931-32)

	First Term 15 Weeks	Second Term 15 Weeks
Architectural Humanities 4·51	15 — 15	.. ..
Color, Design and Application	15 — 60	15 — 60
Design V 4·751, 4·752	375 — 0	175 — 0
European Civilization and Art 4·481, 4·482	30 — 45	30 — 45
Figure Composition 4·052	.. ..	90 — 0
Freehand Drawing 4·051	90 — 0	.. ..
Philosophy of Architecture 4·52	.. ..	15 — 15
Town Planning	30 — 45	.. ..
Thesis	.. ..	275 — 0
Hours of exercise and preparation:	720=555+165	720=600+120

COURSE IV-A. ARCHITECTURAL ENGINEERING*

The course in Architectural Engineering was first developed as an option in Architecture and graduated its first class in 1900. The Institute was among the earliest of the technical schools to recognize the growing demand for men with a thorough, fundamental training in engineering who should at the same time have acquired a sufficient acquaintance with the aims and ideals of the architect to be able to work in sympathy with him.

The introduction of new building materials, steel about 1885 and reinforced concrete somewhat later, opened hitherto undreamed of possibilities in the structural problems and added greatly to their complexity. This laid the way for specialization in the architectural profession and gave birth to the new profession of architectural engineer.

Every important architectural structure today is the result of three elements working in close association with one another; first the designing element which is the real creative element, second the engineering element which controls the design of the structure, and lastly the administrative element. Every architectural firm must comprise the creative and the administrative element, in the smaller offices sometimes combined in a single person. The engineering element on the other hand may or may not be directly a part of the office equipment. It is always desirably so, but it may be sought outside the office in one of the structural firms specializing in architectural construction, or it may be sought in the services of a consulting architectural engineer called to work in association with the architect on a particular piece of work.

It is the aim of Course IV-A to offer training leading to a professional career in engineering and in architecture. In addition to the preparatory training given to the other engineering students those of IV-A are required to take courses in history of civilization, of art, and of architecture, and in principles of planning.

In accord with the general policy of the Institute much stress is laid upon the acquisition by the student of the basic principles of engineering and upon his ability to adapt these principles to special cases. Parallel with the theory of structures long periods of structural analysis and design develop the student's initiative and imagination, and expand his power to use his equipment in the solution of the infinite variety of problems with which the structural engineer has to cope. The instruction in this work is largely individual in character and is planned to develop the ability to think independently. This work is carried on in the atmosphere of the architectural department where the student is constantly in touch with the men working in Course IV.

The student who elects IV-A should be interested in mathematics

*Definition adopted by the Association of Collegiate Schools of Architecture, May, 1921. Architectural Engineering: "Essentially an engineering course, giving fundamental and comprehensive training in engineering and including sufficient preparation in Architecture to put the student in full sympathy with the ideals of the architect, but with no attempt to give him facility in Architectural Design."

and their many applications and at the same time his tastes should be of sufficient breadth to have some inclination toward the so-called fine arts. The latter is an essential element in his equipment if he is to be a success as an engineer practicing in Architecture and will form a most useful bond of understanding between himself and the architect.

The course is four years in length and leads to the degree of Bachelor of Science in Architectural Engineering.

Architectural Engineering — COURSE IV-A

First Year, Page 60

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·15, 2·20	45 — 90	45 — 90
Architectural History 4·411, 4·412	30 — 60	30 — 60
Building Construction 4·80	15 — 15	.. ..
English and History E21, E22	45 — 75	45 — 75
Foundry 2·911	.. ..	30 — 0
Mathematics M21, M22	45 — 90	45 — 90
Military Science MS21, MS22	45 — 0	45 — 0
Perspective 4·13	15 — 45	.. ..
Physics 8·03, 8·04	60 — 75	.. ..
Structural Drawing 4·90	.. ..	60 — 0
Hours of exercise and preparation:	750 = 300+450	750 = 360+390

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Acoustics, Illumination and Color 8·06	15 — 30	.. ..
Applied Mechanics 2·20, 2·211	45 — 90	45 — 90
Architectural History 4·421, 4·422	15 — 30	15 — 30
European Civilization and Art 4·461, 4·462	45 — 60	45 — 60
Geology of Materials 12·49	15 — 30	.. ..
Materials 1·43	.. ..	15 — 30
Office Practice 4·22	90 — 0	.. ..
Political Economy Ec31, Ec32	45 — 45	45 — 45
Report Writing E33	30 — 30	.. ..
Structural Design 4·911, 4·912	105 — 0	150 — 0
Structures 1.40	.. ..	45 — 75
Surveying 1·03	.. ..	30 — 0
Hours of exercise and preparation:	720 = 405+315	720 = 390+330

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Estimating 4·25	15 — 30	.. ..
Hydraulics 1·63	30 — 45	.. ..
Mechanical Equipment of Buildings 2·59	.. ..	60 — 45
Professional Relations 4·241, 4·242	15 — 15	15 — 15
Reinforced Concrete Design 2·391, 2·392	105 — 0	90 — 0
Structural Design 4·921, 4·922	120 — 0	195 — 0
Structures 1·41, 1·422	60—120	30 — 60
Testing Materials Laboratory 2·361	30 — 30	.. ..
Testing Materials Laboratory (Concrete) 2·362	30 — 15	.. ..
Thesis	.. ..	150
General Study	30 — 30	30 — 30
Hours of exercise and preparation:	720 = 435+285	720

CHEMISTRY — COURSE V

The curriculum in Chemistry includes a large number of individual courses in Chemistry, most of which are general and fundamental in character. The aim of the course is first to give the student thorough instruction by means of lectures, recitations and laboratory practice, in the fundamental principles of inorganic, analytical, organic, theoretical and industrial chemistry. Instruction in mathematics, physics, and German is included in the course. This fundamental instruction is the same for all students for the first three years.

A second aim is to stimulate and develop the research attitude in the student. In any scientific career, the highest success is attained by those who possess an ability to surmount difficulties as they appear, to attack untried problems systematically, and to use knowledge already acquired to advance the boundaries of the science. This is particularly true of chemical science. The subjects designated as "Research Problems" in the third and fourth years, as well as the thesis required of all students, are intended to develop ability in research. In these subjects each student is assigned a problem of not great difficulty which he is expected to plan and execute, with reasonable aid from an instructor. It is required to present the results of the investigation in a careful and concise report. The extensive equipment of the various laboratories is fully utilized for this work.

Specialized courses, optional in the fourth year, are given in such subjects as the examination of water supplies, foods, oils, gases, sugars and starches, and the methods of proximate technical analysis.

Graduates should be prepared to take responsible parts in the establishment or development of industries which involve an application of chemical principles, to deal with problems of public welfare, to engage in research, or to continue their scientific education as graduate students.

For those students who show special aptitude for investigation opportunity for pursuing graduate courses and research is offered in the Research Laboratories of Physical Chemistry and Organic Chemistry.

Chemistry — COURSE V — *Continued*

First Year, Page 60

REQUIRED SUMMER COURSE (Following First Year)

Qualitative Analysis 5·10, 210—60

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
English and History E21, E22	45 — 75	45 — 75
Language	45 — 75	45 — 75
Mathematics M21, M22	45 — 90	45 — 90
Military Science MS21, MS22	45 — 0	45 — 0
Physics 8·03, 8·04	60 — 75	60 — 75
Quantitative Analysis 5·12, 5·13	105 — 30	105 — 30
Options		
1. Geology 12·331	30 — 30	.. ..
1a. Mineralogy 12·03	.. ..	45 — 15
1b. Optical Examinations of Chemical Precipitates 12.20	.. ..	45 — 15
2. Biology and Bacteriology 7·28, 7·291	45 — 15	45 — 15
Hours of exercise and preparation	(1) 750 = 375 + 375 (2) 750 = 390 + 360	750 = 390 + 360

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Chemical Literature 5·191	30 — 45	.. ..
Chemical Principles 5·651, 5·652	75 — 90	75 — 90
Gas Analysis 5·31	15 — 15	.. ..
Industrial Chemistry 10·201	.. ..	60 — 60
Organic Chemistry I 5·51, 5·52	60 — 45	60 — 30
Organic Chemical Laboratory 5·61, 5·62	135 — 0	195 — 0
Political Economy Ec31, Ec32	45 — 45	45 — 45
Industrial Applications of Quantitative Analysis 5·14	45 — 45	.. ..
Special Methods 5·40	30 — 15	.. ..
General Study	.. ..	30 — 30
Hours of exercise and preparation:	735 = 435 + 300	720 = 465 + 255

Students credited with Elementary and Intermediate French upon entrance will take Elementary and Intermediate German.

Students credited with Elementary and Intermediate German upon entrance will take Elementary French.

Students credited with Elementary French and Elementary German upon entrance will take Intermediate German.

Chemistry — COURSE V — *Continued*

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Chemical Library Technique 5·192	15 — 15	.. ..
Chemical Principles 5·66	45 — 60	.. ..
History of Chemistry 5·93	.. ..	30 — 30
Industrial Chemistry 10·211	45 — 45	.. ..
Inorganic Chemistry 5·06	.. ..	45 — 45
Metallography 3·611	60 — 15	.. ..
Radiation Chemistry 5·79	.. ..	30 — 45
Surface and Colloid Chemistry 5·69	.. ..	30 — 15
Thesis 5·951, 5·952	255	315
Thesis Reports 5·96	.. ..	15 — 15
General Study	30 — 30	.. ..
Elective	105	105
	720	720

ELECTIVE SUBJECTS

Chemistry of Foods 5·251	Either Term 45 — 15
Electrical Engineering, Elements 6·40	Either Term 60 — 90
Food Analysis 5·26	Either Term 75 — 0
Lubrication and Fuel Oil Testing 5·38	Either Term 45 — 15
Optical Methods 5·29	Either Term 30 — 15

First Term

Heat Measurements 8·10	60 — 30
Industrial Chemical Laboratory 10·26	105 — 30
Mathematics M36	45 — 90
Proximate Analysis 5·30	90 — 30

Second Term

Mathematics M37	45 — 90
Metallurgy of Common Metals 3·46	45 — 45
Powder and Explosives 5·57	30 — 30

Optional subjects other than those listed above may be taken with the approval of the head of the Department of Chemistry.

Graduate courses in Chemistry may be elected with the consent of the instructors in charge of the several courses.

ELECTRICAL ENGINEERING — COURSE VI

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. Along with these are associated the essential principles of steam engineering, hydraulic power engineering, the designing of structures and machines and of political economy. The electrical engineering instruction of the junior and senior years take 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, power transmission and distribution, lighting, telephony, 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 testing laboratories and the laboratories devoted to electrical machinery are component parts of the equipment. These laboratories are extensively equipped with apparatus adapted to the needs of undergraduate and advanced study. The laboratory work is carried on with the purpose of developing in the student habits of accurate observation and reflection, besides bringing to his consideration the methods and tests of fundamental importance and questions of economy of time and precision of results. It culminates in a thesis requiring originality and the application of acquired technique.

The importance of work of the nature of scientific research is emphasized. Research laboratories are provided and meetings are held monthly, at which the progress of research work being carried on is reported and discussed. The historical development of the electrical sciences and arts is discussed in monthly meetings of an electrical engineering seminar. These meetings are open to all students.

Under present regulations no students will be admitted to Course VI 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.

Electrical Engineering — COURSE VI — *Continued*

First Year, Page 60

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·16	.. ..	30 — 60
Electrical Engineering, Principles 6·00	.. ..	75 — 90
English and History E21, E22	45 — 75	45 — 75
Foundry 2·912	.. ..	30 — 0
Machine Tool Laboratory 2·941, 2·942	60 — 0	30 — 0
Mathematics M21, M22	45 — 90	45 — 90
Mechanical Engineering and Machine Drawing 2·12	120 — 0	.. ..
Mechanism 2·00	45 — 90	.. ..
Military Science MS21, MS22	45 — 0	45 — 0
Physics 8·03, 8·04	60 — 75	60 — 75
Hours of exercise and preparation:	750 = 420 + 330	750 = 360 + 390

REQUIRED SUMMER COURSE

Surveying and Plotting, 1·02, 70 — 5

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·20, 2·22	45 — 90	45 — 75
Electrical Engineering Laboratory 6·70, 6·71	90 — 75	75 — 75
Electrical Engineering, Principles 6·01, 6·02	45 — 60	75 — 90
Heat Engineering 2·441, 2·451	45 — 90	45 — 90
Mathematics M31	30 — 60	.. ..
Political Economy Ec31, Ec32	45 — 45	45 — 45
General Study	.. ..	30 — 30
Hours of exercise and preparation:	720 = 300 + 420	720 = 315 + 405

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Electrical Engineering Laboratory 6·72	90— 90	.. ..
Electrical Engineering Principles 6·03, 6·04	90—120	75—105
Engineering Laboratory 2·621	.. ..	45 — 30
English E40	.. ..	45 — 75
Hydraulics 1·64	45 — 90	.. ..
Professional Elective	45 — 90	45 — 90
Thesis	.. ..	210
General Study	30 — 30	.. ..
Hours of exercise and preparation:	720 = 300 + 420	720

PROFESSIONAL ELECTIVES

	First Term 15 Weeks	Second Term 15 Weeks
Central Station Design 6·222	.. ..	45 — 90
Central Stations 6·221	45 — 90	.. ..
Electrical Equipment of Buildings 6·23	.. ..	15 — 30
Electrical Engineering Laboratory 6·80 Time specially arranged.		Either term
Electric Machinery Design 6·251, 6·252	45 — 90	45 — 90
Electric Railways 6·24	45 — 90	.. ..
Illumination 6·27	45 — 90	.. ..
Industrial Applications of Electric Power 6·21	.. ..	45 — 90
Power Transmission Equipment 6·20	.. ..	45 — 90
Principles of Radio Communication 6·282	.. ..	45 — 90
Principles of Wire Communication 6·281	45 — 90	.. ..
Storage Batteries 6.29	One Term only 15 — 15	

Subjects in Mathematics, Physics and certain other branches may be substituted by approval of Professor Jackson.

Senior students with high records who wish to emphasize the Research related to their thesis may upon approval of Professor Jackson substitute additional thesis research for one or both of the professional electives.

ELECTRICAL ENGINEERING — VI-C

Students, who wish to follow particularly the theory and practice underlying Electrical Communication, may register for the Electrical Communication 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 work covering wire telephony, carrier telephony and radio telephony, also wire telegraphy, carrier telegraphy and radio telegraphy. The properties and engineering applications of electron tubes are also included.

Electrical Communication Option VI-C

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

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·20	45 — 90	.. ..
Electrical Communications, Principles 6·301, 6·302	45 — 90	45 — 90
Electrical Engineering Laboratory 6·70, 6·71	90 — 75	75 — 75
Electrical Engineering, Principles 6·01, 6·02	45 — 60	75 — 90
Mathematics M31	30 — 60	.. ..
Political Economy Ec31, Ec32	45 — 45	45 — 45
Vector Analysis M77	.. ..	45 — 75
General Study	.. ..	30 — 30
Hours of exercise and preparation:	720 = 300 + 420	720 = 315 + 405

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Electrical Communication, Principles 6·311, 6·312	45 — 60	45 — 60
Electrical Communication Laboratory 6·331, 6·332	45 — 60	45 — 60
Electrical Engineering, Principles 6·03	90 — 120	.. ..
Electrical Engineering Laboratory 6·72	90 — 90	.. ..
Electromagnetic Theory 8·241	30 — 30	.. ..
Electromagnetic Wave Propagation 8·242	.. ..	30 — 45
English E40	.. ..	45 — 75
Sound, Speech and Audition 8·05	.. ..	45 — 90
Thesis	.. ..	180
General Study	30 — 30	.. ..
Hours of exercise and preparation:	720 = 330 + 390	720

ELECTRICAL ENGINEERING — COURSE VI-A

Option 1, Manufacturing. In co-operation with the General Electric Company.

Option 2, Public Utilities.
- **(a) Light and Power. In co-operation with the Edison Electric Illuminating Company of Boston.**
- **(b) Transportation. In co-operation with the Boston Elevated Railway.**
- **(c) Power Systems — Construction and Operation. In co-operation with Stone and Webster, Inc.**

Option 3. Communications. In co-operation with the Bell Telephone System in New York City.

The Institute offers three distinct co-operative courses in Electrical Engineering. Option 1 affords training for the technical and executive responsibilities of electrical manufacturing industries. All of the manufacturing practice is taken at the General Electric Company's plants in Lynn, Schenectady, 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. For those who wish to go into the distribution of light and power, practical experience may be obtained with the Edison Company. Where similar experience is desired on the planning and construction of power systems, it may be obtained with Stone and Webster. For those desiring to go into electric railway work, experience with the Boston Elevated Railway is available.

Each course covers a period of five years, the first two being similar to Course VI, the last three being equally 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, Boston Elevated Railway, Stone and Webster 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 year is definitely of an advanced nature. For Option 1 the emphasis during this year is on problems of administration of large 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 administration of public utilities together with research on technical, scientific and administrative problems incident to the conduct of affairs of such enterprises. In Option 3 the development and research work in Communications is carried on in the Bell Telephone Laboratories in New York City. The training at the plants is laid out and conducted with a view to the maximum 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 with a view to utilizing and developing individual aptitudes.

The successful completion of the courses leads to the degree of Master of Science, together with the Bachelor's degree as of the preceding year.

The number of men who may be admitted to the co-operative training each year is at present limited to sixty men. Candidates for admission are subject to the approval of both the Institute and the co-operating companies. On account of the limitations of number and the unitary nature of 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 may be admitted to advanced standing at the beginning of the co-operative 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, considerably exceeds the tuition charges for the three years of co-operation. 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 intimately discussed. While at the shops students also devote three hours a week to classroom work in electrical theory and general studies, for which six hours' preparation per week is required. At the conclusion of the course, graduates are free to accept employment wherever offered without further obligation to the co-operating company.

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 co-operating company while the other is at the Institute in Cambridge.

COURSE VI-A — *Continued*

In preparation for this curriculum students must have completed the first year of the undergraduate Electrical Engineering Course (VI) at the Institute, or the equivalent.

REQUIRED SUMMER COURSE (Following First Year)

Options 2 and 3. Surveying and Plotting 1·02 70—5

SECOND YEAR

	First Term At M. I. T. 15 Weeks	Second Term At M. I. T. 15 Weeks
ALL OPTIONS AT M. I. T.		
Applied Mechanics 2·16	30 — 60	.. ..
Electrical Engineering, Principles 6·00	.. ..	75 — 90
Electrical Engineering Laboratory 6·75	.. ..	35 — 25
English and History E21, E22	45 — 75	45 — 75
Mathematics M21, M22	45 — 90	45 — 90
Mechanical Engineering and Machine Drawing 2·121	90 — 0	.. ..
Mechanism 2·00	45 — 90	.. ..
Military Science MS21, MS22	45 — 0	45 — 0
Physics 8·03, 8·04	60 — 75	60 — 75
Political Economy Ec31	.. ..	45 — 45
	750=360 +390	750=350 +400

GROUP A

THIRD YEAR

	Summer 1927 At M. I. T. 10 Weeks	First Term At Works 19 Weeks	Second Term At M. I. T. 15 Weeks
ALL OPTIONS AT M. I. T.			
Applied Mechanics 2·20, 2·22	45 — 90	.. ..	45 — 75
Electrical Engineering Laboratory 6·76, 6·77T	65 — 40	.. ..	40 — 35
Electrical Engineering, Principles 6·01T, 6·023	45 — 60	.. ..	75 — 90
Heat Engineering 2·441, 2·451	45 — 90	.. ..	45 — 90
Mathematics M31	.. ..	.. ..	30 — 60
Political Economy Ec32	.. ..	.. ..	45 — 45
Testing Materials Laboratory 2·371 (last 5 weeks)	.. ..	.. ..	20 — 25
MANUFACTURING OPTION (1)			
At General Electric Works			
Committee Work G441	.. ..	30 — 60	.. ..
Electrical Engineering, Principles 6·021	.. ..	30 — 60	.. ..
Manufacturing Practice 6·901	.. ..	48 hrs.p.w.	.. ..
PUBLIC UTILITY OPTION (2)			
At Edison Plants			
Committee Work G441	.. ..	30 — 60	.. ..
Electrical Engineering, Principles 6·021	.. ..	30 — 60	.. ..
Public Utility Practice 6·911	.. ..	48 hrs.p.w.	.. ..
At Boston Elevated Railway			
Committee Work G441	.. ..	30 — 60	.. ..
Electrical Engineering, Principles 6·021	.. ..	30 — 60	.. ..
Public Utility Practice 6·921	.. ..	48 hrs.p.w.	.. ..
At Stone & Webster			
Committee Work G441	.. ..	30 — 60	.. ..
Electrical Engineering, Principles 6·021	.. ..	30 — 60	.. ..
Public Utility Practice 6·931	.. ..	48 hrs.p.w.	.. ..
COMMUNICATIONS OPTION (3)			
At Western Electric Co.			
Committee Work G441	.. ..	30 — 60	.. ..
Electrical Engineering Principles 6·021	.. ..	30 — 60	.. ..
Communications Practice 6·941	.. ..	48 hrs.p.w.	.. ..

Vacations: June 5 — June 12, 1927, inclusive
August 28 — September 25, 1927, inclusive
April 18 — April 22, 1928, inclusive

COURSE VI-A — *Continued*

GROUP B

THIRD YEAR

	Summer 1927 At Works 15 Weeks	First Term At M. I. T. 15 Weeks	Second Term At Works 18 Weeks
ALL OPTIONS AT M. I. T.			
Applied Mechanics 2·20	.. ..	45 — 90	.. ..
Electrical Engineering Principles 6·02	.. ..	75 — 90	.. ..
Electrical Engineering Laboratory 6·76	.. ..	65 — 40	.. ..
Heat Engineering 2·441	.. ..	45 — 90	.. ..
Mathematics M31	.. ..	30 — 60	.. ..
Political Economy Ec32	.. ..	45 — 45	.. ..
MANUFACTURING OPTION (1)			
At General Electric Works			
Business English G442	20 — 40	.. ..	.. ..
Contemporary English Literature G443	.. ..	.. ..	30 — 60
Electrical Engineering Principles 6·01T, 6·031	30 — 75	.. ..	30 — 75
Manufacturing Practice 6·901, 6·902	48 hrs.p.w.	.. ..	48 hrs.p.w.
PUBLIC UTILITY OPTION (2)			
At Edison Plants			
Business English G442	20 — 40	.. ..	.. ..
Contemporary English Literature G443	.. ..	.. ..	30 — 60
Electrical Engineering Principles 6·01T, 6·031	30 — 75	.. ..	30 — 75
Public Utility Practice 6·911, 6·912	48 hrs.p.w.	.. ..	48 hrs.p.w.
At Boston Elevated Railway			
Business English G442	20 — 40	.. ..	.. ..
Contemporary English Literature G443	.. ..	.. ..	30 — 60
Electrical Engineering, Principles 6·01T, 6·031	30 — 75	.. ..	30 — 75
Public Utility Practice 6·921, 6·922	48 hrs.p.w.	.. ..	48 hrs. p.w.
At Stone & Webster			
Business English G442	20 — 40	.. ..	.. ..
Contemporary English Literature G443	.. ..	.. ..	30 — 60
Electrical Engineering, Principles 6·01T, 6·031	30 — 75	.. ..	30 — 75
Public Utility Practice 6·931, 6·932	48 hrs.p.w.	.. ..	48 hrs.p.w.
COMMUNICATIONS OPTION (3)			
At Western Electric Co. (Summer)			
At New York Telephone Co. (2d Term)			
Business English G442	20 — 40	.. ..	.. ..
Contemporary English Literature G443	.. ..	.. ..	30 — 60
Electrical Engineering Principles 6·01T, 6·031	30 — 75	.. ..	30 — 75
Communications Practice 6·941, 6·942	48 hrs.p.w.	.. ..	48 hrs. p.w.

Vacations: June 5 — June 12, 1927, inclusive
December 23, 1927 — January 2, 1928, inclusive
January 29 — February 5, 1928, inclusive

COURSE VI-A — *Continued*

GROUP A

FOURTH YEAR

	Summer 1927 At Works 15 Weeks	First Term At M. I. T. 15 Weeks	Second Term At Works 19 Weeks
ALL OPTIONS AT M. I. T.			
Applied Mechanics 2·22 (1,2)	.. ..	45 — 75	.. ..
Electrical Communications Laboratory 6·330 (3)	.. ..	30 — 45	.. ..
Electrical Communications, Principles 6·311 (3)	.. ..	45 — 60	.. ..
Electrical Engineering Laboratory 6·77 (1,2)	.. ..	30 — 30	.. ..
Electrical Engineering Laboratory 6·771 (3)	.. ..	60 — 75	.. ..
Electrical Engineering, Principles 6·106 (1,2)	.. ..	90—105	.. ..
Electrical Engineering Principles 6·121 (3)	.. ..	90—105	.. ..
Electron Theory and Apparatus 8·21 (1,2)	.. ..	60 — 60	.. ..
Heat Engineering 2·451 (1,2)	.. ..	45 — 90	.. ..
Political Economy Ec31	.. ..	45 — 45	.. ..
Vector Analysis M77 (3)	.. ..	45 — 75	.. ..
MANUFACTURING OPTION (1)			
At General Electric Works			
Business English G442	20 — 40	.. ..	.. ..
Contemporary English Literature G443	.. ..	.. ..	30 — 60
Electrical Engineering, Principles 6·105, 6·107	20 — 40	.. ..	30 — 60
Manufacturing Practice 6·903, 6·904	48 hrs.p.w.	.. ..	48 hrs.p.w.
PUBLIC UTILITY OPTION (2)			
At Edison Plants			
Business English G442	20 — 40	.. ..	.. ..
Contemporary English Literature G443	.. ..	.. ..	30 — 60
Electrical Engineering, Principles 6·105, 6·107	20 — 40	.. ..	30 — 60
Public Utility Practice 6·913, 6·914	48 hrs.p.w.	.. ..	48 hrs.p.w.
At Boston Elevated Railway			
Business English G442	20 — 40	.. ..	.. ..
Contemporary English Literature G443	.. ..	.. ..	30 — 60
Electrical Engineering Principles 6·105, 6·107	20 — 40	.. ..	30 — 60
Public Utility Practice 6·923, 6·924	48 hrs.p.w.	.. ..	48 hrs.p.w.
At Stone & Webster			
Business English G442	20 — 40	.. ..	.. ..
Contemporary English Literature G443	.. ..	.. ..	30 — 60
Electrical Engineering, Principles 6·105, 6·107	20 — 40	.. ..	30 — 60
Public Utility Practice 6·933, 6·934	48 hrs.p.w	.. ..	48 hrs.p.w.
COMMUNICATIONS OPTION (3)			
At New York Telephone Company (Summer)			
At Bell Telephone Laboratories (2d Term)			
Business English G442	20 — 40	.. ..	.. ..
Contemporary English Literature G443	.. ..	.. ..	30 — 60
Electrical Communications Principles 6·342, 6·343	20 — 40	.. ..	30 — 60
Communications Practice 6·943, 6·944	48 hrs.p.w.	.. ..	48 hrs. p.w.

Vacations: June 5 — June 12, 1927, inclusive
December 23, 1927 — January 2, 1928, inclusive
January 29 — February 5, 1928, inclusive

COURSE VI-A — *Continued*

GROUP B

FOURTH YEAR

	Summer 1927 At M. I. T. 10 Weeks	First Term At Works 19 Weeks	Second Term At M. I. T. 15 Weeks
ALL OPTIONS AT M. I. T.			
Applied Mechanics 2·22 (1,2)	45 — 75	.. ..	.. ..
Electrical Engineering Laboratory 6·77, 6·78 (1,2)	30 — 30	.. ..	60 — 45
Electrical Communications Laboratory 6·331 (3)	.. ..	.. ..	45 — 60
Electrical Communications, Principles 6·32 (3)	.. ..	.. ..	45 — 60
Electrical Communications, Principles 6·353, 6·355 (3)	30 — 60	.. ..	75—105
Electrical Engineering Laboratory 6·772, 6·782 (3)	65 — 60	.. ..	80 — 70
Electrical Engineering, Principles 6·115, 6·117 (1,2)	50 — 60	.. ..	75 — 90
Electrical Engineering, Principles 6·122, 6·123 (3)	30 — 60	.. ..	45 — 75
Electromagnetic Theory 8·241 (3)	.. ..	.. ..	30 — 30
Electron Theory and Apparatus 8·21 (1,2)	.. ..	.. ..	60 — 60
Engineering Laboratory 2·621 (1,2)	.. ..	.. ..	45 — 30
English E40 (1,2)	.. ..	.. ..	45 — 75
Heat Engineering 2·451 (1,2)	45 — 90	.. ..	.. ..
Hydraulics 1·64 (1,2)	.. ..	.. ..	45 — 90
Political Economy Ec32	45 — 45	.. ..	.. ..
Vector Analysis M77 (3)	45 — 75	.. ..	.. ..
MANUFACTURING OPTION (1)			
At General Electric Works			
Committee Work G441	.. ..	30 — 60	.. ..
Electrical Engineering, Principles 6·116	.. ..	30 — 60	.. ..
Manufacturing Practice 6·903	.. ..	48 hrs.p.w.	.. ..
PUBLIC UTILITY OPTION (2)			
At Edison Plants			
Committee Work G441	.. ..	30 — 60	.. ..
Electrical Engineering, Principles 6·116	.. ..	30 — 60	.. ..
Public Utility Practice 6·913	.. ..	48 hrs.p.w.	.. ..
At Boston Elevated Railway			
Committee Work G441	.. ..	30 — 60	.. ..
Electrical Engineering, Principles 6·116	.. ..	30 — 60	.. ..
Public Utility Practice 6·923	.. ..	48 hrs.p.w.	.. ..
At Stone & Webster			
Committee Work G441	.. ..	30 — 60	.. ..
Electrical Engineering, Principles 6·116	.. ..	30 — 60	.. ..
Public Utility Practice 6·933	.. ..	48 hrs.p.w.	.. ..
COMMUNICATIONS OPTION (3)			
At New York Telephone Company			
Committee Work G441	.. ..	30 — 60	.. ..
Electrical Communications, Principles 6·354	.. ..	30 — 60	.. ..
Communications Practice 6·943	.. ..	48 hrs.p.w.	.. ..

Vacations: **August 28 — September 25, 1927, inclusive**
April 18 — April 22, 1928, inclusive

COURSE VI-A — *Continued*

GROUP A

FIFTH YEAR

	Summer 1927 At M.I.T. 11 Weeks	First Term At M.I.T. 10 Weeks	First Term At Works 9 Weeks	Second Term At M.I.T. 15 Weeks
ALL OPTIONS AT M. I. T.				
Business Law and Organization Ec63	.. ..	.. ..	.. ..	**45 — 75**
Electrical Engineering Lab. 6·78	60 — 45	.. ..	.. ..	.. ..
Electrical Engineering, Principles 6·591, 6·592	50 — 60	40 — 75	.. ..	.. ..
English E40	..	45 — 75	.. ..	.. ..
Engineering Laboratory 2·621	45 — 30	.. ..	.. ..	.. ..
Graduate Study and Research	.. ..	245	.. ..	600
Hydraulics 1·64	45 — 90	.. ..	.. ..	.. ..
Political Economy Ec32	45 — 45	.. ..	.. ..	.. ..
MANUFACTURING OPTION (1)				
At General Electric Works				
Electrical Engineering, Principles 6·593	.. ..	.. ..	20 — 60	.. ..
Manufacturing Practice 6·905	.. ..	.. ..	48 hrs.p.w.	.. ..
PUBLIC UTILITY OPTION (2)				
At Edison Plants				
Electrical Engineering, Principles 6·593	.. ..	.. ..	20 — 60	.. ..
Public Utility Practice 6·915	.. ..	.. ..	48 hrs. p.w.	.. ..
At Boston Elevated Railway				
Electrical Engineering, Principles 6·593	.. ..	.. ..	20 — 60	.. ..
Public Utility Practice 6·925	.. ..	.. ..	48 hrs.p.w.	.. ..
At Stone & Webster				
Electrical Engineering, Principles 6·593	.. ..	.. ..	20 — 60	.. ..
Public Utility Practice 6·935	.. ..	.. ..	48 hrs. p.w.	.. ..

Vacations: August 28 — September 25, 1927, inclusive
April 18 — April 22, 1928, inclusive

GROUP B
FIFTH YEAR

	Summer 1927 At Works 15 Weeks	First Term At Works 10 Weeks	First Term At M.I.T. 7 Weeks	Second Term At M.I.T. 15 Weeks
ALL OPTIONS AT M. I. T.				
Business Law and Organization Ec63	.. ..	.. ..	.. ..	45 — 75
Electrical Engineering Principles, 6·603	.. ..	.. ..	20 — 70	.. ..
Graduate Study and Research	.. ..	.. ..	245	600
MANUFACTURING OPTION (1)				
At General Electric Works				
Electrical Engineering, Principles 6·601, 6·602	30 — 60	20 — 60	.. ..	.. ..
Manufacturing Practice 6·904, 6·905	48 hrs.p.w.	48 hrs.p.w.	.. ..	.. ..
PUBLIC UTILITY OPTION (2)				
At Edison Plants				
Electrical Engineering, Principles 6·601, 6·602	30 — 60	20 — 60	.. ..	.. ..
Public Utility Practice 6·914, 6·915	48 hrs.p.w.	48 hrs.p.w.	.. ..	.. ..
At Boston Elevated Railway				
Electrical Engineering, Principles 6·601, 6·602	30 — 60	20 — 60	.. ..	.. ..
Public Utility Practice 6·924, 6·925	48 hrs.p.w.	48 hrs.p.w.	.. ..	.. ..
At Stone & Webster				
Electrical Engineering, Principles 6·601, 6·602	30 — 60	20 — 60	.. ..	.. ..
Public Utility Practice 6·934, 6·935	48 hrs.p.w.	48 hrs.p.w.	.. ..	.. ..

Vacations: June 5 — June 12, 1927, inclusive
December 23, 1927 — January 2, 1928, inclusive
January 29 — February 5, 1928, inclusive
April 18 — April 22, 1928, inclusive

BIOLOGY AND PUBLIC HEALTH — COURSE VII

The applications of modern biological sciences have opened up new fields of usefulness for those with broad and properly coördinated training, in public health, research and industry.

To provide the equipment necessary for these positions two groups of related studies, covering four years, have been arranged. The first deals primarily with public health, the second with the industrial or technical applications of biology.

In the public health field useful and inviting careers in the service of the government, states and cities, or with public service or private corporations, health organizations or individuals are now open to ambitious students well trained in general and sanitary biology, bacteriology, industrial hygiene, municipal sanitation and public health administration and the diagnostic procedures used in identification and control of infectious diseases.

For persons proficient in these subjects the demand has of late years generally exceeded the supply, and graduates have readily obtained positions as bacteriologists, health officers, sanitary inspectors or in connection with health work in industrial plants, or as assistants with manufacturers of biologic products, or in research.

These studies also afford an excellent preparation for entrance to those medical schools of high grade which require for entrance special training in physics, chemistry and biological subjects.

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 fisheries or food conservation and manufacture, industrial fermentations and the control of biochemical processes. The two options here described are in Fisheries Technology, and Food Technology. Fisheries industries have especially requested training of this type in order to be able to secure men properly equipped in biological, engineering and administrative subjects to become superintendents of plants, managers, and administrators. This basic industry, comparable in significance to Forestry or Animal Husbandry, has had but slight attention from the standpoint of technical training, so that a course in Fisheries Technology should lead to positions of industrial importance and great technical interest. The corresponding work in Food Technology has been so developed that it trains especially for the other great food conservation industries and provides a thorough grounding in the chemistry and bacteriology of foods, in biochemistry and fermentation and in statistics, business management and other economic subjects desirable for important professional or commercial positions.

Either of the two subdivisions of the course in Biology and Public Health thus furnishes certain essential elements for well-rounded education with professional training for special occupations.

Biology and Public Health — COURSE VII — *Continued*

OPTION 1. Biology and Public Health

First Year, Page 60

REQUIRED SUMMER COURSES (Following First Year)

Qualitative Analysis 5·11	105 — 30
Quantitative Analysis 5·12	105 — 30

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Accounting Ec50	.. ..	45 — 45
Biology, General 7·01	75 — 45	..
Botany 7·06	.. ..	60 — 30
Chemical Theory, Elements of 5·83	.. ..	30 — 60
English and History E21, E22	45 — 75	45 — 75
Mathematics M21	45 — 90	.. ..
Military Science MS21, MS22	45 — 0	45 — 0
Organic Chemical Laboratory 5·615	.. ..	75 — 15
Organic Chemistry 5·501	45 — 30	.. ..
Physics 8·03, 8·04	60 — 75	60 — 75
Political Economy Ec21	45 — 75	.. ..
Zoölogy 7·10	.. ..	60 — 30
Hours of exercise and preparation:	750 = 360 + 390	750 = 420 + 330

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Anatomy and Histology 7·11, 7·12	120 — 75	120 — 60
Bacteriology 7·301, 7·302	90 — 60	75 — 45
Chemistry of Foods 5·25	75 — 15	.. ..
Microscopy of Waters 7·34	15 — 15	.. ..
Municipal Sanitation 7·57	.. ..	60 — 50
Personal Hygiene and Nutrition 7·22	30 — 45	.. ..
Physiology 7·20	.. ..	120 — 75
Water Supplies 5·20	45 — 15	.. ..
General Study	60 — 60	60 — 60
Hours of exercise and preparation:	720 = 435 + 285	725 = 435 + 290

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Biochemistry 7·80	120 — 75	.. ..
Biological Colloquium 7·91, 7·92	15 — 15	15 — 15
Industrial Hygiene 7·52	.. ..	60 — 60
Industrial Microbiology 7·361	75 — 30	.. ..
Infection and Immunity 7·50	45 — 75	.. ..
Parasitology 7·08	.. ..	30 — 60
Public Health Administration 7·541, 7·542	30 — 30	30 — 45
Public Health Laboratory Methods 7·551, 7·552	45 — 15	90 — 30
Public Health Surveys 7·56	.. ..	15 — 30
Theoretical Biology 7·03	30 — 45	.. ..
Vital Statistics 7·58	30 — 45	.. ..
Thesis	.. ..	240
Hours of exercise and preparation:	720 = 390 + 330	720

Biology and Public Health — COURSE VII — *Continued*

OPTION 2. Industrial Biology

a. Fisheries Technology b. Food Technology

First Year, Page 60

REQUIRED SUMMER COURSES (Following First Year)

Qualitative Analysis 5·11	**105 — 30**
Quantitative Analysis 5.12	**105 — 30**

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Accounting Ec50	.. ..	45 — 45
Biology, General 7·01	75 — 45	.. ..
Botany 7·06	.. ..	60 — 30
English and History E21, E22	45 — 75	45 — 75
Mathematics M21	45 — 90	.. ..
Mechanism 2·01	.. ..	30 — 60
Military Science MS21, MS22	45 — 0	45 — 0
Organic Chemical Laboratory 5·615	.. ..	75 — 15
Organic Chemistry 5·501	45 — 30	.. ..
Physics 8·03, 8·04	60 — 75	60 — 75
Political Economy Ec21	45 — 75	.. ..
Zoölogy 7·10	.. ..	60 — 30
Hours of exercise and preparation:	750 = 360 + 390	750 = 420 + 330

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Bacteriology 7·301, 7·302	90 — 60	75 — 45
Business Management Ec70	.. ..	45 — 45
Chemistry of Foods 5·25	75 — 15	.. ..
Economics of Corporations G27	.. ..	30 — 30
Microscopy of Water 7·34	15 — 15	.. ..
Municipal Sanitation 7·57	.. ..	60 — 50
Personal Hygiene and Nutrition 7·22	30 — 45	.. ..
Statistics Ec65	45 — 15	.. ..
Water Supplies 5·20	45 — 15	.. ..
General Study	30 — 30	30 — 30
(*a*) Food Fishes 7·421, 7·422	120 — 75	105 — 60
(*a*) Navigation 1·15	.. ..	15 — 45
(*a*) Fish Culture 7·43	.. ..	30 — 30
(*b*) Mycology 7·07	45 — 30	.. ..
(*b*) Technology of Food Supplies 7·701, 7·702	75 — 45	90 — 75
(*b*) Industrial Hygiene 7·52	.. ..	60 — 60
Hours of exercise and preparation:	720 = 450 + 270	725 = 390 + 335

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Biochemistry 7·80	120 — 75	.. ..
Biological Colloquium 7·91, 7·92	15 — 15	15 — 15
Business Law Ec61, Ec62	30 — 60	30 — 60
Business Management Ec71, Ec72	60 — 90	60 — 90
Industrial Microbiology 7·361, 7·362	75 — 30	60 — 30
Plant Sanitation 7·53	.. ..	15 — 15
Theoretical Biology 7·03	30 — 45	.. ..
(*a*) Technology Fishery Products 7·441, 7·442	30 — 30	75 — 60
(*b*) Technology Food Products 7·711, 7·712	30 — 30	75 — 60
Thesis	30	210
Hours of exercise and preparation:	735	735

PHYSICS — COURSE VIII

The course in Physics is intended to be sufficiently broad to provide for the needs of those men who desire to prepare for graduate work in Theoretical Physics and for research in pure Physics as well as for those students who intend to prepare themselves for work in Industrial Physics. Experience has shown that for graduate work or for later research and investigation work both of a theoretical and of a practical nature, sound fundamental training in Theoretical Physics is necessary, and this work is therefore carried through to the end of the fourth year. Ample laboratory courses are provided in order to furnish opportunity for the students to become familiar with physical manipulation and with the methods and processes involved in the design and study of physical apparatus for designed special problems. Considerable instruction in the third and fourth years as well as in the graduate years is given by prominent physicists, not members of the regular staff, who give from time to time extensive courses upon the newer developments in Physics.

The department reserves the right to limit admission to Course VIII above the sophomore year to that number of students (at present about twelve or fifteen in each class) who may be properly trained with the professional equipment available. The limitation if necessary will be effected by the selection of the applicants of highest grade.

Physics — COURSE VIII — *Continued*

First Year, Page 60

REQUIRED SUMMER COURSES (Following First Year)

Qualitative Analysis 5·11	105 — 30
Mechanism 2·01	30 — 60

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
English and History E21, E22	45 — 75	45 — 75
Language	45 — 75	45 — 75
Machine Tool Laboratory 2·96	.. ..	60 — 0
Mathematics M21, M22	45 — 90	45 — 90
Military Science MS21, MS22	45 — 0	45 — 0
Organic Chemistry 5·50	30 — 30	.. ..
Photography 8·15	30 — 15	.. ..
Photographic Laboratory 8·151	45 — 15	.. ..
Physics 8·03, 8·04	60 — 75	60 — 75
Elective	.. ..	105
Hours of exercise and preparation:	720 = 345 + 375	720

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Advanced Physics I 8·221, 8·222	45 — 75	45 — 75
Calculus, Advanced M36, M37	45 — 90	45 — 90
Electricity 8·201, 8·202	75 — 60	75 — 90
Electrochemistry, Principles of 8·801, 8·802	60 — 90	45 — 90
Geometrical Optics 8·17	.. ..	30 — 45
Heat Measurements 8·10	60 — 30	.. ..
Political Economy Ec31, Ec32	45 — 45	45 — 45
Hours of exercise and preparation:	720 = 330 + 390	720 = 285 + 435

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Advanced Physics II 8·231, 8·232	45—105	45—105
Fourier's Series and Integral Equations M451	30 — 50	.. ..
Metallography 3·612	.. ..	40 — 20
Physical Optics 8·18	60 — 40	.. ..
Physics Colloquium 8·451, 8·452	15 — 15	15 — 15
Precision of Measurements 8·94	10 — 20	.. ..
Sound, Speech and Audition 8·05	.. ..	45 — 90
X-Rays and Radiology 8·33	45 — 15	.. ..
General Study	30 — 30	30 — 30
Elective	120	120
Thesis	90	165
Hours of exercise and preparation:	720	720

Students credited with Elementary and Intermediate French upon entrance will take Elementary and Intermediate German.

Students credited with Elementary and Intermediate German upon entrance will take Elementary French.

Students credited with Elementary French and Elementary German will take Intermediate German.

GENERAL SCIENCE — COURSE IX-A

This course, largely elective in the senior year, is planned to offer first, a substantial education along scientific lines, and to provide subsequently, through its electives, for a more intensive training in some one branch of science, or in closely interrelated sciences. There is, also, an opportunity to elect a considerable amount of such humanistic studies as English, modern language, history, economics and social science.

Such a course possesses many advantages in view of the ever increasing interrelations of the various sciences, and should prove particularly valuable to those who have not fully decided upon any particular line of specialization, or to those who intend to specialize in graduate work later.

The choice of electives in the third and fourth years must in all cases be approved by the committee in charge of Course IX.

GENERAL ENGINEERING — COURSE IX-B

This course is designed to meet the needs of those who desire training in fundamental engineering subjects, and who either do not wish to specialize in any particular branch of engineering to the extent demanded by one of the regular courses, or who may wish to follow some line or lines of work not provided for by the schedule of any particular course.

A schedule, except for that portion listed as elective, has been prepared and is offered as one suitable for a broad training in engineering. There is also opportunity for the election of economic and business subjects, or of courses in literature and modern languages. In all cases the choice of electives must be approved by the committee in charge of Course IX.

MATHEMATICS — COURSE IX-C

The Institute offers exceptional opportunities for the study of mathematics particularly as applied to scientific and engineering work.

The course outlined is for men who desire to specialize in Applied Mathematics. It is well adapted to serve as a preparation for specialization in pure mathematics, in mathematical physics, or along lines of experimental physics or engineering requiring proficiency in mathematics.

Considerable latitude in the choice of subjects is provided for in the third and fourth years in order that the student shall be able to take, in addition to his purely mathematical courses, a considerable amount of work in general studies, or in scientific and engineering subjects in which mathematics plays an important part. For example, he may elect courses in thermodynamics, mechanics, electricity or in physical chemistry.

While a definite schedule for the second year is offered, any student who has completed satisfactorily the work of the first two years in any of the professional courses of 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 option.

General Science — COURSE IX-A — *Continued*

First Year, Page 60

OPTIONAL SUMMER COURSE (Following First Year)

Qualitative Analysis 5.11 105 — 30

Students taking this course in the Summer Session will take Quantitative Analysis in the first term of the second year.

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Biology and Bacteriology 7·28, 7·291	45 — 15	45 — 15
English and History E21, E22	45 — 75	45 — 75
Language	45 — 75	45 — 75
Mathematics M21, M22	45 — 90	45 — 90
Military Science MS21, MS22	45 — 0	45 — 0
Physics 8·03, 8·04	60 — 75	60 — 75
Qualitative Analysis 5·11	105 — 30	.. ..
Quantitative Analysis 5·12	.. ..	105 — 30
Hours of exercise and preparation:	750 = 390 + 360	750 = 390 + 360

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Geology, 12·30	.. ..	45 — 45
Heat Measurements 8·11	30 — 15	.. ..
Mineralogy 12·03	.. ..	45 — 15
Organic Chemistry 5·50	30 — 30	.. ..
Organic Chemical Laboratory 5·615	.. ..	75 — 0
Organic Evolution G64	.. ..	30 — 30
Political Economy Ec31, Ec32	45 — 45	45 — 45
Professional Elective	465	345
General Study	30 — 30	.. ..
Hours of exercise and preparation:	720	720

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Descriptive Astronomy G66	.. ..	30 — 30
General Study	30 — 30	.. ..
Geology 12·31	75 — 45	.. ..
Major Professional Elective	135	135
Professional Elective and Thesis	405	525
Hours of exercise and preparation:	720	720

General Engineering — COURSE IX-B — *Continued*

First Year, Page 60

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·15	.. ..	45 — 90
English and History E21, E22	45 — 75	45 — 75
Machine Tool Laboratory 2·96	.. ..	60 — 0
Mathematics M21, M22	45 — 90	45 — 90
Mechanical Engineering and Machine Drawing 2·121	90 — 0	.. ..
Mechanism 2·01	30 — 60	.. ..
Military Science MS21, MS22	45 — 0	45 — 0
Physics 8·03, 8·04	60 — 75	60 — 75
Surveying 1·03	.. ..	30 — 0
Elective	135	90
Hours of exercise and preparation:	750	750

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·20	45 — 90	.. ..
Electrical Engineering, Elements 6·40	.. ..	60 — 90
Engineering Science M51, M52	45 — 90	45 — 90
Heat Engineering 2·40, 2·42	45 — 90	45 — 75
Political Economy Ec31, Ec32	45 — 45	45 — 45
General Study	30 — 30	30 — 30
Electives	165	45
(*a*) Hydraulics 1·62	.. ..	45 — 75
(*b*) Structures 1·40	.. ..	45 — 75
Hours of exercise and preparation:	720	720

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Electrical Engineering Laboratory 6·85	30 — 45	.. ..
Engineering Laboratory 2·62	60 — 30	.. ..
Engineering Science M53	45 — 90	.. ..
General Study	30 — 30	30 — 30
Elective and Thesis	360	660
Hours of exercise and preparation:	720	720

Mathematics — COURSE IX-C — *Continued*

First Year, Page 60

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
English and History E21, E22	45 — 75	45 — 75
Mathematics M21, M22	45 — 90	45 — 90
Military Science MS21, MS22	45 — 0	45 — 0
Physics 8·03, 8·04	60 — 75	60 — 75
Language	45 — 75	45 — 75
Elective	195	195
Hours of exercise and preparation:	750	750

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Advanced Physics 8·221, 8·222	45 — 75	45 — 75
Calculus, Advanced M36, M37	45 — 90	45 — 90
Mathematical Elective	45 — 90	45 — 90
Political Economy Ec31, Ec32	45 — 45	45 — 45
Elective	180	180
General Study	30 — 30	30 — 30
Hours of exercise and preparation:	720	720

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Least Square and Probability M26	30 — 30	.. ..
Mathematical Laboratory M54	.. ..	45 — 75
Physics, Advanced 8·231, 8·232	45—105	45—105
Elective and Thesis	450	450
General Study	30 — 30	.. ..
Hours of exercise and preparation:	720	720

CHEMICAL ENGINEERING — COURSE X

The efficiency of any industrial chemical process depends not only upon a knowledge of the chemical reactions forming the basis of the process, but also upon a knowledge of the mechanical principles on which depend the design, construction and maintenance of plant for carrying on these reactions. To prepare students capable of filling the demand for men competent to build and operate manufacturing industries based upon chemical principles is the purpose of this course in Chemical Engineering.

The professional work of the course falls naturally into three groups: first, courses which provide a thorough knowledge of the fundamental principles of chemistry. Second, those courses which furnish a sound knowledge of mechanical engineering subjects, both in theory and in practice. Third, courses which deal with chemical engineering as a separate entity.

The course therefore includes a training in inorganic, analytical, organic, physical and industrial chemistry, which is the same as that given to students in the course in Chemistry except in the case of some of the laboratory courses. The training in mechanism, heat engineering, applied mechanics, and other important mechanical engineering subjects is given in the Department of Mechanical Engineering, with special reference to the particular needs of this course. This is true also of the work of the course which is given in the Electrical Engineering Department. The instruction in Chemical Engineering and Industrial Chemistry is of a distinctly professional nature.

A graduate year of the course is provided in which opportunity for the development and correlation of these fundamental subjects in the field of chemical engineering is presented.

CHEMICAL ENGINEERING PRACTICE — COURSE X-B

The privileges of the School of Chemical Engineering Practice are available for a selected group of Institute undergraduates the last part of the senior year. Students desiring this course should apply the second term of the third year and those accepted will be given special courses in the first term of the fourth year to prepare them for the work of the Practice School.

Chemical Engineering — COURSE X—*Continued*

First Year, Page 60

REQUIRED SUMMER COURSE (Following First Year)

Qualitative Analysis 5·10 210-60

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·15	.. ..	45 — 90
English and History E21, E22	45 — 75	45 — 75
Language	45 — 75	45 — 75
Mathematics M21	45 — 90	.. ..
Mechanism 2·01	.. ..	30 — 60
Military Science MS21, MS22	45 — 0	45 — 0
Physics 8·03, 8·04	60 — 75	60 — 75
Problems of the Chemical Engineer 10·11	15 — 0	.. ..
Quantitative Analysis 5·121, 5·131	135 — 45	90 — 15
Hours of exercise and preparation:	750 = 390 + 360	750 = 360 + 390

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 both Elementary French and Elementary German will take Chemical Engineering Literature 10·191, two General Studies and sixty hours Elective.

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·20	45 — 90	.. ..
Chemical Principles 5·651, 5·652	75 — 90	75 — 90
Heat Engineering 2·44, 2·45	45 — 75	45 — 75
Industrial Chemistry 10·20	.. ..	75 — 75
Organic Chemistry I 5·51, 5·52	60 — 45	60 — 30
Organic Chemistry Laboratory 5·612, 5·622	105 — 0	45 — 0
Political Economy Ec31, Ec32	45 — 45	45 — 45
General Study	.. ..	30 — 30
Hours of exercise and preparation:	720 = 375 + 345	720 = 375 + 345

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Calculus, Applications of M41	45 — 90	.. ..
Chemical Engineering 10·31, 10·32	75 — 75	60 — 60
Electrical Engineering, Elements 6·40	60 — 90	.. ..
Electrical Engineering Laboratory 6·85	.. ..	30 — 45
Engineering Laboratory 2·62	60 — 30	.. ..
Industrial Chemical Laboratory 10·26	105 — 30	.. ..
Industrial Chemistry 10·21	30 — 30	.. ..
Testing Materials Laboratory 2·37	.. ..	20 — 10
Thesis Reports 10·15	.. ..	15 — 0
Thesis	.. ..	270
General Study	.. ..	30 — 30
Elective	.. ..	150
Hours of exercise and preparation:	720 = 375 + 345	720

The time devoted to Electives must be not less than 120 hours and not more than 180 hours, the time adjustment being made with the hours assigned to thesis.

Students admitted to Course X-A must take Analytical Chemisty 5·16 (60-15) as an optional subject in the second term of the fourth year.

Chemical Engineering Practice X-B—*Continued*

Students desiring to take the work of the School of Chemical Engineering Practice as undergraduates may apply for admission at the end of the third year of Course X. If accepted, they will substitute for the fourth year the program shown below:

FOURTH YEAR

	First Period 12 Weeks	Second Period 22 Weeks
Calculus, Applications of M41	36 — 72	.. ..
Chemical Engineering 10·33, 10·34	72—168	30 — 60
Electrical Engineering, Elements 6·41	48 — 72	.. ..
Industrial Chemistry 10·22	24 — 24	.. ..
General Study	24 — 24	.. ..
School of Chemical Engineering Practice, 10·84, 10·85, 10·86, and Thesis	.. ..	1010
Hours of exercise and preparation: 564=204+360		1100

SANITARY AND MUNICIPAL ENGINEERING — COURSE XI

The course in Sanitary and Municipal Engineering is an offshoot of the Civil Engineering course intended to fill the needs of students wishing to give particular attention to problems affecting the health and convenience of the public. The course resembles the general option in Civil Engineering except for a reduction in the time devoted to structural engineering and an entire omission of the courses in astronomy, geodesy and foundations. The time thus gained is devoted principally to courses in organic chemistry; in bacteriology, biology and allied subjects; and in the special fields of water supplies and the disposal of sewage and other municipal wastes. In these courses it is intended to give the students such training as shall fit them to interpret properly the results of researches in sanitary chemistry and in bacteriology, to design and supervise the operation of modern filtration and sewage disposal plants and to deal intelligently with the problems arising in the construction, maintenance and care of city streets.

Special attention is given to the problems arising in water supply engineering and sewerage engineering and to the principles involved in the purification of water supplies and the disposition of sewage. The relation between drinking waters and disease is also thoroughly investigated.

Considerable practice in the chemical and biological laboratories is required and the student is instructed in the methods of water analyses and is taught to observe and identify the more important animal and vegetable organisms present in water and sewage.

Graduates of this course should be especially qualified to enter the service of private and public engineering organizations dealing with the increasingly numerous and difficult problems of water supply and sewage disposal confronting our larger cities, or to join the engineering staff of a municipality, or to enter the service of national, state or municipal boards of health.

COURSE XI — *Continued*

First Year, Page 60

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·15	.. ..	45 — 90
English and History E21, E22	45 — 75	45 — 75
Map Reading and Topographical Drawing 1·18	30 — 0	.. ..
Mathematics M21, M22	45 — 90	45 — 90
Mechanism 2·011	30 — 45	.. ..
Military Science MS21, MS22	45 — 0	45 — 0
Physics 8·03, 8·04	60 — 75	60 — 75
Qualitative Analysis 5·11	105 — 30	.. ..
Quantitative Analysis 5·12	.. ..	105 — 30
Surveying and Plotting 1·00, 1·01	30 — 45	30 — 0
Hours of exercise and preparation:	750 = 390 + 360	735 = 375 + 360

REQUIRED SUMMER COURSES AT CAMP TECHNOLOGY

Geodetic and Topographical Surveying 1·06	95 — 5
Hydrographic Surveying 1·60	75 — 0
Plane Surveying 1·05	90 — 10
Railway Fieldwork 1·20	80 — 0

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·20	45 — 90	.. ..
Biology and Bacteriology 7·28, 7·29	45 — 15	75 — 30
Electrical Engineering, Elements 6·40	60 — 90	.. ..
Electrical Engineering Laboratory 6·86	.. ..	15 — 30
Hydraulics 1·62	.. ..	45 — 75
Industrial Water Analysis 5·21	.. ..	30 — 0
Materials 1·43	.. ..	15 — 30
Organic Chemistry 5·50	30 — 30	.. ..
Political Economy Ec31, Ec32	45 — 45	45 — 45
Railway Drafting 1·23, 1·24	60 — 0	45 — 0
Railway and Highway Engineering 1·211, 1·22	20 — 40	30 — 30
Roads and Pavements 1·35	20 — 25	.. ..
Structures 1·40	.. ..	45 — 75
General Study	30 — 30	30 — 30
Hours of exercise and preparation:	720 = 355 + 365	720 = 375 + 345

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Engineering and Hydraulic Laboratory 2·63	.. ..	30 — 30
Engineering Construction and Estimates 1·25	30 — 45	.. ..
Geology 12·321	30 — 15	.. ..
Heat Engineering 2·46, 2·47	60—105	30 — 45
Microscopy of Water 7·34	15 — 15	.. ..
Sanitary Design 1·80	.. ..	90 — 0
Sanitary Engineering 1·77, 1·78	60 — 75	45 — 60
Structures 1·41, 1·421	60 — 120	30 — 60
Structural Design 1·52	.. ..	90 — 0
Testing Materials Laboratory 2·37	.. ..	20 — 10
Water Supply and Wastes Disposal 5·22	30 — 15	.. ..
Thesis	.. ..	120
General Study	30 — 30	30 — 30
Hours of exercise and preparation:	735 = 315 + 420	720

GEOLOGY AND GEOLOGICAL ENGINEERING — COURSE XII

The geologist and the geological engineer have lately won for themselves a place in many technical enterprises related to mining, civil engineering and water supply. Course XII is planned with this fact in view, though it is also adapted for those who desire to follow geology in its more theoretical aspects.

The course prescribes during the first two years the usual subjects taken by all the engineering and science courses. It also requires summer work in surveying and, throughout the upper years, a carefully arranged list of geologic subjects fundamental to one specializing in geology. A considerable amount of time is left for electives which may be chosen from either engineering subjects closely related to geology, such as mining engineering, or from more advanced geological subjects. The course is thus given considerable flexibility and can be adapted to the needs of students desiring to specialize in one of the larger divisions of geologic science; the same flexibility makes it possible to adapt the course to the needs of students from other colleges who may have in part anticipated the prescribed studies of the course.

Geology — COURSE XII — *Continued*

First Year, Page 60

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
English and History E21, E22	45 — 75	45 — 75
Geology 12·30	.. ..	45 — 45
Mathematics M21, M22	45 — 90	45 — 90
Military Science MS21, MS22	45 — 0	45 — 0
Mineralogy 12·01, 12·02	120 — 30	75 — 15
Physics 8·03, 8·04	60 — 75	60 — 75
Qualitative Analysis 5·11	105 — 30	.. ..
Quantitative Analysis 5·12	.. ..	105 — 30
Hours of exercise and preparation:	720 = 420 + 300	750 = 420 + 330

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Geology 12·31	75 — 45	.. ..
Geology, Economic 12·40	.. ..	75 — 45
Language	45 — 75	45 — 75
Mining, Elements of 3·05	30 — 30	.. ..
Ore Dressing 3·23	.. ..	45 — 30
Organic Evolution G64	.. ..	30 — 30
Paleontology 12·511, 12·512	45 — 30	15 — 15
Petrography 12·151, 12·152	90 — 30	90 — 30
Political Economy Ec31, Ec32	45 — 45	45 — 45
Quantitative Analysis 5·13	105 — 30	.. ..
Professional Elective	.. ..	120
Hours of exercise and preparation:	720 = 435 + 285	735

REQUIRED COURSES AT SUMMER MINING CAMP

Surveying 1·10	345 — 15
Field Geology 12·36	50 — 0

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Economic Geology 12·42	.. ..	30 — 15
Economic Geology Laboratory 12·41	90 — 30	.. ..
Economic Geology of Non-metallic Deposits 12.46	60 — 45	.. ..
Engineering Geology and Hydrology 12.48	.. ..	45 — 30
Field Geology 12·33	45 — 30	.. ..
Geological Seminar 12·621, 12·622	30 — 60	30 — 60
Geological Surveying 12·34	.. ..	120 — 45
Geology of Coal and Petroleum 12·80	60 — 45	.. ..
Historical Geology 12·50	45 — 30	.. ..
Metallurgy of Common Metals 3·46	.. ..	45 — 45
Physiography 12·38	.. ..	45 — 15
Thermochemistry and Chemical Equilibrium 5·68	30 — 60	.. ..
General Study	30 — 30	.. ..
Thesis	.. ..	195
Hours of exercise and preparation:	390 + 330 720	720

Professional Electives may be chosen in Metallurgy, Mining, Paleontology and Advanced Mineralogy or Petrography.

NAVAL ARCHITECTURE AND MARINE ENGINEERING
COURSE XIII. General, Option 1

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 ship-builders, 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 mechanism, thermodynamics, applied mechanics, hydraulics, heat engineering, 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 manœuvring, and also of power, proportion 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. The student makes a model, lays out plating and draws up specifications. 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.

Lectures are also given on the Organization and Management of Shipyards, including buildings, plant personnel, wages, trades unions, etc.

Ship Operation — Option 2

The Option in Ship Operation is intended for students who wish to enter the fields of ship operation and management or to engage in other maritime pursuits such as marine insurance, admiralty law, and the various branches of marine transportation.

The Course is a combination of science, engineering, economics, business studies, naval architecture and marine engineering, especially prepared to train men for the activities of this field. In many respects it parallels the courses in Engineering Administration given at the Institute.

Men with a knowledge of economics, business methods, and a training in the fundamentals of the exact sciences and engineering should be particularly well qualified to visualize and analyze the problems of ship operation, after they have had the necessary practical experience and training in subordinate positions with a ship owning organization.

The instruction in naval architecture, ship construction and design takes up the technical and economic aspects of these subjects but the treatment is more from the point of view of the ship owner and operator than from that of designer and builder.

As a thorough knowledge of a ship's power plant is essential to the ship operator who must have a large share in the selection and economic operation of the propelling machinery, marine engineering, covering all types of steam and Diesel machinery, is given a prominent place in the course.

Special features in the schedule of studies are the courses in Shipping Administration, Terminal Facilities and the Economics of Ship Operation.

Nearly twenty per cent of the student's time is devoted to economics and business administration subjects.

COURSE XIII — Option 1 — *Continued*

Option 1. Naval Architecture and Marine Engineering.

First Year, Page 60

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·16	.. ..	30 — 60
English and History E21, E22	45 — 75	45 — 75
Forging 2·901, 2·902	30 — 0	30 — 0
Foundry 2·912	.. ..	30 — 0
Mathematics M21, M22	45 — 90	45 — 90
Mechanical Engineering and Machine Drawing 2·121	90 — 0	.. ..
Mechanism 2·00	45 — 90	.. ..
Military Science MS21, MS22	45 — 0	45 — 0
Physics 8·03, 8·04	60 — 75	60 — 75
Ship Construction 13·31, 13·32	30 — 30	30 — 30
Ship Drawing 13·41	.. ..	105
Hours of exercise and preparation:	750 = 390 + 360	750 = 420 + 330

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·20, 2·221	45 — 90	45 — 90
Engineering Laboratory 2·611	.. ..	30 — 15
Heat Engineering 2·40, 2·42	45 — 90	45 — 75
Machine Tool Laboratory 2·951, 2·952	90 — 0	60 — 0
Marine Engineering 13·51	.. ..	30 — 30
Materials of Engineering 2·30	.. ..	30 — 30
Naval Architecture 13·01, 13·02	30 — 30	30 — 30
Political Economy Ec31, Ec32	45 — 45	45 — 45
Ship Construction 13·33	45 — 60	.. ..
Ship Design 13·42, 13·43	60 — 0	45 — 0
General Study	30 — 30	30 — 30
Hours of exercise and preparation:	735 = 390 + 345	735 = 390 + 345

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Accounting Ec50	.. ..	45 — 45
Applied Chemistry 5·35	.. ..	20 — 25
Electrical Engineering Elements 6·40	60 — 90	.. ..
Electrical Engineering Laboratory 6·89	.. ..	30 — 30
Engineering Laboratory 2·612, 2·613	30 — 30	30 — 30
Hydraulics 1·63	30 — 45	.. ..
Marine Diesel Engines and Auxiliaries 13·72	.. ..	30 — 45
Marine Engine Design 13·61, 13·62	45 — 0	90 — 0
Marine Engineering 13·52, 13·53	20 — 10	30 — 30
Naval Architecture 13·03	45 — 45	.. ..
Ship Design 13·45, 13·46	105 — 0	45 — 0
Shipyard Organization 13·38	.. ..	30 — 15
Steam Turbines 13·70	30 — 45	.. ..
Testing Materials Laboratory 2·36	30 — 15	.. ..
Thesis	.. ..	105
General Study	30 — 30	30 — 30
Hours of exercise and preparation:	735 = 425 + 310	735

COURSE XIII — Option 2 — *Continued*

Option 2. Ship Operation

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Accounting Ec50	.. ..	45 — 45
Applied Mechanics 2·16	.. ..	30 — 60
English and History E21, E22	45 — 75	45 — 75
Mathematics M21, M22	45 — 90	45 — 90
Mechanical Engineering Drawing 2.101	60 — 0	.. ..
Mechanism 2·00	45 — 90	.. ..
Military Science MS21, MS22	45 — 0	45 — 0
Physics 8·03, 8·04	60 — 75	60 — 75
Political Economy Ec21	45 — 75	.. ..
Ship Construction 13·321	.. ..	30 — 30
Ship Drawing 13·411	.. ..	75 — 0
Hours of exercise and preparation:	750 = 345 + 405	750 = 375 + 375

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·20, 2·221	45 — 90	45 — 90
Banking Ec37	.. ..	45 — 60
Corporate Organization Ec56	45 — 90	.. ..
Corporation Finance and Investments Ec57	.. ..	45 — 90
Engineering Laboratory 2·611	.. ..	30 — 15
Forging 2·901	30 — 0	.. ..
Heat Engineering 2·40, 2·42	45 — 90	45 — 75
Marine Engineering 13·51	.. ..	30 — 30
Naval Architecture 13·011, 13·021	30 — 30	30 — 30
Report Writing E33	30 — 30	.. ..
Ship Construction 13·331	30 — 30	.. ..
Shipping Administration Ec80	.. ..	30 — 45
Statistics Ec65	45 — 15	.. ..
Terminal Facilities 13·83	30 — 15	.. ..
Hours of exercise and preparation:	720 = 330 + 390	735 = 300 + 435

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Chemistry 5·35	.. ..	20 — 25
Business Law Ec61, Ec62	30 — 60	30 — 60
Cost Accounting Ec51	60 — 75	.. ..
Electrical Engineering, Elements 6·40	60 — 90	.. ..
Engineering Laboratory 2·612	30 — 30	.. ..
Foundry 2·912	.. ..	30 — 0
Industrial Relations Ec46	.. ..	45 — 60
Machine Tool Laboratory 2·961	.. ..	30 — 0
Marine Diesel Engines and Auxiliaries 13·72	.. ..	30 — 45
Marine Engine Design 13·66	.. ..	45 — 0
Marine Engineering 13·52	20 — 10	.. ..
Materials of Engineering 2·31	15 — 30	.. ..
Ship Design 13·47	90 — 0	.. ..
Ship Operation 13·81, 13·82	30 — 30	45 — 60
Steam Turbines 13·70	30 — 45	.. ..
Testing Materials Laboratory 2·37	.. ..	20 — 10
General Study	.. ..	30 — 30
Thesis	.. ..	105
Hours of exercise and preparation:	735 = 365 + 370	720

Naval Construction — COURSE XIII-A

Course for Naval Constructors

SENIOR YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Alternating Currents and Alternating Current Machinery 6·451, 6·452	30 — 60	30 — 60
Business Law Ec61	30 — 60	.. ..
Electrical Engineering Laboratory 6·871, 6·872	30 — 20	30 — 25
Internal Combustion Engines 2·48	.. ..	15 — 30
Marine Engine Design 13·63, 13·64	45 — 0	60 — 30
Marine Engineering 13·58	30 — 30	.. ..
Merchant Shipbuilding 13·37	.. ..	30 — 30
Model Making 13·48	.. ..	30 — 0
Naval Architecture 13·01, 13·02	30 — 30	30 — 30
Political Economy Ec35	45 — 75	.. ..
Shipyard Practice 13·39	.. ..	30 — 30
Steam Turbines 13·71	.. ..	30 — 60
Theory of Warship Design 13·11, 13·12	60 — 90	60 — 60
Warship Design 13·21, 13·22	120 — 0	120 — 0
Hours of exercise and preparation:	785 = 420 + 365	820 = 465 + 355

GRADUATE YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Aeronautics 16·76, 16·78	30 — 60	45 — 75
Naval Architecture 13·03	45 — 45	.. ..
Precision of Measurements 8·07	10 — 10	.. ..
Rigid Dynamics M731, M732	45 — 90	45 — 90
Structural Design 1·46	.. ..	30 — 0
Structures 1.45	45 — 90	.. ..
Theory of Warship Design 13·13, 13·14	75 — 120	75 — 90
Warship Design 13·23, 13·24	150 — 0	150 — 0
Thesis	.. ..	195
Hours of exercise and preparation:	815 = 400 + 415	795

ELECTROCHEMICAL ENGINEERING — COURSE XIV

The course in Electrochemical Engineering 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 undertake various lines of purely electrical or chemical as well as electrochemical work, if they so desire. The course also offers a very satisfactory foundation in Science for the subsequent study of Patent Law.

The main features of the curriculum are a very thorough training in electrical engineering and chemical subjects, which extend throughout the whole course, upon which is based the distinctly professional work in electrochemistry, which runs through the third and fourth years. The electrical studies are similar to those taken by students in electrical engineering, and include courses in the theory of direct and alternating currents, courses in direct and alternating current generators and motors and power transmission, with practice in the laboratories of electrical engineering and electrical testing. The instruction in chemistry is devoted chiefly to courses in analytical, organic and industrial chemistry. In addition to these subjects are included courses in mechanism, applied mechanics, and the examination of materials by the methods of metallography and X-rays.

In the third year the underlying principles of electrochemical and chemical phenomena are discussed both from the kinetic and thermodynamic points of view. This course is completed in the first term of the fourth year, when it is accompanied by extended laboratory practice in electrochemical measurements. In the second term the instruction is continued by a course on applied electrochemistry, including electro-deposition, accumulators, electric furnaces and their products, electrolytic processes, and electrometallurgy, and by work in the laboratory of applied electrochemistry. Current periodical literature is reviewed in a weekly colloquium. The latter part of the course is devoted principally to the preparation of a thesis on some electrochemical topic.

A wide range of elective studies is allowed in the fourth year to meet the needs of students who desire to specialize along certain lines of work.

Admission to the laboratory courses in electrochemistry is necessarily restricted to the capacity of the special laboratories equipped for this work.

Electrochemical Engineering — COURSE XIV — *Continued*

First Year, Page 60

REQUIRED SUMMER COURSES (Following First Year)

Mechanism 2.01	**30 — 60**
Qualitative Analysis 5·101	**130 — 30**

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Electrical Engineering, Principles 6·06	.. ..	45 — 75
English and History E21, E22	45 — 75	45 — 75
Language	45 — 75	45 — 75
Machine Tool Laboratory 2·96	60 — 0	.. ..
Mathematics M21, M22	45 — 90	45 — 90
Military Science MS21, MS22	45 — 0	45 — 0
Physics 8·03, 8·04	60 — 75	60 — 75
Quantitative Analysis 5·12, 5·132	105 — 30	60 — 15
Hours of exercise and preparation:	750 = 405 + 345	750 = 345 + 405

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·16, 2·20	30 — 60	45 — 90
Electrochemistry, Principles of 8·801, 8·802	60 — 90	45 — 90
Electrical Engineering, Principles of 6·07, 6·08	60 — 90	60 — 90
Electrical Engineering Laboratory 6·81, 6·82	40 — 35	40 — 35
Heat Measurements 8·11	30 — 15	.. ..
Organic Chemistry 5·50	30 — 30	.. ..
Organic Chemical Laboratory 5·615	.. ..	75 — 0
Political Economy Ec31, Ec32	45 — 45	45 — 45
General Study	30 — 30	30 — 30
Hours of exercise and preparation:	720 = 325 + 395	720 = 340 + 380

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Electrochemical Laboratory 8·871, 8·872	35 — 0	35 — 0
Applied Electrochemistry 8·851, 8·852	15 — 30	25 — 80
Colloquium 8·93	.. ..	15 — 15
Electrical Engineering, Principles of 6·09	60 — 90	.. ..
Electrical Engineering Laboratory 6·83	40 — 35	.. ..
Electrochemical Laboratory 8·86	70 — 0	.. ..
Electrochemistry 8·82	30 — 60	.. ..
Industrial Chemistry 10·201	.. ..	60 — 60
Metallography 3·611	.. ..	60 — 15
Precision Measurements 8·94	10 — 20	.. ..
X-Rays and Radiology 8·33	45 — 15	.. ..
Thesis	30	180
Elective	135	175
Hours of exercise and preparation:	720	720

Students credited with Elementary and Intermediate French on entrance will take Elementary German or if they have had preparation Intermediate German.

Students credited with Elementary and Intermediate German on entrance will take Elementary French or if they have had preparation Intermediate French.

Students credited with Elementary French and Elementary German on entrance will take Intermediate German.

ENGINEERING ADMINISTRATION — COURSE XV

The course in Engineering Administration provides a training for men who expect to enter positions concerned with the management or administration of manufacturing, construction, and transportation enterprises which demand a knowledge of scientific and engineering principles. Studies in the methods, economics, and law of business are combined with instruction in general engineering. The course includes (1) the instruction common to all courses, in literature, language and history, and in chemistry, physics and mathematics; (2) a choice of engineering studies, classified under three options: Civil Engineering, Mechanical and Electrical Engineering, Chemical Engineering; and (3) a selected group of subjects in business and economics. While the amount of time assigned to engineering subjects is less than that prescribed in the other courses of the Institute, the fundamental subjects have been retained which will enable graduates to fill many of the positions open to engineers.

Approximately one-fourth of the total time is given to business subjects which are primarily chosen to train students to analyze commercial and industrial problems. In this group special emphasis is placed upon accounting, business law, the industrial organization of society, and business management. The course in Accounting is designed to be of service to administrative officers in the analysis of accounts and financial reports, rather than to make bookkeepers, auditors, or accountants in a technical sense. Business Law treats of contracts, agency, negotiable instruments, sales, and patents. The two extended subjects of Industrial Organization and Business Management deal with the financial operations of corporations and the conduct of business from the standpoint of the individual employer. Among other subjects included in the group of business studies are banking, statistics, report writing, industrial relations, and securities and investments.

Civil Engineering Option. The Civil Engineering Option is intended to meet the needs of students expecting to enter upon administrative positions in organizations engaged in transportation or the construction of works pertaining thereto, or in the development and distribution of hydraulic power. The course differs from the regular Civil Engineering Course by the substitution of business subjects for some of the specialized optional subjects of the fourth year and for the following subjects of earlier years: astronomy, geodesy, geology, railway drafting, and topographical drawing. The graduates of this option are, however, trained in the fundamental principles and professional subjects upon which the practice of civil engineering depends.

Mechanical and Electrical Engineering Option. The Option in Mechanical and Electrical Engineering is planned to give a training in a sufficient number of the fundamental engineering subjects to make its graduates competent to deal with engineering affairs other than the direct design and construction of plants. It includes many of the important subjects given in the regular course in Mechanical Engineering, omitting, however, certain of the more specialized subjects. The option differs from the course in Electrical Engineering in that less attention is given to design and to the more theoretical parts of electrical engineering, the aim being to give the students a general knowledge, which, together with the laboratory practice, should make them capable of employment in the operating or in directing the operating of electrical plants.

Chemical Engineering Option. The Chemical Engineering Option affords instruction in the more important branches of chemistry and in the fundamental principles of mechanical engineering. The time devoted in this option to organic chemistry is much less, and that devoted to the other branches of chemistry is somewhat less than in the Chemical Engineering Course. The training is, however, adequate to fit capable students to take business positions in establishments concerned with industrial chemistry. The instruction in mechanical and electrical engineering is also less extended than that in the Chemical Engineering Course. The primary purpose of the option is to give the information and training necessary to prepare men to deal with the economic administration rather than with the scientific development and control of the processes involved in the industries devoted to the manufacture of materials, such as textiles paper, leather, rubber, fertilizers, iron and steel, foods, and chemicals.

Engineering Administration — COURSE XV — *Continued*

First Year, Page 60

Option 1. Civil Engineering

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Accounting Ec50	.. ..	45 — 45
Applied Mechanics 2·16	.. ..	30 — 60
Banking Ec37	.. ..	45 — 60
English and History E21, E22	45 — 75	45 — 75
Mathematics M21, M22	45 — 90	45 — 90
Mechanism 2·02	30 — 30	.. ..
Military Science MS21, MS22	45 — 0	45 — 0
Physics 8·03, 8·04	60 — 75	60 — 75
Political Economy Ec21	45 — 75	.. ..
Statistics Ec65	45 — 15	.. ..
Surveying and Plotting 1·00, 1·01	30 — 45	30 — 0
Hours of exercise and preparation:	750 = 345 + 405	750 = 345 + 405

REQUIRED SUMMER COURSES AT CAMP TECHNOLOGY

Geodetic and Topographic Surveying 1·06	95 — 5
Hydrographic Surveying 1·60	75 — 0
Plane Surveying 1·05	90 — 10
Railway Fieldwork 1·20	80 — 0

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·20	45 — 90	.. ..
Business Management Ec70	.. ..	45 — 45
Corporate Organization Ec56	45 — 90	.. ..
Corporate Finance and Investments Ec57	.. ..	45 — 90
Electrical Engineering, Elements 6·40	60 — 90	.. ..
Electrical Engineering Laboratory 6·89	.. ..	30 — 30
English E31	30 — 60	.. ..
Heat Engineering 2·44, 2·45	45 — 75	45 — 75
Materials 1·43	.. ..	15 — 30
Railway and Highway Engineering 1·21, 1·22	30 — 60	30 — 30
Report Writing E33	.. ..	30 — 30
Structures 1·40	.. ..	45 — 75
Testing Materials Laboratory 2·37	.. ..	20 — 10
Hours of exercise and preparation:	720 = 255 + 465	720 = 305 + 415

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Business Law Ec61, Ec62	30 — 60	30 — 60
Business Management Ec71, Ec72	60 — 90	60 — 90
Cost Accounting Ec51	60 — 75	.. ..
Engineering and Hydraulic Laboratory 2·63	.. ..	30 — 30
Engineering Construction and Estimates 1·25	30 — 45	.. ..
Foundations 1·48	15 — 15	.. ..
Hydraulics 1·64	.. ..	45 — 90
Industrial Relations Ec46	.. ..	45 — 60
Structural Design 1·53	60 — 0	.. ..
Structures 1·41, 1·421	60 — 120	30 — 60
Thesis	.. ..	105
Hours of exercise and preparation:	720 = 315 + 405	735

Engineering Administration — COURSE XV — *Continued*

OPTION 2. Mechanical and Electrical Engineering

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Accounting Ec50	.. ..	45 — 45
Applied Mechanics 2·16	.. ..	30 — 60
Banking Ec37	.. ..	45 — 60
English and History E21, E22	45 — 75	45 — 75
Mathematics M21, M22	45 — 90	45 — 90
Mechanism 2·00	45 — 90	.. ..
Military Science MS21, MS22	45 — 0	45 — 0
Physics 8·03, 8·04	60 — 75	60 — 75
Political Economy Ec21	45 — 75	.. ..
Statistics Ec65	45 — 15	.. ..
Surveying 1·03	.. ..	30 — 0
Hours of exercise and preparation:	750 = 330 + 420	750 = 345 + 405

REQUIRED SUMMER COURSES

Foundry 2.912	**30 — 0**
Machine Tool Laboratory 2.971	**45 — 0**
Mechanical Engineering Drawing 2.11	**75 — 0**

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·20, 2·221	45 — 90	45 — 90
Business Management Ec70	.. ..	45 — 45
Corporate Organization Ec56	45 — 90	.. ..
Corporate Finance and Investments Ec57	.. ..	45 — 90
Electrical Engineering, Elements 6·40	.. ..	60 — 90
English E31	30 — 60	.. ..
Heat Engineering 2·40, 2·42	45 — 90	45 — 75
Heat Engineering 2·41	30 — 30	.. ..
Machine Drawing 2·131	75 — 0	.. ..
Machine Tool Laboratory 2.972	.. ..	45 — 0
Materials of Engineering 2·31	15 — 30	.. ..
Report Writing E33	30 — 30	.. ..
Testing Materials Laboratory 2·36	.. ..	30 — 15
Hours of exercise and preparation:	735 = 315 + 420	720 = 315 + 405

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Business Law Ec61, Ec62	30 — 60	30 — 60
Business Management Ec71, Ec72	60 — 90	60 — 90
Cost Accounting Ec51	60 — 75	.. ..
Electrical Engineering Laboratory 6·89	30 — 30	.. ..
Engineering Laboratory 2·614, 2·615	60 — 45	30 — 30
Generation and Distribution of Electric Energy 6·43	.. ..	60 — 90
Hydraulics 1·64	45 — 90	.. ..
Industrial Relations Ec46	.. ..	45 — 60
Machine Design 2·721, 2·722	60 — 0	60 — 0
Thesis	.. ..	105
Hours of exercise and preparation:	735 = 345 + 390	720

Engineering Administration — COURSE XV — *Continued*

OPTION 3. Chemical Engineering

REQUIRED SUMMER COURSES (Following First Year)

Mechanism 2.01	**30 — 60**
Qualitative Analysis 5·101	**180 — 30**

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Accounting Ec50	.. ..	45 — 45
Applied Mechanics 2·16	.. ..	30 — 60
Banking Ec37	.. ..	45 — 60
English and History E21, E22	45 — 75	45 — 75
Machine Tool Laboratory 2·961	.. ..	30 — 0
Mathematics M21	45 — 90	.. ..
Military Science MS21, MS22	45 — 0	45 — 0
Physics 8·03, 8·04	60 — 75	60 — 75
Political Economy Ec21	45 — 75	.. ..
Quantitative Analysis 5·12, 5·13	105 — 30	105 — 30
Statistics Ec65	45 — 15	.. ..
Hours of exercise and preparation:	750 = 390 + 360	750 = 405 + 345

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·20	45 — 90	.. ..
Business Management Ec70	.. ..	45 — 45
Chemical Engineering 10·35	.. ..	45 — 60
Corporate Organization Ec56	45 — 90	.. ..
Corporate Finance and Investments Ec57	.. ..	45 — 90
English E31	30 — 60	.. ..
Heat Engineering 2·44, 2·45	45 — 75	45 — 75
Industrial Chemistry 10·201	.. ..	60 — 60
Organic Chemistry 5·501	45 — 30	.. ..
Organic Chemistry Laboratory 5·614, 5·624	45 — 0	60 — 0
Report Writing E33	.. ..	30 — 30
Testing Materials Laboratory 2·37	.. ..	20 — 10
Thermochemistry and Chemical Equilibrium 5·681	45 — 75	.. ..
Hours of exercise and preparation:	720 = 300 + 420	720 = 350 + 370

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Business Law Ec61, Ec62	30 — 60	30 — 60
Business Management Ec71, Ec72	60 — 90	60 — 90
Chemical Engineering 10·36	45 — 75	.. ..
Cost Accounting Ec51	60 — 75	.. ..
Electrical Engineering, Elements of 6·40	60 — 90	.. ..
Electrical Engineering Laboratory 6·85	.. ..	30 — 45
Engineering Laboratory 2·62	.. ..	60 — 30
Industrial Chemical Laboratory 10·27	.. ..	90 — 15
Industrial Chemistry 10·212	45 — 30	.. ..
Industrial Relations Ec46	.. ..	45 — 60
Thesis	.. ..	105
Hours of exercise and preparation:	720 = 300 + 420	720

AERONAUTICAL ENGINEERING

The Course in Aeronautical Engineering is designed 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. Following the usual preliminary work in the subjects fundamental to all engineering, part of the time in the third year and most of that in the fourth is devoted to professional subjects, lectures being supplemented by drafting room practice and by laboratory work both in the methods of aeronautical research and in the operations and maintenance of airplanes in the field.

While a graduate in Aeronautical Engineering is especially prepared for work in the engineering department of a company manufacturing airplanes, the subjects taught are not so specialized as to go beyond the proper and necessary interest of any man entering any part of the aeronautical field. In particular, it furnishes a sound basic training for those desirous of associating themselves with enterprises engaged in the operation of aircraft, whether their primary concern is with the selection of equipment or with its maintenance.

Aeronautical Engineering — COURSE XVI — *Continued*

First Year, Page 60

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·15	.. ..	45 — 90
English and History E21, E22	45 — 75	45 — 75
Forging 2·90	.. ..	45 — 0
Foundry 2·91	60 — 0	.. ..
Machine Drawing 2·13	.. ..	90 — 0
Mathematics M21, M22	45 — 90	45 — 90
Mechanical Engineering Drawing 2·10	90 — 0	.. ..
Mechanism 2·00	45 — 90	.. ..
Military Science MS21, MS22	45 — 0	45 — 0
Pattern Making 2·92	.. ..	30 — 0
Physics 8·03, 8·04	60 — 75	60 — 75
Surveying 1·03	30 — 0	.. ..
Hours of exercise and preparation:	750 = 420 + 330	735 = 405 + 330

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·20, 2·21	45 — 90	45 — 75
Heat Engineering 2·40, 2·42	45 — 90	45 — 75
Machine Tool Laboratory 2·951, 2·952	90 — 0	60 — 0
Materials of Engineering 2·30	.. ..	30 — 30
Political Economy Ec31, Ec32	45 — 45	45 — 45
Report Writing E33	.. ..	30 — 30
Rigging and Maintenance of Aircraft 16·51	45 — 15	.. ..
Theoretical Aeronautics M43, M44	45 — 90	45 — 90
General Study	30 — 30	30 — 30
Hours of exercise and preparation:	705 = 345 + 360	705 = 330 + 375

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Aeronautical Engine Laboratory 16·90	.. ..	45 — 0
Aeronautical Engines 16·82	.. ..	30 — 30
Aeronautical Laboratory 16·62	.. ..	60 — 30
Airplane Construction 16·54	.. ..	30 — 15
Airplane Design 16·01	75 — 90	.. ..
Airplane Design Practice 16·11, 16·12	30 — 0	60 — 0
Dynamics of Machines 2·251	30 — 60	.. ..
Electrical Engineering Elements 6·40	60 — 90	.. ..
Electrical Engineering Laboratory 6·85	.. ..	30 — 45
Machine Design 2·731, 2·732	30 — 60	30 — 60
Physical Chemistry 5·82	30 — 30	.. ..
Propellers and Airships 16·72	.. ..	30 — 30
Testing Materials Laboratory 2·35	60 — 30	.. ..
General Study	30 — 30	30 — 30
Thesis	.. ..	135 — 0
Hours of exercise and preparation:	735 = 345 + 390	720 = 480 + 240

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BUILDING CONSTRUCTION

This course is planned to prepare students to enter the business of building.

It is based on the Course in Civil Engineering with the mathematics and scientific training generally associated with that profession. In addition there are certain subjects taken from the Course in Architecture, mainly for the purpose of giving the student an acquaintance with architectural history, periods and forms sufficient to enable him to understand the architect's language and point of view. Subjects in building finance, and management, cost accounting and professional and industrial relations are also included. Finally a broad course, extending over three years, is given in the analysis, details and assembly of the materials of building, whereby the student is given a thorough understanding of construction methods and procedure, covering dwellings, and industrial and commercial structures.

Building Construction — COURSE XVII

FIRST YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Architectural Drawing 4·10	.. ..	45 — 0
Chemistry 5·01, 5·02	120 — 75	120 — 75
Descriptive Geometry D21	45 — 10	.. ..
English and History E11, E12	45 — 75	45 — 75
Graphics 4·061	.. ..	55 — 0
Mathematics M11, M12	45 — 90	45 — 90
Mechanical Drawing D11	45 — 0	.. ..
Military Science MS11, MS12	45 — 0	45 — 0
Physical Training PT1, PT2	20 — 0	20 — 0
Physics 8·01, 8·02	60 — 75	60 — 75
Hours of exercise and preparation:	750=425+325	750=435+315

Building Construction — COURSE XVII — *Continued*

SECOND YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Applied Mechanics 2·15	.. ..	45 — 90
Architectural Drawing 4·413	30 — 60	.. ..
English and History E21, E22	45 — 75	45 — 75
Mathematics M21, M22	45 — 90	45 — 90
Physics 8·03, 8·04	60 — 75	60 — 75
Building Construction 17·21, 17·22	225 — 0	180 — 0
Military Science MS21, MS22	45 — 0	45 — 0
Hours of exercise and preparation: 750 =	450 + 300	750 = 420 + 330

THIRD YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Accounting Ec50	.. ..	45 — 45
Applied Mechanics 2·20	45 — 90	.. ..
Building Construction 17·31	210 — 0	.. ..
Building Construction and Materials 17·32	.. ..	195 — 30
Carpentry 2·921	.. ..	30 — 0
Electrical Engineering, Elements 6·40	60 — 90	.. ..
Electrical Engineering Laboratory 6·89	.. ..	30 — 30
Geology 12·321	30 — 15	.. ..
Hydraulics 1·62	.. ..	45 — 75
Industrial Relations Ec46	.. ..	45 — 60
Political Economy Ec21	45 — 75	.. ..
Structures 1·40	.. ..	45 — 75
General Study	30 — 30	.. ..
Hours of exercise and preparation: 720 =	420 + 300	750 = 435 + 315

REQUIRED SUMMER COURSES

Surveying 1.09	150 — 50
Graphic Statics 1.39	45 — 15

FOURTH YEAR

	First Term 15 Weeks	Second Term 15 Weeks
Building Construction 17·41, 17·42	120 — 0	150 — 0
Building Finance Ec53	45 — 90	.. ..
Business Management Ec74	.. ..	45 — 90
Electrical Equipment of Buildings 6·23	.. ..	15 — 30
Foundations and Soil Mechanics 1·481	45 — 75	.. ..
Job Management 17·50	.. ..	15 — 15
Mechanical Equipment of Buildings 2·59	.. ..	60 — 45
Professional Relations 4·241	15 — 15	.. ..
Reinforced Concrete Design and Laboratory 2·390	105 — 0	.. ..
Structures 1·41, 1·422	60 — 120	30 — 60
Testing Materials Laboratory 2·37	20 — 10	.. ..
General Study	.. ..	30 — 30
Thesis	.. ..	105 — 0
Hours of exercise and preparation: 720 =	410 + 310	720 = 450 + 270

MILITARY ENGINEERING

Open to regular officers of the United States Army or the United States Navy.

Graduates of the United States Military Academy at West Point or the United States Naval Academy at Annapolis will be admitted on their credentials; Army Officers or Navy Officers of the United States of America not graduates of either of the government schools, who are graduates of a technical school, will be admitted on showing that they have had the necessary preliminary training.

Military Engineering

Required Courses to be taken in the Summer

Preceding the Academic Year

Applied Mechanics 2·20	45 — 90
Applied Mechanics 2·21	45 — 75
Heat Engineering 2·46	60—105
Heat Engineering 2·47	30 — 45
Structures 1·40	45 — 75

FOURTH YEAR

	First Term	Second Term
Bacteriology 7·31	30 — 30	.. ..
Concrete Building Design and Specifications 2·395	.. ..	60 — 30
Engineering and Hydraulic Laboratory 2·631	.. ..	45 — 45
Electrical Engineering Elements 6·40	60 — 90	.. ..
Electrical Engineering Laboratory 6·85	.. ..	30 — 45
Engineering Construction and Estimates 1·25	30 — 45	.. ..
Heat Treatment 2·857	.. ..	30 — 0
Industrial Applications of Electric Power 6·46	.. ..	45 — 30
Materials of Engineering 2·30	.. ..	30 — 30
Municipal Sanitation 7·57	.. ..	60 — 50
Physical Chemistry 5·82	30 — 30	.. ..
Reinforced Concrete Design 1·581	90 — 30	.. ..
Structures 1·41, 1·42	60 — 120	60 — 120
Testing Materials Laboratory 2·361	30 — 30	.. ..
Testing Materials Laboratory 2·362 (Concrete)	30 — 15	.. ..
Thesis	45	90
	795	800

UNDERGRADUATE SCHEDULES FOR RESERVE OFFICERS' TRAINING CORPS

The Reserve Officers' Training Corps instruction consists of two courses, the Basic Course and the Advanced Course, each of two academic years. The Basic Course is compulsory; the Advanced Course is elective and includes one summer camp period.

BASIC COURSE

The completion of this course is a prerequisite for graduation, and unless completed in this or some other R. O. T. C. the student will not be eligible to elect the advanced course leading to a commission in the Officers' Reserve Corps of the Army of the United States.

First Year. Required of all able-bodied male citizen students registered in the Freshman Class except where suitable evidence of equivalent work already performed is presented to the Professor of Military Science and Tactics before the first term begins.

	First Term	Second Term
MS11		
Infantry Drill	21 — 0	.. ..
Elementary Subjects of Military Training	15 — 0	.. ..
Infantry Weapons and Rifle Marksmanship	95 — 0	.. ..
MS12		
Infantry Drill	.. ..	45 — 0
	45 — 0	45 — 0

(Upon certificate from the Medical Director that Infantry Drill would be harmful the student will be excused from that part of the course; but he must register with the Department, present his certificate and take all the other subjects of the course.)

As a result of demonstrated efficiency in Infantry Drill during the first term, a certain number of students are appointed Cadet Corporals for the rest of the year.

Second Year. Required of all able-bodied male citizen students registered in the Sophomore Class except where suitable evidence of equivalent work already performed is presented to the Professor of Military Science and Tactics before the first term begins.

From among those who demonstrated their proficiency in Infantry Drill during the first year are selected a suitable number of students for appointment as Cadet Sergeants with the obligation for at least one hour per week.

	First Term	Second Term
MS21		
Topography and Map Reading	18 — 0	.. ..
Field Fortifications	15 — 0	.. ..
Signal Communications	6 — 0	.. ..
Lectures on the work of the various Units	6 — 0	.. ..
	45 — 0	

Opportunity is given the student to choose the unit in which he prefers to continue his instruction during the second term. Those who fail to report their preference at the office of the Professor of Military Science and Tactics before the end of the first term will be assigned arbitrarily to some unit for the second term.

During this term opportunity is given to all who desire to elect the Advanced Course of the Air Corps Unit to take the special physical examination. Those who fail to pass this examination will not be permitted to sign contracts for the advanced course in the Air Service Unit.

	First Term	Second Term
MS221 Coast Artillery Unit: Instruction of the Second Class Gunner	.. ..	45 — 0
MS222 Engineer Unit: Elements of Engineer Training	.. ..	45 — 0
MS223 Signal Unit: Electrical Communications	.. ..	45 — 0
MS224 Ordnance Unit: Interior and Exterior Ballistics	.. ..	45 — 0
MS225 Air Corps Unit: Tactics and Communications	.. ..	45 — 0
MS226 Chemical Warfare Unit: Theoretical and Tactical	.. ..	45 — 0

ADVANCED COURSE

"The Head of a Department is authorized to allow at his option credit towards graduation for military taught subjects."

" 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."

Open to third year students who have completed the Basic Course, who are acceptable to the Professor of Military Science and Tactics, and who receive the approval of the Professor-in-charge of the Institute Department in which they may be registered.

The student must execute a contract to continue the course of instruction for two years should he remain that length of time in the Institute and the fulfillment of this contract then becomes a prerequisite for graduation.

Those who execute this contract will be entitled while not subsisted in kind to the commutation of subsistence fixed by the Secretary of War in accordance to law.

All students in the Advanced Course R. O. T. C. are required to take Military History and Policy of the United States, G98, 30-30 during the first term and International Law G3, 30-30, during the second term. Either of these subjects may be taken with the approval of the Registration Officer in either the third or fourth years as best suits the individual's Institute schedule.

The courses of study for students enrolled in any of the units of the R. O. T. C. which have been arranged by the departments are shown immediately following the military requirements for those units. Students in departments which have not submitted schedules will arrange their courses in consultation with the heads of the departments concerned.

From among the R. O. T. C. graduates each year there may be designated as " Honor Graduates R. O. T. C." not to exceed three per cent of the total number of students who on March 1 of that year were enrolled in the second year of the advanced course of the R. O. T. C.

Since Course VI-A is a coöperative course extending over a period of five years, during a part of which time the student is not in residence, members of this course may consider their third or fourth year as their junior year and their fourth or fifth year as their senior year, for purposes of arranging Military Science schedules.

First Year of Advanced Course (3d year M. I. T.). From among those students who have demonstrated marked proficiency and interest are selected the Cadet Second Lieutenants who are required to give one hour per week in assisting in the instruction in Infantry Drill.

Summer Camp. One of the obligations contained in the contract to be signed before beginning the R.O.T.C. Advanced Course is one to attend one Advanced Camp. This camp normally comes between the junior and senior years. Authority can usually be obtained for good reasons, to attend this camp after the sophomore year though this is not general as the work of the junior year is designed to enable the student to obtain the greatest good from the camp instruction . In very exceptional cases attendance at camp may be postponed until after the senior year, but only upon the express agreement that the student's diploma will be withheld until after the completion of his R. O. T. C. Course.

Second Year of Advanced Course (4th year M. I. T.). From among those who continue especially to demonstrate their proficiency and interest and who were Second Lieutenants during their junior year will be selected the Cadet First Lieutenants and Cadet Captains under the same obligation to devote one hour per week to assist in instruction in Infantry Drill.

Those students who did not take G98 and G3 during the junior year must take those subjects during this year.

COAST ARTILLERY UNIT No. 1

Open to students in all courses except V, XV₁, XV₂. Students whose Institute courses do not include Surveying, or who are unable to demonstrate proficiency in this subject, will be required to take one of the Institute Surveying subjects.

	First Term	Second Term
MS311		
Fire Control Instruments	15 — 15	.. ..
Computation of Firing Data for Heavy Mobile Artillery	30 — 30	.. ..
MS312		
Dispersion and Probability of Fire	.. ..	21 — 21
Observation and Adjustment of Fire	.. ..	24 — 24
	45 — 45	45 — 45
MS411		
Coast Artillery Material	9 — 9	.. ..
Organization and Administration of Coast Artillery Corps	9 — 9	.. ..
Camp Sanitation and Military Hygiene	6 — 6	.. ..
Gunnery for Anti-Aircraft Artillery	15 — 15	.. ..
Examinations during Term	6 — 6	.. ..
MS412		
Tactical Employment of Artillery, Fixed Anti-Aircraft and Heavy Mobile Artillery and Military Law	.. ..	45 — 45
	45 — 45	45 — 45

Civil Engineering — Course I. All Options

Third Year

	First Term	Second Term
Regular schedule with the following changes:		
Add:		
Military Science MS311, MS312	45 — 45	45 — 45

Fourth Year

	First Term	Second Term
Regular schedule with the following changes:		
Add:		
Military Science MS411, MS412	45 — 45	45 — 45

Mechanical Engineering — Course II

Third Year

	First Term	Second Term
Regular schedule with the following changes:		
Add:		
Military Science MS311, MS312	45 — 45	45 — 45
(Advised to take Machine Tool Laboratory in summer following second year.)		

Fourth Year

General Course

	First Term	Second Term
Regular schedule with the following changes:		
Omit:		
Testing Materials Laboratory 2·35	60 — 30	.. ..
Industrial Plants 2·782	.. ..	60 — 0
Add:		
Military Science MS411, MS412	45 — 45	45 — 45
Testing Materials Laboratory 2·36	30 — 15	.. ..
(G98 and G3 required as General Studies.)		

Options 1, 2, 3 and 4

Applicants from these options will be admitted to the Coast Artillery Unit subject to the approval of their schedule by the Military Department and the Head of the Mechanical Engineering Department.

COAST ARTILLERY UNIT — *Continued*

Mining Engineering — Course III. Option 1

Third Year

	First Term	Second Term
Regular schedule with the following changes:		
Add:		
Military Science MS311, MS312	45 — 45	45 — 45

Fourth Year

Regular schedule with the following changes:		
Omit:		
Thesis	.. ..	150 — 0
Add:		
Military Science MS411, MS412	45 — 45	45 — 45
Thesis	.. ..	120 — 0

Metallurgy — Course III. Option 2

Third Year

	First Term	Second Term
Regular schedule with the following changes:		
Add:		
Military Science MS311, MS312	45 — 45	45 — 45

Fourth Year

Regular schedule with the following changes:		
Omit:		
Thesis	.. ..	165
Add:		
Thesis	.. ..	150
Military Science MS411, MS412	45 — 45	45 — 4

Electrical Engineering — Course VI

Third Year

	First Term	Second Term
Regular schedule with the following changes:		
Omit:		
Political Economy Ec31, Ec32	45 — 45	45 — 45
Add:		
Military Science MS311, MS312	45 — 45	45 — 45
General Study G98	30 — 30	.. ..
(G3 required as General Study in second term.)		

Fourth Year

Electrical Engineering, Principles of, 6·03, 6·04	90 — 120	75 — 105
Electrical Engineering Laboratory 6·72	90 — 90	.. ..
Engineering Laboratory 2·621	.. ..	45 — 30
English E40	.. ..	45 — 75
Hydraulics 1·64	45 — 90	.. ..
Military Science MS411, MS412	45 — 45	45 — 45
Political Economy Ec31, Ec32	45 — 45	45 — 45
Thesis	30 — 0	180
	345—390 735	735

Electrochemical Engineering — Course XIV

Third Year

	First Term	Second Term
Regular schedule with the following changes:		
Add:		
Military Science MS311, MS312	45 — 45	45 — 45

Fourth Year

Regular schedule with the following changes:		
Omit:		
Optional Studies	135 — 0	175 — 0
Add:		
Military Science MS411, MS412	45 — 45	45 — 45
Optional Studies	45 — 0	85 — 0

COAST ARTILLERY UNIT — *Continued*

Engineering Administration — Course XV. Option 2

Third Year

	First Term	Second Term
Regular schedule with the following changes:		
Omit:		
Report Writing E33	30 — 30	.. ..
Machine Tool Laboratory 2·972	.. ..	45 — 0
Add:		
Military Science MS311, MS312	45 — 45	45 — 45
General Study G98	30 — 30	.. ..
Report Writing E33	.. ..	30 — 30

Fourth Year

	First Term	Second Term
Regular schedule with the following changes:		
Omit:		
Machine Design 2·722	.. ..	60 — 0
Add:		
Military Science MS411, MS412	45 — 45	45 — 45
General Study G3	.. ..	30 — 30

ENGINEER UNIT No. 2

Open to students in all courses except V. All instruction for this unit throughout the fourth year is given by Institute personnel.

	First Term	Second Term
MS321		
Organization and Duties of Engineers	12 — 12	.. ..
Administration, Supply, Equipment	9 — 9	.. ..
Musketry and Combat Principles	24 — 24	.. ..
MS322		
General Construction in War	.. ..	24 — 24
Field and Permanent Fortifications	.. ..	21 — 21
	45 — 45	45 — 45

Civil Engineering — Course I. All Options

Third Year

	First Term	Second Term
Regular schedule with the following changes:		
Add:		
Military Science MS321, MS322	45 — 45	45 — 45
General Studies to be	G98	G3

Fourth Year

No change from the regular schedule.

Mechanical Engineering — Course II

Third Year

	First Term	Second Term
Regular schedule with the following changes:		
Add:		
Military Science MS321, MS322	45 — 45	45 — 45

(Advised to take Machine Tool Laboratory in the summer following the second year.

Fourth Year

General Course

	First Term	Second Term
Regular schedule with the following changes:		
Add:		
Roads and Pavements 1·35	20 — 25	.. ..

(G98 and G3 required as General Studies.)

ENGINEER UNIT — *Continued*

Course II (*Continued*)

Options 1, 2 and 3

Fourth Year

Applicants from these options will be admitted to the Engineer Unit subject to the approval of their schedule by the Military Department and the Head of the Mechanical Engineering Department.

Option 4

	First Term	Second Term
Regular schedule with the following change:		
Add:		
Roads and Pavements 1·35	20 — 25	.. ..
(G98 and G3 required as General Studies.)		

Mining Engineering — Course III. Option 1

Third Year

Regular schedule with the following changes:		
Add:		
Military Science MS321, MS322	45 — 45	45 — 45

Fourth Year

No change from regular schedule.

Metallurgy — Course III. Option 2

Third Year

Regular schedule with the following changes:		
Add:		
Military Science MS321, MS322	45 — 45	45 — 45

Fourth Year

No change from regular schedule.

Electrical Engineering — Course VI

Third Year

	First Term	Second Term
Regular schedule with the following changes:		
Omit:		
Political Economy Ec31, Ec32	45 — 45	45 — 45
Add:		
Military Science MS321, MS322	45 — 45	45 — 45
(G3 required as General Study in second term)		

Fourth Year

Electrical Engineering, Principles 6·03, 6·04	90 — 120	75 — 105
Electrical Engineering Laboratory 6·72	90 — 90	.. ..
Engineering Laboratory 2·621	.. ..	45 — 30
English E40	.. ..	45 — 75
Hydraulics 1·64	45 — 90	.. ..
Political Economy Ec31, Ec32	45 — 45	45 — 45
Thesis	.. ..	255
General Study G98	30 — 30	.. ..
General Study	30 — 30	.. ..
	330—405 735	720

ENGINEER UNIT — *Continued*

Electrochemical Engineering — Course XIV

Third Year

	First Term	Second Term
Regular schedule with the following changes:		
Add:		
Military Science MS321, MS322	45 — 45	45 — 45

Fourth Year

Regular Institute schedule.

Engineering Administration — Course XV. Option 1

Third Year

Regular schedule with the following changes:		
Add:		
Military Science MS321, MS322	45 — 45	45 — 45

Fourth Year

Regular schedule with the following changes:		
Add:		
General Study G98, G3	30 — 30	30 — 30

Course XV, Option 2

Third Year

Regular schedule with the following changes:		
Add:		
Military Science MS321, MS322	45 — 45	45 — 45

Fourth Year

Regular schedule with the following changes:		
Add:		
General Study G98, G3	30 — 30	30 — 30

Course XV, Option 3

Third Year

Regular schedule with the following changes:		
Add:		
Military Science MS321, MS322	45 — 45	45 — 45

Fourth Year

Regular schedule with the following changes:		
Add:		
General Study G98, G3	30 — 30	30 — 30

SIGNAL UNIT No. 3

Open only to students in Courses VI, VI-C, VI-A, VIII, IX-B and XIV. All instruction for this unit throughout the fourth year is given by Institute personnel. Students are required to take for their R. O. T. C. course the required Institute subjects, Wire and Radio Communication 6·281, 6·282, two terms, 45 — 90 per term.

	First Term	Second Term
MS313 (MS3131 for VI-C)		
Signal Communication and Tactics	45 — 45	.. ..
MS323 (MS3231 for VI-C)		
Codes and Ciphers, Radio	.. ..	33 — 33
Practical Signal Work in the Field	.. ..	12 — 12
	45 — 45	45 — 45

Electrical Engineering — Course VI

Third Year

Regular schedule with the following changes:

Omit:		
Political Economy Ec31, Ec32	45 — 45	45 — 45
Add:		
Military Science MS331, MS332	45 — 45	45 — 45
General Study G98	30 — 30	.. ..
(G3 required as General Study in the second term.)		

Fourth Year

Electrical Engineering, Principles of, 6·03, 6·04	90 — 120	75 — 105
Electrical Engineering Laboratory 6·72	90 — 90	.. ..
Engineering Laboratory 2·621	45 — 30	.. ..
English E40	.. ..	45 — 75
Political Economy Ec31, Ec32	45 — 45	45 — 45
Principles of Wire Communication 6·281	45 — 90	.. ..
Principles of Radio Communication 6·282	.. ..	45 — 90
Thesis	30 — 0	195
	345—375 720	720

Electrical Engineering — Course VI-C

Third Year

Regular schedule with the following changes:

Add:		
Military Science MS3311, MS3321	30 — 15	30 — 15
(G3 required as General Study in the second term.)		

Fourth Year

egular schedule with the following change:
G98 required as General Study in first term.

ORDNANCE UNIT No. 4

Open only to students in Courses II, III₂, VI-A, X, X-A, X-B and XV₂.

	First Term	Second Term
MS341		
Organization, Mission and Function of the Ordnance Department	3 — 3	.. ..
History of Development of Ordnance	2 — 2	.. ..
Light Artillery Material	10 — 10	.. ..
MS342		
Heavy Artillery Material	.. ..	15 — 15
	15 — 15	15 — 15

All instruction for this unit during the fourth year is given by Institute personnel.

Mechanical Engineering — Course II

Third Year

Regular schedule with the following changes:

Add:

	First Term	Second Term
Military Science MS341, MS342	15 — 15	15 — 15

Fourth Year

	First Term	Second Term
Dynamics of Machines 2.251	30 — 60	.. ..
Electrical Engineering Laboratory 6.89	30 — 30	.. ..
Engineering Laboratory 2.601, 2.603	60 — 60	30 — 30
Heat Engineering 2.43	30 — 60	.. ..
Heat Treatment 2.856	.. ..	60 — 0
Hydraulics 1.64	45 — 90	.. ..
Industrial Plants 2.781	.. ..	45 — 45
Machine Design 2.71	90 — 0	.. ..
Mechanics of Engineering 2.26	.. ..	45 — 90
Ordnance Engineering 2.88	.. ..	75 — 45
Power Plant Design 2.58	.. ..	60 — 0
Production Methods 2.98	.. ..	15 — 15
Testing Materials Laboratory 2.35	60 — 30	.. ..
Thesis	.. ..	105
General Study	30 — 30	30 — 30
	375—360 735	720

Options 1, 2, 3, and 4

Applicants from these options will be admitted to the Coast Artillery Unit subject to the approval of their schedule by the Military Department and the Head of the Mechanical Engineering Department.

Metallurgy — Course III. Option 2

Third Year

Regular schedule with the following changes:

Add:

	First Term	Second Term
Military Science MS341, MS342	15 — 15	15 — 15

Fourth Year

Same as regular schedule.

ORDNANCE UNIT — *Continued*

Chemical Engineering — Course X

Third Year

	First Term	Second Term
Regular schedule with the following changes:		
Add:		
Military Science MS341, MS342	15 — 15	15 — 15

Students planning to take Course X-B must take G3 as a general study in the second term.

Fourth Year

	First Term	Second Term
Calculus, Applications of, M41	45 — 90	.. ..
Chemical Engineering 10·311, 10·321	75 — 75	60 — 60
Electrical Engineering Laboratory 6·85	.. ..	30 — 45
Electrical Engineering, Elements of, 6·40	60 — 90	.. ..
Engineering Laboratory 2·62	60 — 30	.. ..
Industrial Chemical Laboratory 10·26	105 — 30	.. ..
Industrial Chemistry 10·214	30 — 30	.. ..
*Optional Studies	.. ..	90
Powder and Explosives 5·57	.. ..	30 — 30
Testing Materials Laboratory 2·37	.. ..	20 — 10
Thesis Reports 10·15	.. ..	15 — 0
Thesis	.. ..	270
General Study G98, G3	30 — 30	30 — 30
	405—375 780	720

Optional studies may be not less than 60 or more than 120 hours.

Students admitted to Course X-A must take Analytical Chemistry 5·16 (60—15) in the second term of the fourth year as an optional study.

Chemical Engineering Practice — Course X-B

Fourth Year

	First Term	Second Term
Calculus, Applications of, M41	36 — 72	.. ..
Chemical Engineering 10·331, 10·341	72—168	30 — 60
Electrical Engineering, Elements of, 6·41	48 — 72	.. ..
*General Study, G98	24 — 24	.. ..
Industrial Chemistry 10·224	24 — 24	.. ..
School of Chemical Engineering Practice 10·84, 10·85, 10·86 and Thesis	.. ..	1010
	564	1100

Engineering Administration — Course XV. Option 2

Third Year

	First Term	Second Term
Regular schedule with the following changes:		
Add:		
Military Science, MS341, MS342	15 — 15	15 — 15
General Study G3	.. ..	30 — 30

Fourth Year

	First Term	Second Term
Regular schedule with the following changes:		
Omit:		
Thesis	.. ..	105 — 0
Machine Design 2.722	.. ..	60 — 0
Add:		
Thesis	.. ..	90 — 0
Ordnance Engineering 2·88	.. ..	90 — 30
General Study G98	30 — 30	.. ..

AIR CORPS UNIT NO. 5

Open to students in all courses in the Institute except Course V, provided that only those applicants who have passed the required physical examination or whose apparent physical condition is such as to indicate that they will pass this examination will be accepted for enrollment.

All members of the Unit are required to take MS35, G98, and G3, prior to graduation. For other requirements see the schedules for individual courses.

MS35	First Term	Second Term
Airplane Engines	.. ..	15 — 15
Observation Aviation	.. ..	15 — 15
Aerial Photography	.. ..	15 — 15
		45 — 45

Civil Engineering — Course I. All Options

Third Year

Regular schedule with the following change:

Add:

Military Science MS35	.. ..	45 — 45

Fourth Year

Regular schedule.

Mechanical Engineering — Course II

Except students who have definitely determined to take the Automotive option (Option 1).

Third Year

Regular schedule with the following changes:

Add:

Airplane Design, 16·015	45 — 45	.. ..
Military Science MS35	.. ..	45 — 45

Fourth Year

Regular schedule with the following changes:

Add:

Aeronautics, 16·785	45 — 45	.. ..
Aeronautics, 16·115	.. ..	45 — 45

Mechanical Engineering — Course II. Option 1

Third Year

Regular schedule with the following changes:

Add:

Military Science, MS35	.. ..	45 — 45

Students in this section must take Aero Engines, 16·82 prior to attending summer camp.

Fourth Year

Regular Schedule

Course III, IV, IV-A, VI, VI-A (1 and 2), VII, IX, X, XI, XII, XIII, XV, XVI, XVII

Third Year

Regular schedule with the following changes:

Add:

Airplane Design, 16·015	45 — 45	.. ..
Military Science, MS35	.. ..	45 — 45

Fourth Year

Regular schedule with the following changes:

Add:

Aeronautics, 16·785	45 — 45	.. ..
Aeronautics, 16·115	.. ..	45 — 45

Course VI-A (Option 3, Communications)

Third Year

Regular schedule with the following change:

Students of these courses must have completed Military Science, MS35, prior to attending summer camp.

Fourth Year

Regular schedule.

Course VI-C Electrical Engineering (Communications Option)

Third Year

	First Term	Second Term
Regular schedule with the following change:		
Add:		
Military Science MS35	.. ..	45 — 45

Fourth Year

Regular schedule

Course VIII

Third Year

	First Term	Second Term
Regular schedule with the following change:		
Add:		
Military Science MS35	.. ..	45 — 45

Fourth Year

Regular schedule.

Course XIV

Third Year

	First Term	Second Term
Regular schedule with the following changes:		
Add:		
Military Science MS35	.. ..	45 — 45
Photographic Laboratory 8·151	.. ..	45 — 15
Photography 8·15	30 — 15	.. ..
Omit:		
General Study	.. ..	30 — 30

Fourth Year

	First Term	Second Term
Regular schedule with the following change:		
Add:		
General Study	.. ..	30 — 30

Course XVI

Third Year

	First Term	Second Term
Regular schedule with the following changes:		
Add:		
Military Science MS35	.. ..	45 — 45
Omit:		
Airplane Rigging 16·51	.. ..	60

Fourth Year

Regular Schedule.

CHEMICAL WARFARE UNIT No. 6

Open to students in Course V, X, XIV, XV₁.	First Term	Second Term
MS362 Organization and Duties of C.W.S. Personnel and Materiel	.. ..	45 — 45

Chemistry — Course V

Third Year

Chemical Literature 5·191	30 — 45	.. ..
Chemical Principles 5·651, 5·652	75 — 90	75 — 90
Gas Analysis 5·31	25 — 5	.. ..
Industrial Applications of Quantitative Analysis 5·14	45 — 45	.. ..
Industrial Chemistry 10·202	.. ..	75 — 75
Military Science MS362	.. ..	45 — 45
Organic Chemistry I, 5·511, 5·521	60 — 45	60 — 30
Organic Chemical Laboratory 5·611, 5·621	135 — 0	135 — 0
Political Economy Ec31, Ec32	45 — 45	45 — 45
Special Methods 5·40	30 — 15	.. ..
Study of War Gases 5·33	.. ..	15 — 15
	445—290	450—300
	735	750

Fourth Year

All instruction in this year given by Institute personnel.

Chemical Library Technique 5·192	15 — 15	.. ..
Chemical Principles 5·66	45 — 60	.. ..
History of Chemistry 5·93	.. ..	30 — 30
Industrial Chemistry 10·213	45 — 45	.. ..
Inorganic Chemistry 5·06	.. ..	45 — 45
Metallography 3·611	60 — 15	.. ..
Powder and Explosives 5·57	.. ..	30 — 30
Radiation Chemistry 5·79	.. ..	30 45
Surface and Colloid Chemistry 5·69	.. ..	30 — 15
Thesis Reports 5·96	.. ..	15 — 15
Thesis 5·95	255	315
General Study G98, G3	30 — 30	30 — 30
General Study	30 — 30	.. ..
Electives	.. ..	75
	675	810

Chemical Engineering — Course X

Third Year

Applied Mechanics 2·20	45 — 90	.. ..
Chemical Principles 5·651, 5·652	75 — 90	75 — 90
Heat Engineering 2·46, 2·47	60 — 105	30 — 45
Industrial Chemistry 10·203	.. ..	75 — 75
Military Science MS362	.. ..	45 — 45
Organic Chemistry 5·511, 5·521	60 — 45	60 — 30
Organic Chemical Laboratory 5·613, 5·623	90 — 0	60 — 0
Political Economy Ec31, Ec32	45 — 45	45 — 45
General Study G3	.. ..	30 — 30
	375—375	420+360
	750	780

Fourth Year

Calculus, Applications of M41	45 — 90	.. ..
Chemical Engineering 10·311, 10·321	75 — 75	60 — 60
Electrical Engineering, Elements of 6·40	60 — 90	.. ..
Electrical Engineering Laboratory 6·85	.. ..	30 — 45
Engineering Laborstory 2·62	60 — 30	.. ..
Industrial Chemical Laboratory 10·26	105 — 30	.. ..
Industrial Chemistry 10·214	30 — 30	.. ..
Powder and Explosives 5·57	.. ..	30 — 30
Testing Materials Laboratory 2·37	.. ..	20 — 10
Thesis Reports 10·15	.. ..	15 — 0
Thesis	.. ..	270
General Study G98	30 — 30	.. ..
Optional Studies	.. ..	150
	405—375	720
	780	

Time devoted to option must be not less than 120 nor more than 180 hours, time adjustment being made on the hours assigned to thesis.

Students planning to enter Course X-A will take Analytical Chemistry 5·16 (60—15) in the second term of the fourth year as an optional study.

CHEMICAL WARFARE UNIT — *Continued*

Chemical Engineering Practice — Course X-A

Students planning to enter Course X-A will take Analytical Chemistry, 5·16, (60—15) in the second term of the fourth year as an Optional Study.

Chemical Engineering Practice — Course X-B

Fourth Year

	First Term	Second Term
Calculus, Applications of M41	36 — 72	.. ..
Chemical Engineering 10·331, 10·341	72 — 168	30 — 60
Electrical Engineering, Elements of, 6·41	48 — 72	.. ..
General Study G98	24 — 24	.. ..
Industrial Chemistry 10·224	24 — 24	.. ..
School of Chemical Engineering Practice 10·84, 10·85, 10·86 and Thesis	.. ..	1010
	564	1100

Electrochemical Engineering — Course XIV

Third Year

Regular schedule with the following changes:

Add:

	First Term	Second Term
Military Science MS362	.. ..	45 — 45

Fourth Year

Students will elect as part of their Optional Studies, Study of War Gases, 15—15, and Chemistry of Powder and Explosives 5·57, second term 30—30.

Engineering Administration — Course XV. Option 3

Third Year

Regular schedule with the following changes:

	First Term	Second Term
Omit:		
Heat Engineering 2·44, 2·45	45 — 75	45 — 75
Add:		
Heat Engineering 2·46, 2·47	60 — 105	30 — 45
Military Science MS362	.. ..	45 — 45

Fourth Year

Regular schedule with the following changes:

	First Term	Second Term
Omit:		
Thesis	.. ..	120 — 0
Add:		
Thesis	.. ..	90 — 0
General Study G98, G3	30 — 30	30 — 30
Chemistry of Powder and Explosives 5·57	.. ..	30 — 30

DESCRIPTION OF SUBJECTS

CIVIL AND SANITARY ENGINEERING

The instruction in Civil and Sanitary Engineering is given by means of lectures and recitations, and by practice in the field, the drafting-room and the laboratory. The strictly professional work begins in the second year and includes a thorough classroom course in surveying, followed by field practice in the use of surveying instruments and by drafting-room work consisting of computations and the preparation and interpretation of maps and profiles. This work is preliminary to an extensive summer course in which thorough training is given in surveying and in railroad fieldwork. Students in civil engineering also take astronomy and a brief course in graphic statics during this year, while the sanitary engineers have extended courses in qualitative and quantitative analysis; students in both courses also begin applied mechanics during this year.

In the third year the chief professional subjects for the civil engineers are railway and highway engineering and the theory of structures; students in both courses also complete during this year their formal instruction in applied mechanics and in materials. The sanitary engineers continue chemistry and begin subjects of biology and bacteriology, while both the civil engineers and the sanitary engineers are given a course of considerable length in electrical engineering. Students taking the hydro-electric option take a slightly different course in the third year from the other civil engineering students. In the fourth year the work is almost entirely professional and leads the student into various branches of engineering. The work of this year is divided into three distinct options: (1), general, (2) transportation engineering, (3) hydro-electric engineering. Option 1 gives special attention to the application of the principles of hydraulics to branches of engineering which have to do with public water supplies, irrigation, sewage and its disposal, and the development of water power. Option 2 is divided into two parts, permitting the student to give special attention to either railway transportation or highway transportation. Option 3 deals in considerable detail with the problems that arise in hydro-electric developments.

In all this work the object is to enable the student to apply intelligently to practical problems the principles that he has studied; to give power, to avoid rule-of-thumb methods, and to train the students to have courage and self-reliance in solving the problems that the engineer has to meet.

Subjects 1·00 to 1·99 (see page 59)

1·00, 1·01. Surveying and Plotting. A thorough classroom drill in the principles of surveying accompanied by fieldwork, computations, and the making of scale drawings, profiles, and contour maps, followed by a study of their application to the solution of engineering problems. Textbook: *Breed and Hosmer's Principles and Practice of Surveying, Vol. I.*

1·02. Surveying and Plotting. Given in the summer between the second and third years, covers the same ground as 1·00 and 1·01 somewhat more briefly. Textbook: *Breed and Hosmer's Principles and Practice of Surveying, Vol. I.*

1·03. Surveying. The methods of using the compass, transit, tape, and level, in making plane surveys, are explained by lectures and by field exercises. In the drafting room the computations and drawings necessary to interpret and plot surveying field notes are made.

1·04. Surveying. At Camp Technology. Consists of 355 hours, lectures, recitations, fieldwork and drafting. The fieldwork consists of plane, topographic, hydrographic and elementary railway surveying. Plans and maps will be made in the drafting room from notes taken in the field.

This course satisfies the requirements in surveying for students in Courses II, IV-A, VI, IX-B and XV_2. It will not be accepted in place of the work in surveying for students in Courses I, XI and XV_1.

It will not be given unless eight or more students apply, and is open to all students having the necessary preparation. Textbook: *Breed and Hosmer's Principles and Practice of Surveying, Vols. I and II.*

1·05. Plane Surveying. At Camp Technology. Given in the summer between the second and third years; it consists of lectures, fieldwork, and drafting. The fieldwork consists in making surveys with the transit and tape, the running of profiles and cross-sectioning with the level, and in the astronomical determination of a meridian time and latitude. The work in the drafting-room consists of making computations which arise in surveying operations and of making scale drawings, profiles and contour maps from field notes. Textbook: *Breed and Hosmer's Principles and Practice of Surveying, Vol. I*; *Hosmer's Practical Astronomy.*

1·06. Geodetic and Topographic Surveying. At Camp Technology. Given in the summer between the second and third years; it consists of lectures, fieldwork, computations and drafting. The fieldwork consists of th' making of topographic surveys with the transit including triangulation and stadia surveying; the making of large and small scale maps with the plane table; the use of the sextant in hydrographic surveys; the use of the traverse plane table in making road traverses for small scale maps. It also includes trigonometric and barometric leveling. The work in the drafting room consists of making the computations and drawings necessary to interpret the results of the field observations. Textbook: *Breed and Hosmer's Principles and Practice of Surveying, Vol. II.*

1·07. Geodetic Surveying. At Camp Technology. Given in the summer between third and fourth years; it covers three weeks of field and office work and consists of the measurement of a base line; triangulation with repeating and with direction instrument; precise and trigonometric leveling; observations for time, latitude and longitude with astronomical transit; and magnetic observations for declination, dip and intensity. Students will also be required to calibrate instruments and to determine constants. (Elective for a limited number of students in Course I who have satisfactorily completed the third year.)

1·09. Surveying. Consists of 200 hours lectures, recitations, fieldwork and drafting. The work is limited to plane surveying, and is planned especially to meet the requirements of the Course in Building Construction. Textbook: *Breed and Hosmer's, Principles and Practice of Surveying, Vol. I.*

1·10. Surveying. At Summer Mining Camp, Dover, New Jersey. Given during the summer between the second and third years. It consists of 360 hours, lectures, recitations, fieldwork and drafting.

The fieldwork consists of plane, topographic, magnetic dip-needle and mine surveying. In the drafting room, plans and maps, both surface and underground, are made from the notes taken in the field. The class work consists of discussions of surveying methods and is supplemented by numerous problems. Textbook: *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. The class work in 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. Textbook: *Hosmer's Practical Astronomy.*

1·13. Geodesy. The methods of conducting a geodetic survey are discussed in detail, and the theory of the figure of the earth and the methods of determining it, both by arc measurements and by gravity observations, are briefly considered. Textbook: *Hosmer's Geodesy.*

1·14. Advanced Geodesy. Includes methods of developing the higher formulas for computing geodetic postions; the theories of potential and of the earth's figure; the application of least squares to geodetic surveys; and the theories of astronomical, magnetic and gravity observations. Textbook: *Jordan's Handbuch der Vermessungkunde* and *Clark's Geodesy.*

1·15. Navigation. Such theory and practice of navigation as is required for examination for officers' licenses, and includes (1) use of compass, log and chart, (2) piloting, (3) dead-reckoning, (4) Mercator and Great-circle sailing, (5) observations for latitude, longitude and azimuth, and (6) Sumner's Method. Practice is given in adjusting the compass for error of deviation and in making the sextant observations. Textbook: *Bowditch's Navigator.*

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.

1·20. Railway Fieldwork. Given at Camp Technology in the summer between the second and third years; it consists of classroom and fieldwork. A survey is made for a railroad about two miles in length. A reconnaissance is first made, followed by a preliminary survey including the necessary topography to permit of determining the position of the location line; the location line is then staked out. There is also a systematic drill in the laying out of curves by various methods, including the A. R. E. A. spirals, and in setting slope stakes for grading. Sufficient class work of an elementary character is given at the Camp to supplement the fieldwork. Textbooks: *Allen's Railroad Curves and Earthwork; Allen's Field and Office Tables.*

1·21, 1·211, 1·22. Railway and Highway Engineering. A thorough study of curves and earthwork. The first term is devoted to the mathematics of curves with applications to the location of railways and highways, and to the layout of tracks and pavements. The second term is devoted principally to the methods of staking out and computing earthwork and masonry. Recitation work predominates, particularly in the first term, and many problems are assigned for solution outside and in the classroom. The applications of this subject are further developed by subjects 1·23, 1·24. So much of this subject as relates specifically to railways is omitted by students in Courses I_1 and XI. Textbooks: *Allen's Railroad Curves and Earthwork; Allen's Field and Office Tables.*

1·23, 1·24. Railway Drafting. Consists of two parts: (*a*) The making of a plan and a profile from the notes of a railway location survey made at Camp Technology; (*b*) the application of the theory of curves and earthwork developed in 1·21 and 1·22 to the solution of problems in hydraulic, railway or highway construction.

1·25. Engineering Construction and Estimates. Deals primarily with the construction of railways, highways, dams, and similar projects. The subjects covered are engineering organization and duties, construction methods, estimates of quantities and costs, contracts and specifications. Some consideration is given to the methods of financing engineering projects. Some of the details considered are the acquisition of land, clearing the site, earth handling, culverts, abutments and retaining walls. The methods of laying out and carrying on construction work and of making estimates are illustrated by studies of typical projects.

1·26, 1·27. Railway Engineering. The subjects treated include: maintenance of way and structures; yards and stations; interlocking and block signals; rolling stock, including tractive effort of locomotives, the economics of railway engineering, with a critical study of train resistance, tonnage rating and the influence of grade, distance, curvature and rise and fall on operating costs; I. C. C. accounting, valuation, and public regulation. The object is to give the student a comprehensive knowledge of railway engineering and a general knowledge of railway accounting and operating. The solution of problems on signals, tractive effort, economics and railway accounting is required. Textbooks: *Tratman's Railway Track and Maintenance; Neostyled Notes on Railway Signaling and on Economics of Railway Engineering.*

1·28. Railway Design. Drafting room course, including problems in railway location on United States geological maps; the proportioning of culverts and waterways; the complete computation and detailed design of a division yard, including a locomotive terminal; and other practical railway problems involving the application of the principles taught in subjects 1·21, 1·22, 1·26 and 1·27.

1·301, 1·302. Advanced Railway Engineering. A continuation of the undergraduate courses in railway engineering, 1·26, 1·27. Special attention is given to the design and operation of freight and passenger yards and terminals; locomotive terminals; coal handling plants; electrification; electric railways; interrelation of highway and railway transportation; use of motor transport by railways. The principles of railway accounting, rates and public regulation and control are thoroughly discussed. Students make individual investigations and reports upon problems involving railway operation and economics. Will not be given unless a sufficient number of adequately prepared students apply. Textbooks: *Droege's Passenger Terminals and Trains, Droege's Freight Terminals and Trains; Reports of the American Railway Engineering Association, and various other reports and periodicals.*

1·311, 1·312. Advanced Railway Design. A continuation of 1·28 and closely correlated with 1·301 and 1·302. Includes the design of freight, passenger and locomotive terminals; a study of problems arising in grade crossing eliminations, and in the handling of traffic during construction, and a consideration of the methods of making cost estimates. Will not be given unless a sufficient number of adequately prepared students apply.

1·35. Roads and Pavements. An outline of the principles governing the location, construction and maintenance of roads, and the construction and maintenance of pavements for city streets. Textbook: *Agg's Construction of Roads and Pavements.*

1·36. Testing Highway Materials. Physical tests of various kinds of road materials and discussion of their value in highway construction.

1·37. Highway Transportation. Discussion, recitations and problems on relation of highway and railway transportation, highway legislation, traffic surveys, layout and construction of roads, types of motor vehicles, loads, pavements and grade resistances, economics of motor transport and economics of highway location. Textbook: *Neostyled Notes on Highway Transportation.*

1·38. Highway Design. A design for an improvement of an existing road by substitution of improved alignment, grades and new pavement suitable for assumed traffic.

1·39. Graphic Statics. Graphic methods of solution of problems dealing with forces and reactions, curves of bending moment and shear and stresses in simple trussed structures. Textbook: *Hudson and Squire, Elements of Graphic Statics.*

1·40. Theory of Structures. An introductory course 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 of plate girders. Textbook: *Spofford's Theory of Structures.*

1·401. Structures. Adapted to the needs of Students in Aeronautical Engineering.

1·41, 1·42. Theory of Structures. An extended course, in continuation of 1·40. It treats of the computation and design of structures of wood, steel and masonry, by analytical and by graphic methods. The subjects considered in the first term are roof and bridge trusses of various forms. In the second term the subjects treated are earth pressure; retaining walls; masonry dams; arches of metal, stone and concrete; and the theory of reinforced concrete design. The object is to train the student thoroughly in the application of the principles of mechanics to the design of the more common engineering structures. Textbook: *Spofford's Theory of Structures.*

1·421. Theory of Structures. A continuation of 1·41 intended for students in the hydro-electric option of Course I, and also for students in Courses XI and XV. The subjects included are: the theory of reinforced concrete, earth pressures, deflection of trusses and theory of least work. Textbook: *Spofford's Theory of Structures.*

1·422. Theory of Structures. A continuation of 1·41 intended for students in architectural engineering and building construction. The subjects covered are deflection of trusses, the method of least work as applied to the determination of stresses in statically indeterminate structures, and stresses in space frameworks and high building frameworks. Textbook: *Spofford's Theory of Structures.*

1·43. Materials. Designed to acquaint the student with the properties of the various structural materials used by the engineer, such as stone, brick, cement, concrete, wood, iron and steel. Textbook: *Mills' Materials of Construction. Third edition.*

1·44. Stationary Structures. A short course for students in mining engineering, designed to give them a knowledge of the fundamentals of the theory of structures. Textbook: *Spofford's Theory of Structures.*

1·45. 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 computing and designing structures. The subject matter includes the use of influence lines and the computation of stresses in simple trusses, portals, rigid frames, trusses with redundant members, and space frameworks. Textbook: *Spofford's Theory of Structures.*

1·46, 1·461. Structural Design. Designing and partial detailing of simple structures such as columns, roof trusses, footings, etc. Intended to illustrate and amplify the work of 1·45 by practical design problems.

1·48. Foundations. A study of the methods of constructing foundations for bridges, buildings and other structures. Textbook: *Hool and Kinne's Foundations, Abutments and Footings.*

1·481. Foundations and Soil Mechanics. The subject is divided as follows: (a) Physics and mechanics of the subsoil; soil classification based on geological and on physical characteristics; subsoil investigation by test pits and test borings; application of Mohr's diagram to bearing capacity problems; effect of loaded area and of depth of foundation on settlement; loading tests. (b) Principles of design and of construction of foundations; allowable soil pressures; municipal building codes; spread footings and simple raft foundation shallow foundations on ground with unequal resistance; concrete and timber piles; pile driving; static and dynamic pile resistance; pile formulae; bearing capacity on groups of piles; pile foundations; timbering in deep, open pits; open caissons, Gow cylinder and Chicago shaft method; compressed air foundations; hydrostatic upward pressure on cellar floors; waterproofing; cofferdams and pumping; excavation and drainage in fine sands. (c) Special foundation problems; foundations of tall buildings, shoring and underpinning; pre-test system; bridge piers and abutments; weir foundations on permeable ground; dam foundations on compact and on fissured rock; grouting; legal aspects of foundation engineering. Textbook: *Hool and Kinne's Foundations, Abutments and Footings, also Papers by Dr. Terzaghi.*

1·491, 1·492. Soil Mechanics. Covers the whole field of recent scientific investigations relating to earthwork engineering. The course is divided into two parts, the first dealing with the physical factors involved in earth pressure phenomena, which includes a study of all those physical properties of the soils which are of practical importance in connection with engineering operations, such as fluidity, plasticity, cohesion, internal friction, nature and effect of the colloidal content, permeability, movement of capillary water, hydro-static stress phenomena and elasticity, including a discussion of the physical causes of these properties. The second portion of the course will be devoted to a thorough and critical study of the various soil phenomena which are known to occur in connection with earthwork operations and foundation work. This study is based on the results of modern soil research and includes the following topics: the relation between settlement and the bearing area of buildings, the interpretation of loading tests, a consideration of floating foundations extending over both uniformly compressible and unequally compressible ground, settlement due to local drainage of the ground, dynamic and static pile driving resistance, the effect of time on pile driving resistance, settlement of pile groups, hydro-dynamic stress in silt and mud deposits and their effect on the bearing capacity of the ground, quicksand phenomena, mechanics of landslides, stress conditions in hydraulic fill dams and weir foundations on permeable ground with particular attention to the piping effect of the seepage water.

1·501, 1·502. Bridge Design. Shows the relations of the theory of structures to engineering practice through the preparation of designs and drawings for a plate girder railway bridge, a wooden roof truss, several reinforced concrete structures and a riveted steel truss highway bridge. Emphasis is laid on the development of careful, systematic and practical habits of computation.

1·511, 1·512. Structural Design. Abridged from 1·501, 1·502 and especially adapted to the needs of students in I$_1$.

1·52. Structural Design. A drafting room subject similar in character to 1·501, 1·502, giving only an outline of the subject.

1·53. Structural Design. A drafting room subject similar in character to 1·501, 1·502, giving only an outline of the subject.

1·55. Structural Design (Advanced). Supplements Advanced Structures and illustrates the applications of the principles there studied. Much of the allotted time is devoted to the determination of stresses in suspension bridges and in arch bridges of both the hinged and no hinged type.

1·561, 1·562. Advanced Structures. Includes an exhaustive treatment of fundamental principles used in the investigation and design of complicated structures of a statically indeterminate type, such as suspension bridges, arches, framed domes and frameworks of high buildings. Various methods of determining the deflections of such structures are considered, and the applications of deflections to the determination of stress. The method of least work is considered at length and illustrated by its application to numerous structures. The slope deflection method is also considered. In general, the effort is made to give a sound fundamental training in underlying principles to the end that the student will be prepared to deal with the numerous types of complicated structures which are likely to occur in modern practice. Textbook: *Mimeographed Notes, prepared by Professor Spofford; Textbooks by Various American and German Authors; Monographs and Professional Papers.*

1·57. Secondary Stresses. Within the last ten years the importance of secondary stresses in bridges and similar structures resulting from distortion has become widely recognized and during this period engineering periodicals have contained descriptions of a large number of modern bridges in which the secondary stresses have been computed. In this subject, the student investigates the various sources of secondary stresses, computes the secondary stresses in a number of trusses, and studies various methods of design for controlling secondary stresses and preventing their becoming of large magnitude. Textbook: *Johnson, Bryan and Turneaure's Modern Framed Structures, Part II.*

1·581, 1·582. Reinforced Concrete Design. A consideration of the theoretical and practical principles involved in the design of structures of reinforced concrete. In the first term a study is made of the rules and methods of design commonly used in this country together with the reasons for their adoption. Parallel with this work, a complete design is made of an interior bay of a typical factory building. In the second term the following topics are taken up: (*a*) an investigation of bending moments in reinforced concrete structures by exact methods, such as those of least work, slope deflections, etc.; (*b*) the design of chimneys, tanks, tunnels, and similar structures.

1·60. Hydrographic Surveying. Given at Camp Technology in the summer between the second and third years; it consists of lectures, fieldwork, computations and drafting. (*a*) Stream gagings. Designed to instruct the student in the principles underlying the art of measuring the flow of water in open channels. The equipment of the Camp includes a complete gaging station on a nearby stream where each student is instructed in the use of various types of current meters, and the rate of flow of the stream computed. In the drafting room a portion of the data thus secured is plotted. (*b*) Soundings. On Gardner's Lake, the student is instructed in the method of making soundings and practices the use of the sextant and the transit in locating them. Textbook: *Liddell's Stream Gaging.*

1·62. Hydraulics. A thorough study of the elementary principles of Hydrostatics and Hydrokinetics, 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. All portions of the subject covered in 1·63 are included. Textbook: *Russell's Hydraulics.*

1·63. Hydraulics. Comprises the essentials of 1·62 but the subject of flow in open channels is abbreviated.

1·64. Hydraulics. Comprises the elements of hydraulics followed by a study of the theory and practical selection of hydraulic turbines, and certain of the more important problems relating to hydro-electric developments.

1·66. Hydraulics (Advanced). Offered for students in the graduate year who are desirous of pursuing further their studies in theoretical and applied hydraulics. The subjects treated relate in a general way to problems arising in water-supply and water-power engineering, and subjects which are only fundamentally treated in 1·62 are further elaborated and discussed. An important feature of the subject is the study of the relations existing between the performances of models and their originals, involving the discussion of the laws of hydraulic similitude. The outside preparation includes a certain amount of reference study in addition to the usual problems and the writing of reports.

1·70. Water Power Engineering. This subject and 1·71 is intended to acquaint the student with the various general problems involved in the location, design and construction of hydro-electric developments and to provide a suitable foundation for practice in this field or for the more detailed and advanced studies of the graduate year. The subjects studied follow the order of investigations as usually made for water power projects. They include a thorough study of hydrology — precipitation, run-off, water losses and their relations; methods of analyzing, and using stream flow data as a basis for estimates of water power; flood flow and spillway capacity and the effect of storage and pondage, followed by a study of the theory and practice applicable to the selection of hydraulic turbines for the plant, as well as general plant arrangement. Textbook: *Barrows' Water Power Engineering.*

1·71. Water Power Engineering. Continuing from 1·70 the elements of design of the main features of a hydro-electric development — the dam, waterway and power house are studied. The work of this term is also accompanied by drafting room exercises, consisting of computations, reports and problems of design. Textbook: *Barrows' Water Power Engineering.*

1·731, 1·732. Advanced Water Power Engineering. This and Water Power Design 1·851, 1·852 are based upon the undergraduate courses in Water Power Engineering 1·70, 1·71. These two graduate courses, which are supplementary to each other, have for their special object the study of some water power site and the design of its principal features. An actual power site is used for which survey data and other necessary information are available. The following representative topics illustrate the scope of these courses: (*a*) hydrograph (or mass curve) study of the storage effect; (*b*) plant capacity and output; (*c*) plant lay-out, including canal penstock and power house location and arrangement; (*d*) power house design; (*e*) surge tank and penstock design; (*f*) head gatehouse and gate design; (*g*) valuation of water power privilege. In the classroom attention is also given to other general problems of power development and the theory and practice upon which their solution is based. Numerous references and reports upon special features of plants and their accessories are also considered. A field trip of several days duration is taken early in the course during which several modern and representative power developments are examined in detail. A test of a hydraulic turbine is usually made at the Holyoke testing flume at this time. Reports based upon the information thus gathered are required and form a basis for discussion and assistance in the problems of design given later in the year. Textbook: *Barrow's Water Power Engineering.*

1·75. Hydraulic and Sanitary Engineering. Includes investigations of problems of sewerage and sewage disposal, theories of sewage treatment and design of disposal plants and other sewage works, plumbing systems, etc., together with the relationship of sanitation to the public health. The latter part of the course deals with the engineering problems of irrigation and land drainage. Textbooks: *Metcalf and Eddy's Sewerage and Sewage Disposal, a Textbook*; *Etcheverry's Irrigation Practice and Engineering, Vol. I.*

1·76. Hydraulic and Sanitary Engineering. Deals with the principles and practice of securing adequate public water supplies and the purification of same. Includes hydrographic studies of rainfall and runoff, evaporation, methods of determining required storage for given demands, and the principles of design of earth and masonry dams, distributing systems and purification plants. The principles of design and testing of hydraulic turbines also given during the last four weeks of the course. Textbooks: *Turneaure and Russell's Public Water Supplies; Daugherty's Hydraulic Turbines.*

1·77. Sanitary Engineering. Deals with (*a*) the relationship of bacteriology to sanitation; (*b*) the theory and design of sewer systems, sewage disposal plants and storm water drains; (*c*) methods of disposal of garbage and of industrial wastes; (*d*) the design of plumbing systems for buildings; (*e*) the relationship of sanitation and drainage to the public health. Textbook: *Metcalf and Eddy's Sewerage and Sewage Disposal, a Textbook.*

1·78. Sanitary Engineering. Deals with the problems of securing adequate public water supplies together with the theories and design of water purification works. Includes rainfall and runoff studies, evaporation, stream yield, computation of required storage, design of distributing systems, earth and masonry dams, filtration plants, and the making of sanitary surveys, studies of vital statistics and the prediction of changes in population. Textbook: *Turneaure and Russell's Public Water Supplies.*

1·79. Hydraulic and Sanitary Design. Deals with the design and preparation of plans, maps and profiles for a system of sanitary sewers for a selected area and given conditions and of a storm water drainage system for a similar area.

1·80. Sanitary Design. Includes the layout and design of a system of sanitary sewers for a given area, a system of storm sewers for a similar area and the design of special structures used by the sanitary engineer.

1·811. Advanced Sanitary Engineering. Deals with the most recent developments in the methods of disposal of sewage and municipal refuse. No textbook is used but the student is required to consult the monographs, reports and engineering periodicals and prepare abstracts covering research in connection with (*a*) the activated sludge method of sewage disposal; (*b*) colloidal chemistry and sewage treatment; (*c*) sludge — its nature, treatment and uses; (*d*) filtration and special problems connected with operation of sewage filters; (*e*) hydrogen-ion adjustment and its effect upon sewage treatment; (*f*) acidification of sewage; (*g*) disinfection of certain trade wastes; (*h*) treatment of special trade wastes; (*i*) improved methods of garbage disposal; (*j*) elimination of odors; (*k*) other phases of sanitary engineering which are more complex and specific than can be included in a general course for undergraduates.

1·812. Advanced Sanitary Engineering. A study of the recent progress in problems connected with water supplies and their purification including (*a*) principles of design of dams of previous materials; (*b*) principles of design of hydraulic fill dams; (*c*) special spillway considerations; (*d*) recent flood flow studies; (*e*) operating experience of purification plants; (*f*) recent water-borne epidemics of intestinal diseases; (*g*) studies of factors influencing coagulation; (*h*) hydrogen-ion adjustment; (*i*) special problems in treating water for industrial uses; (*j*) treatment of soft, colored waters; (*k*) friction losses in sand; (*l*) flow of underground waters; (*m*) design of lay-out as affecting fire insurance rates, etc.

1·851, 1·852. Advanced Water Power Design. For description see Advanced Water Power Engineering 1·731, 1·732.

1.881, 1·882. Advanced Sanitary Design. Carried on in parallel with Advanced Sanitary Engineering 1·811 and 1·812 and affords an opportunity of applying the theoretical factors studied in these subjects to special problems in connection with the design of plan for the disposal of sewage and the purification of water. Inspection trips to plants in various parts of the State are made at frequent intervals and the effect of special design features upon efficiency and economy of operation are studied under actual operating conditions.

MECHANICAL ENGINEERING

Many of the subjects taught by the Mechanical Engineering Department are fundamentals in nearly all of the different branches of engineering; consequently instruction is given not only to students in Mechanical Engineering, but also to those taking Civil, Sanitary and Municipal, Electrical, Chemical, Electrochemical, Architectural and Mining Engineering, and Naval Architecture and Marine Engineering.

The course in Mechanical Engineering aims first to give the student a thorough training in the fundamentals of physics, mathematics, and applied mechanics; then, by means of lectures, laboratory work and drawing room work in his different professional subjects, to familiarize him with the various problems with which the mechanical engineer has to deal. He is also given training in the mechanic arts sufficient to make him familiar with the use of shop tools, foundry practice, pattern work and forging, such knowledge being essential to the successful designer of machinery.

A considerable portion of time is devoted to non-professional work in English, history, economics and allied subjects.

The work in mechanism, supplemented by a course in mechanical engineering drawing, includes the study of linkages, cams, gear teeth and valve gears of steam engines; followed by a more advanced course on the mechanisms of machine tool and automatic machinery.

The instruction in applied mechanics in the second and third years covers the fundamental principles of statics, kinetics, strength of materials and the theory of elasticity; particular attention being given to the solution of problems illustrating the application of these principles in engineering practice. A series of lectures on engineering materials makes the student familiar with the important physical properties of the materials used in engineering and with the effects on these properties of impurities and of manufacturing defects. Consideration is given the relationship existing between constitution and microstructure of metals and the effect of heat treatment, cold working, etc., upon the physical properties. This is followed by laboratory work where tests are made to determine the quality of materials and to obtain data for use in design.

The student is taught how to carry out the usual routine tests required for any material and to appreciate the significance of specifications. Modern methods for the examination of materials by photoelasticity, X-Ray and by macroscopic analyses are taken up. In the heat treatment laboratory a study is made of the changes which the common properties of metals undergo when subjected to heat treatment and a student is taught how to determine the proper treatment to bring out any property desired.

The course in heat engineering covers thermodynamics, steam engines, turbines, boilers, gas engines, gas producers, heat transmission, refrigeration and power station accessories. A course in Physical Chemistry designed to familiarize a student with the subject of molecular structure is given simultaneously with the course in heat engineering.

A thorough course in theoretical hydraulics is followed by a course in hydraulic engineering in which both the estimation and utilization of hydraulic power are discussed. The courses in heat engineering and hydraulics are supplemented by engineering laboratory work extending through the latter half of the third year and through two terms of the fourth year. The work is planned to follow the classroom work and thereby assist the student in getting a better grasp of the subjects taught. The laboratories are equipped to provide for an extended series of experiments on steam and its properties, steam engines, turbines, compressed air, gas and oil engines, gas producers, refrigerating machinery, hydraulics, pumps, water wheels and turbines, devices for the mechanical transmission of power, transmission and absorption dynamometers. The main power plant of the Institute is available for complete power plant tests.

The instruction in mechanic arts aims to give a systematic training in the typical operations to be performed with the different tools and appliances used in the foundry, in the forge shop, in the machine shop and in wood working. The student is taught how to sharpen and to adjust all edge tools used, also the proper speeds, cutting angles and feeds for the various materials worked. In order to make a student familiar in as short a time as possible with the different operations and with the different methods used in any branch of the work, every problem given him is so chosen as to bring in each time one or more new operations.

The instruction is mainly by lecture, each new operation being described and discussed just before the work is to be undertaken; notes and textbooks are also used. Supplementary illustrated lectures are given in connection with many of the courses descriptive of industrial appliances and methods of production used in large establishments.

The professional work of the fourth year includes courses in machine design, power plant design, refrigeration, internal combustion engines; the design and equipment of a manufacturing plant including a study of structural details and heating and ventilating equipment and problems in financing and the management of such an establishment; courses in dynamics of machinery and mechanics of engineering which involve the application of the principles of mechanics in more advanced engineering problems.

At the beginning of the second term of the fourth year, a student has to decide whether to take the general course with choice of a professional elective, or to take one of the four options offered.

These options — 1, Automotive; 2, Engine Design; 3, Textile Engineering; 4, Refrigeration, Ordnance Engineering — differ from the general course in that the time alloted to electives has been definitely assigned to the main subject of the option. The time allotted in the second term to the design of an industrial plant has also been assigned to the main subject of the options.

Subjects 2·00 to 2·99 (see page 59).

2·00. Mechanism. A study of the forms and motions of various mechanisms occurring in machines, independently of their strength, such as rolling cylinders and cones, belting, screws, cams, linkages, wheel trains and the design of gear teeth. Textbook: *Elements of Mechanism, Schwamb, Merrill and James.*

2·01. Mechanism. Abridgment of 2·00. Textbook: *Elements of Mechanism, Schwamb, Merrill and James.*

2·011. Mechanism. Abridgment of 2·00. Textbook: *Elements of Mechanism, Schwamb, Merrill and James.*

2·02. Mechanism. Abridgment of 2·01. Textbook: *Elements of Mechanism, Schwamb, Merrill and James.*

2·03. Mechanisms. A course combining the theory of mechanisms with their practical applications, including wrapping connectors, linkwork, gearing, cams, screws, etc. Suitable materials with their properties, forms and proportions of parts, efficiencies, friction, etc., are discussed. Complete calculations for the design of a punch and shear are made, together with sufficient drawing lay-out to show the design of the frame casting, and the relation of the parts.

2·04. Mechanical Engineering Equipment. A description of different types of steam engines, condensers, pumps, cooling towers and other power station accessories. Textbook: *Power Plant Machinery, Vol. II, James and Dole.*

2·05. Mechanism of Machines. Supplements the work in pure mechanism. The discussion is intended to familiarize the student with the practical applications of mechanical movements to various classes of machinery, such as machine tools, textile machinery, shoe machinery, etc. The practical advantages and disadvantages of the different mechanisms are taken up, together with such details as methods of reducing friction, providing for wear, etc. Problems assigned in the drawing room are intended to illustrate the principles of graphical analysis as applied to the solution of problems in valve gears and allied subjects. Several lectures on the principles involved in the construction of nomographic charts are included. Textbooks: *Graphical and Mechanical Computations Part I, Lipka; Notes and Lithographs, Mechanical Engineering Department.*

2·06. Mechanism of Machines. Includes the lectures of 2·05, omitting the graphical analysis drawing room assignments and nomographic charts.

2·07, 2·08. Automatic Machinery. Discussion of automatic machines used in production work, such as wire working machines, automatic screw machines, machine tools, etc.

2·09. Design of Automatic Machinery. A continuation of 2·850, involving a discussion of more complex mechanisms and the design of a full automatic machine.

2·10. Mechanical Engineering Drawing. Drafting-room exercises giving training in the solution of practical problems supplementary to the course in mechanism, such as problems in belting, the design of cams and gears, and the investigation by means of drafting board constructions, of velocities and accelerations of moving parts. Textbooks: *Working Drawings of Machinery, James and Mackenzie; Elements of Mechanism, Schwamb, Merrill and James.*

2·101. Mechanical Engineering Drawing. Abridgment of 2·10.

2·11. Mechanical Engineering Drawing. Abridgment of 2·10.

2·12. Mechanical Engineering and Machine Drawing. Includes parts of 2·10 and 2·13. Textbooks: *Working Drawings of Machinery, James and Mackenzie; Elements of Mechanism, Schwamb, Merrill and James.*

2·121. Mechanical Engineering and Machine Drawing. Abridgment of 2·12.

2·13. Machine Drawing. Lectures and drafting room exercises giving instruction and practice in detailing from actual machines or design layouts and preliminary sketches; also in making assembly drawings from blue print details of other machines. The student is thus given practice in making and reading working drawings and in building up a general drawing from details. Lectures are also given on processes for reproducing drawings, such as blue printing, zinc plate and wax plate engraving and half-tone work. Textbook: *Working Drawings of Machinery, James and Mackenzie.*

2·131. Machine Drawing. Abridgment of 2·13.

2·14. Machine Drawing. Drafting-room exercises devoted to making detail and assembly drawings. Textbook: *Working Drawings of Machinery, James and Mackenzie.*

2·15. Applied Mechanics (Statics and Kinetics). Resolution and composition of forces by analytical and graphical methods; the laws of equilibrium of force systems with their application in determining the reactions at the supports and the stresses in various types of frames; the analysis of distributed forces; determination of centers of gravity, moments and products of inertia and radii of gyration of plane areas and solids; principal axes and principal moments of inertia in two dimensions only; also a study of kinetics of solid bodies in plane motions, including the application of the principles of momentum and kinetic energy and the determination of work and power. Textbook: *Applied Mechanics, Vol. I, Fuller and Johnston.*

2·16. Applied Mechanics (Statics). Resolution and composition of forces by analytical and graphical methods; the laws of equilibrium of force systems with their application in determining the reactions at the supports and the stresses in various types of frames; the analysis of distributed forces; determination of centers of gravity, moments and products of inertia and radii of gyration of plane areas and solids; principal axes and principal moments of inertia in two dimensions only. Textbook: *Applied Mechanics, Vol. I, Fuller and Johnston.*

2·17. Applied Mechanics (Statics and Strength of Materials). An elementary course in statics and graphic statics, especially arranged for students in Course IV, including determination of center of gravity and moments of inertia of plane areas; Textbook: *Applied Mechanics, Vol. I, Fuller and Johnston.*

2·18. Applied Mechanics. (Strength of Materials and Graphic Statics.) An abbreviation of 2·20 especially arranged for the students in Course IV. Textbook: *Applied Mechanics, Vol. II,* Fuller and Johnston.

2·20. Applied Mechanics (Strength of Materials). Physical properties of materials; stresses and strains in bodies subjected to tension, compression and shear; the common theory of bending, including shearing forces, bending moments, distribution of normal and shearing stresses; equation of the elastic curve and the determination of slopes and deflections in beams; stresses due to combination of bending and axial loads; theories for determining the strength of columns; the torsion theory and the methods of obtaining the stresses and deformation in shafting and bars subjected to torsion. Textbook: *Applied Mechanics, Vol. II, Fuller and Johnston.*

2·21. Applied Mechanics. Theory of elasticity applied to cases involving plane stress or strain, including applications to shafting and bars subjected to combined bending and torsion, helical springs, cylinders and flat plates; analytical and graphical solutions of some more advanced problems in dynamics and strength of materials. Textbook: *Applied Mechanics, Vols. I and II, Fuller and Johnston.*

2·211. Applied Mechanics. Includes the graphical solution of some of the more advanced problems in statics and strength of materials, the calculation of stresses and deflections of continuous beams and girders, the theory of reinforced concrete as applied to beams and columns. Textbook: *Applied Mechanics, Vol. II, Fuller and Johnston.*

2·22. Applied Mechanics. A study of the fundamental principles of kinetics and application to engineering problems, including the determination of stresses in the moving parts of machinery; analytical and graphical solutions of some of the more advanced problems in statics and strength of materials. Textbook: *Applied Mechanics, Vols. I and II, Fuller and Johnston.*

2·221. Applied Mechanics. A study of the fundamental principles of kinetics and application to engineering problems; the theory of elasticity applied to cases involving plane stress or strain including applications to shafting and bars subjected to combined bending and torsion, cylinders and flat plates. Textbook: *Applied Mechanics, Vols. I and II, Fuller and Johnston.*

2·251. Dynamics of Machines. A study of the forces and stresses involved in machinery, due to the work done and to inertia of the moving parts themselves. Graphical and analytical methods of determining accelerations in plane motion are studied, and application made to the crank-and-connecting-rod problem and the limitation of speed fluctuation by means of a fly-wheel. Harmonic motions, and the motions produced by cams of various forms are discussed. Includes a study of dynamometers for the measurement of power.

2·252. Advanced Dynamics of Machines. Includes a study of the accelerations of points moving in paths of varying curvature; paths and accelerations of any points in links or other machine parts having plane motion, where the motions of two points are given; use of the acceleration centers, and velocity and acceleration images; composition and resolution of rotations about intersecting axes; moments of inertia about axes in any directions; natural axes, centrifugal couples and the dynamics of rotation. Open only to students at General Electric Company.

2·254. Dynamics of Engines. Lectures and drawing-room exercises on the inertia forces and the stresses in the running parts of fast gasoline engines. Application is made chiefly to the types of engines used in automobiles.

2·255. Dynamics of Aircraft Engines. An advanced course given to students having considerable knowledge of engine balancing and practical experience with aircraft engines.

2·26. Mechanics of Engineering. Application of the theory of reinforced concrete to the determination of the stresses in beams and columns; followed by advanced problems in mechanics, including the determination of the stresses in moving parts of machinery, losses due to friction, critical speeds, applications of the theory of least work, stresses in transmission lines and tramways, problems in the design of ordnance and others with which the mechanical engineer has to deal. Textbook: *Applied Mechanics, Vols. I and II, Fuller and Johnston.*

2·271. Theory of Elasticity. A continuation of 2·891 including a study of the fundamental principles of the theory of elasticity as applied to determining stress components on different planes through a point in a body subjected to plane stress and the relations between these components and the strains in elastic bodies. The course includes the solution of a considerable number of problems illustrating the application of the theory as developed.

2·272. Theory of Elasticity. A continuation of 2·271 which includes the application of the principles of the Theory of Elasticity in the design of built-up guns, also the design of wire-wrapped guns.

2·281, 2·282. Advanced Mechanics and Theory of Elasticity. An advanced course in the strength of materials and dynamics, including the theory of flexure of curved bars and the elastic arch, bending of unsymmetrical bars, the principles of the mathematical theory of elasticity and applications including St. Venant's theory of flexure, stresses in plates, stresses and strains in rotating shafts, cylinders and discs, the design of compound cylinders, temperature effects, etc.

2·283. Advanced Mechanics. An advanced course in Strength of Materials and Dynamics, including the theory of flexure of curved bars, the bending of unsymmetrical bars and applications to the more complex problems in mechanics.

2·284. Theory of Elasticity. A study of the fundamental principles of the mathematical theory of elasticity with applications including stresses in flat places, the design of cylinders simple and compound, the stresses in rotating shafts, cylinders, and disks, temperature effects, critical speeds, etc.

2·29. Interior Ballistics. The study of pressures developed by powders, development of the pressure volume curve and the discussion of formulas for determining velocity of a projectile in a gun. Textbook: *Ordnance and Gunnery, Tschappat.*

2·30. Materials of Engineering. The manufacture, physical properties, and testing of iron, steel, alloys, plaster, lime, cement, concrete, brick, timber and other engineering materials. Special attention is paid to the relationship existing between constitution and physical properties, the effect of change of composition, hot and cold work and heat treatment upon the properties of the metals. Textbook: *Materials of Construction, Mills.* (*Third edition.*)

2·301. Materials of Engineering. The time is devoted to a discussion of the testing and specifications of materials. Open only to officers of the United States Navy. Textbooks: *Materials of Construction, Mills*; *Engineering Steel, Aitchinson.*

2·305. Materials and Testing. Presents the possibilities and limitations of the modern methods available for the examination of materials of construction, including microscopic and macroscopic analysis, examination by means of X-rays and stress analysis by means of polarized light. Open only to students in the Graduate Coöperative Course with the General Electric Company.

2·31. Materials of Engineering. A study of the manufacture, physical properties and testing of iron, steel, alloys, plasters, lime, cement, concrete, brick, timber and other engineering materials. Textbook: *Materials of Construction, Mills.* (*Third edition.*)

2·331, 2·332. Physical Metallurgy. Conferences and laboratory exercises dealing with the structure and physical properties of metals used in torpedoes or ordnance construction. Open only to officers of the United States Navy.

2·333. Physical Metallurgy. Conference and laboratory exercises dealing with the physical properties of metals used in aircraft engine construction.

2·341, 2·342. Physical Metallurgy. Conferences and laboratory work, for graduate students, dealing with the structure and physical properties of iron, steel and other metals and the changes taking place when the materials are subjected to mechanical work, distortion, alternating stresses and heat treatment.

2·35. Testing Materials Laboratory. Study of the behavior of engineering materials under stress including tests of concrete and fabrics. Some attention is also given macroscopic examination of metals, microscopic examination of non-metallic materials, stress analysis by means of polarized light, and radiology. Textbook: *Materials Testing, Cowdrey and Adams.*

2·36. Testing Materials Laboratory. Methods of making physical tests for the properties of the more common engineering materials, and a study of their behavior under stress. Textbook: *Materials Testing, Cowdrey and Adams.*

2·361. Testing Materials Laboratory. A study of the behavior of engineering materials under stress including tests of concrete and the determination of stress distribution in fabricated members. Textbook: *Materials Testing, Cowdrey and Adams.*

2·362. 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.

2·37. Testing Materials Laboratory. Similar to course 2·36 but abbreviated. Textbook: *Materials Testing, Cowdrey and Adams.*

2·371. Testing Materials Laboratory. Methods of making physical tests for the properties of materials, adapted to the needs of students in VI-A. Textbook: *Materials Testing, Cowdrey and Adams.*

2·381, 2·382. Testing and Examination of Materials Advanced.

A. Physical Metallurgy. The examination of alloys of technical importance by means of the microscope and macroscopic analysis. Special attention will be paid to failures in metals, and to the methods used in determining improper heat treatment, mechanical defects, faulty manufacturing methods and similar conditions.

B. Testing Materials Laboratory. Detailed study of testing machines and their calibration, errors in measuring instruments, adaptability of different types of measuring instruments, the effect of form and size of test specimens on the observed physical properties, measurement of strains in parts subjected to both direct and combined stresses, study of the methods for determining hardness. Erickson test for sheet metal, determination of the variation in physical characteristics of metals under high and low temperatures using both static and impact methods, effect of heat treatments and overstrain on the physical properties of metals, the testing of timber, the testing of reinforced concrete, microscopic examination of non-metallic materials, etc.

C. Photoelasticity. The method of stress analysis by means of polarized light with special reference to structural problems and testing of materials, problems of internal and thermal stress and problems of dynamic stresses using special equipment.

D. Radiology. The methods and apparatus which are used in the examination of materials by means of X-rays. The subject is divided into two parts which are known as Radiography and the Analysis of Crystal Structure. In Radiography the method of examining the gross interior structure of an object is taken up and the apparatus, technique and limitations of the method are considered. The use of the X-ray spectograph for the analysis of crystal structure and the applications of this information to the structure of metals is also considered in more or less detail.

2·390. Reinforced Concrete Design and Laboratory. The design course develops the theory for reinforced concrete beams and columns with applications to the design of floor systems, interior and exterior columns. The laboratory course covers the selection of concrete materials, methods of proportioning for strength and economy, and special treatments of concrete.

2·391. Reinforced Concrete Design. 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. Textbook: *Concrete Engineer's Handbook, Hool and Johnson.*

2·392. Reinforced Concrete Design. A continuation of 2·391 consisting of the complete design of a typical cross section for a building. Special designs are made for corner columns, stairs, floor openings, etc.

2·393. Reinforced Concrete Design, Advanced. For graduate students. Affords opportunity for special problems in reinforced concrete design of a more advanced nature than that covered by 2·391 and 2·392. The problem matter will be determined by consultation between the instructor and the student.

2·394. Concrete Research. For graduate students. Gives opportunity for an investigation of special problems concerning concrete material or concrete construction.

2·395. Concrete Buildings Design and Specifications. The theory of reinforced concrete construction is applied to the design of the typical cross-section of a building. This includes a discussion of economical considerations, cost keeping, and the writing of specifications.

2·40. Heat Engineering. Begins a detailed study of the laws of thermodynamics and their application to engineering problems. Includes a discussion of the physical properties of gases, and of saturated and superheated vapors — especially of air and steam. The student learns to use equations, vapor tables and diagrams through independent solution of drill and engineering problems. This is followed by a study of the ideal and actual cycles of hot air, and internal combustion engines together with an analysis of the nature and magnitude of the various losses affecting the efficiencies of the various machines. Textbooks: *Thermodynamics of the Steam Engine, Peabody; The Temperature Entropy Diagram, Berry; Problems in Heat Engineering, Miller, Riley, Berry.*

2·41. Heat Engineering. Covers description of different types of boilers, mechanical stokers, fuels and their combustion, conveyors, superheaters, feed-water heaters, economizers, traps and various accessories of steam boiler plants. The latter part of the subject deals with the discussion of the various types of gas, gasoline and oil engines, together with the fuel ignition systems and auxiliary apparatus. Gas producers and the principle of combustion are discussed in detail. Textbook: *Steam Boilers, Peabody and Miller or Gebhardt, Steam Power Plant Engineering.*

2·42. Heat Engineering. Continuation of 2·40. Includes a discussion of the flow of fluids, of the steam engine and the air compressor, and of the cooling tower, besides other engineering applications of heat. Textbooks: *Thermodynamics of the Steam Engine, Peabody; The Temperature Entropy Diagram, Berry; Problems in Heat Engineering, Miller, Riley, Berry.*

2·421. Heat Engineering. Similar to 2·42, except that about one third of the theoretical problems are replaced by a description of engines and accessories similar to 2·04.

2·43. Heat Engineering. Includes a discussion of problems arising in compression refrigerating systems, a study of the properties of various refrigerants, and the laws of heat flow with application to walls, pipes, furnaces, etc.

2·44. Heat Engineering. A descriptive discussion of the various types of steam engines, condensers, pumps, cooling towers and other power plant accessories, followed by lectures taking up a study of the elementary laws of thermodynamics and their applications. These include a discussion of the properties of gases and of saturated and superheated vapors. The use of vapor tables and charts is taught by the solution of problems. A brief study is also made of the flow of compressible fluids. Textbooks: *Mac Naughton, Elementary Steam Power Engineering; Taft, Notes on Elementary Thermodynamics; Blaisdell and Estep, Problems in Thermodynamics and Steam Power Plant Engineering; Marks and Davis, Steam Tables.*

2·441. Heat Engineering. Similar to 2·44.

2·45. Heat Engineering. Continues the work of 2·44. About one third of the time is used in the discussion of steam boilers. A brief study is made of the theoretical and the actual steam engine and of the laws of gases as applied to air compressors. The remainder of the time is divided equally between the steam turbine and the internal combustion engine. Includes both theory and practice. Textbooks: *Mac Naughton, Elementary Steam Power Engineering; Blaisdell and Estep, Problems in Thermodynamics and Steam Power Plant Engineering; Marks and Davis, Steam Tables.*

2·451. Heat Engineering. A continuation of 2·44. About fifteen lectures are used in the discussion of steam boilers and about twenty in a study of steam turbine theory and practice. The theoretical and the actual steam engine and the internal combustion engine are also discussed briefly.

Textbooks: *MacNaughton, Elementary Steam Power Engineering; Blaisdell and Estep, Problems in Thermodynamics and Steam Power Plant Engineering; Marks and Davis, Steam Tables.*

2·46, 2·461. Heat Engineering. Begins with the study of valve gears which are treated and designed by both the Reuleaux and Zeuner methods. Following valve gears, the laws of thermodynamics are discussed and the application of the laws shown by application to engineering problems. The subject includes a discussion of thermodynamics of saturated vapors and of superheated steam. Many engineering problems involving thermodynamics and their application are used as illustrations. The accessories of a power station, including condensers, heaters, circulating pumps, dry vacuum pumps are discussed. Textbooks: *Thermodynamics of the Steam Engine, Peabody; Mechanism of the Steam Engine, James and Dole; Power Plant Machinery, Vol. II, James and Dole; Steam Tables, either Marks and Davis, or Peabody.*

2·47, 2·471. Heat Engineering. A continuation of 2·46. Includes the thermodynamics of mixed gases and vapors, heat transmission, Rankine cycle efficiencies, flow of fluids, injectors, probable power of engines, the principles of heating and ventilation. Also discussion of steam boilers, their accessories and their operation. Textbooks: *Thermodynamics of the Steam Engine, Peabody; Steam Boilers, Peabody and Miller, or Gebhardt, Steam Power Plant Engineering.*

2·48. Internal Combustion Engines. Oil and gasoline engines, adapted to the needs of naval constructors.

2·49. Refrigeration. A thermodynamic study of the absorption refrigerating system, of the properties of various brine solutions, of problems encountered in the manufacture of ice, and in other applications of mechanical refrigeration. A general discussion of the application of refrigeration to warehouses and industrial processes, refrigerator cars, etc., including also the proper handling of foods in storage, fungus growths and their effect on the decay of foods in storage.

2·501. Advanced Heat Engineering. 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. Textbook: *Notes prepared for class.*

2·502. Advanced Heat Engineering. A study of the variations of surface coefficients, conductivities, etc., under varying conditions followed by a discussion of the 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 application of Fourier's series to cases involving fluctuating temperature conditions. Textbook: *Notes prepared for class.*

2·503. Advanced Heat Engineering. Rapid review of the fundamental principles of thermodynamics and the use of the temperature entropy diagram, discussion of nozzle flow, cooling tower calculations followed by the thermodynamics of mixtures of gases and vapors with various applications, liquefaction of gases and separation of gaseous mixtures, the laws of heat transmission, study of the variation of surface coefficients, and the application of the laws to various power station accessories.

2·51. 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.

2·58. Power Plant Design. Includes: first, a study of the fundamental data required, such as location, water supply, fuel supply and load conditions; second, the choice and layout of the machinery for the plant for best economy consistent with dependability, including a study of typical plants. Calculations of the sizes of apparatus and computations to show probable fuel consumption and cost of operation will be made. Third, a study of the buildings, especially foundations and structural work, together with the principal calculations; fourth, the making of drawings to include plan, elevation, and necessary sections to show the location of apparatus and main pipe lines. These drawings will be sufficiently complete in detail to make it possible to calculate. Fifth, the probable total first cost of the plant and the operating cost. Textbook: *Notes on Power Plant Design, Miller and Holt.*

2·59. Mechanical Equipment of Buildings, Heating and Ventilation. Includes: first, a study of the elementary principles of the thermodynamics of gases and steam with their application to the equipment of a building; second, a study of the principles and practice of heating and ventilation, and third, a discussion of the various other mechanical equipment of a building, such as elevators, dust collecting systems, etc. Fifteen hours of this subject are given over to trips.

2·601. Engineering Laboratory. Designed to give a fundamental knowledge of methods of testing machinery in operation. Begins with exercises such as calibration of gauges, the use of planimeters, steam engine indicators, friction brakes, etc., and continues with problems involving heat engineering such as the use of steam calorimeters, the measurement of the flow of fluids by orifice, pitot tube, ventuir meter, nozzle and weir. Includes exercises in valve setting, some hydraulic experiments and tests of simple steam engines, air compressors, pumps and internal combustion engines. A report is required from each student on every exercise.

2·602. Engineering Laboratory. A continuation of 2·601, involving the testing of larger units including a test of a boiler plant. More complete and detailed reports of the tests are required than in the previous subject. Gas and fuel analysis and heat measurements are given as a part of this subject.

2·603. Engineering Laboratory. A continuation of 2·601. Larger machines are treated and more complete reports of the tests are required than in the previous subject.

2·611. Engineering Laboratory. An experimental subject teaching the use of various instruments used for testing power machinery preparatory to the subsequent subjects 2·612 and 2·613. A few exercises are used for the study of valve gears of steam pumps and engines. Tests are made on an engine, an air compressor and air lift pump.

2·612. Engineering Laboratory. A continuation of 2·611. Tests are run on steam engines, pumps, fans and internal combustion engines. The methods employed in conducting these tests and the reports required are intended to demonstrate the proper procedure for such testing and to teach the student to write a complete report of the work and to draw correct conclusions from the results obtained.

2·613. Engineering Laboratory. A continuation of 2·612. Gas and fuel analysis is offered briefly and a test on a steam boiler plant is included.

2·614. Engineering Laboratory. Covers the same ground as 2·601 but less complete reports are required.

2·615. Engineering Laboratory. A continuation of 2·614. Larger machines are tested and more complete reports are required.

2·62. Engineering Laboratory. Similar to 2·601 in subject matter but so arranged that the preparation requirements are less.

2·621. Engineering Laboratory. Covers parts of 2·611 and 2·612.

2·63. Engineering and Hydraulic Laboratory. Work is designed to teach the use of instruments required for testing steam and hydraulic machinery also to give some practice in conducting tests on such machinery. A report is required from each student on every experiment.

2·631. Engineering and Hydraulic Laboratory. Similar to 2·63 but more time is devoted to hydraulic experiments.

2·64. Refrigeration Laboratory. A general experimental course on refrigerating machines and experiments on heat transmission.

2·65. Power Laboratory. Exercises in the laboratory with outside work on calculations and reports. The object is to familiarize the student with the method of testing various types of power equipment and the proper method of writing reports of such tests. In addition, an attempt is made to familiarize the men with the operation of pumps and engines. Open to army officers only.

2·651. Gas Engine Laboratory. Consists in the stripping and assembling of different types of gasoline engines and accessories used in the Ordnance Department, United States Army. Complete performance and efficiency tests are made on these engines. A considerable amount of time is spent both on operation and on what is known as "Troubles" with the idea of familiarizing the men with the various troubles which are likely to occur in field operations. Open to Army Officers, Navy Officers, R.O.T.C. and Automotive students. Notes prepared by the instructor in charge will be used. Textbooks: *Automobile and Air Craft Engines, Judge; The Gasoline Motor, Heldt; Electrical Equipment, Heldt; catalogues and instruction books published by manufacturers of engines and accessories; The Testing of High Speed Internal Combustion Engines by Judge; The Internal Combustion Engine, Vols. I and II by Ricardo.*

2·66. Automobile Laboratory. Construction and operation of various motor vehicles, engines, accessories and equipment explained in detail by instructors. Tractors, tanks, motor vehicles, automobile, airplane and marine engines and equipment used for demonstration and study. Students prepare notes and sketches of work covered.

2·661. Maintenance and Operation of Automotive Equipment. Lectures followed by conferences where the maintenance and operation of motor vehicles is considered from the standpoint of design for efficient maintenance and operation, followed by a study of systems in use by various operating companies. The maintenance and operation of rail cars, busses, taxicabs, and trucks is studied. Fleet operation, store delivery systems, street railway bus lines, and the relation of motor vehicles to steam and electric railways are studied. Preparation time is spent in the study of reports of operating companies and engineering papers. Textbook: *S. A. E. Journal, engineering papers, companies' cost sheets, etc.*

2·671. Engine Testing. Prony brakes, water brakes, and electric dynamometers studied and operated. Engines mounted, lined up and couplings fitted for testing. Airplane, automobile, marine and tractor engines tested for complete performance including brake and indicated horse powers, fuel consumption, efficiencies, etc. Effect on engine performance of changes in cooling, lubricating carburetion, and ignition systems studied. Investigations of detonation, distribution, vibration, etc., conducted. Effect of various adjustments and use of accessories on engine performance obtained. Textbook: *Manufacturer's Handbooks, Engineering Papers and Reports; The Testing of High Speed Internal Combustion Engines by Judge; S. A. E. Data Sheets and Test Forms.*

2·672. Motor Vehicle Testing. Ten hours devoted to lectures and recitations. Sixty-five hours given to testing of motor vehicles. Chassis dynamometers, accelerometer, etc., used. Performance of motor vehicles studied in laboratory and on road. Riding comfort, braking ability, fuel mileage, effect of various tires on performance, etc., investigated. Accessories tested. Preparation time devoted to design of test apparatus, reports, and reading of current literature. Textbook: *Manufacturers handbooks, automotive magazine, engineering papers and engineering reports; S. A. E. Handbook and Journals.*

2·681. Aero Engine Laboratory. Devoted to the study of engine mounting, couplings, fuel measuring devices, power measuring devices and instruments used in aero engine testing. Short test runs made and performance of engines obtained. Gives practice in the fundamentals of testing. Textbook: *Manufacturers and Government Handbooks and Reports, S. A. E. Journals, Data Sheets and Test Forms, etc.*

2·691. Aero Engine Laboratory. Lectures on the fundamentals of aero engine construction, design, and operation and the study in the laboratory of the aero engines and their parts. Short engine tests are made to obtain performance of engines and give experience in handling test apparatus, and engine operation. Textbook: *Manufacturers and Government Handbooks and Reports.*

2·70. Machine Design. Embraces typical problems in machine design which may be solved by the application of the principles of statics. As an introduction the student is required to make complete calculations and drawings for the design of one of the simpler machines in which the stresses are statically determinate, such as a punch, shear, press or riveter. The remainder of the time is spent in the design for a fire-tube, water-tube or marine boiler, a vulcanizer, stand-pipe or steel stack. In this connection the shells of cylinders, riveted joints, and the staying of flat surfaces are thoroughly discussed. Graphical methods are employed for the analysis of motions and the determination of forces wherever possible. Textbooks: *Design of Steam Boilers and Pressure Vessels, Haven and Swett; Notes on Machine Design, Haven.*

2·71. Machine Design. The design of machines involving dynamic forces. Such a machine as a power-driven punch, press, shear or pump is chosen as a type and its various proportions as far as possible are calculated by rational methods. The stiffness and strength of shafting, belts, ropes, fly-wheel stresses, force fits, journals, and bearings, together with the stresses in moving parts, are studied at considerable length. A complete set of drawings and calculations for a complicated machine of the above type is required. Textbook: *Notes prepared for class.*

2·711. Machine Design. Similar to 2·71, but briefer and adapted more directly to questions relating to manufacture and duplication of parts. Textbook: *Notes prepared for class.*

2·712. Machine Design. An extension of 2·711 with special reference to combined stresses and problems involving rigidity of parts. Textbook: *Notes prepared for class.*

2·721. Machine Design. Lectures and calculation and drawing upon the principle and action of modern machine tools together with the design of pressure vessels such as tanks, boilers and standpipes. Numerous problems are studied in relation to cutting and feeding speeds. The stresses are thoroughly analyzed in the shells and joints of pressure vessels. Textbook: *Notes and lithographs prepared for class.*

2·722. Machine Design. An extension of 2·721 with special reference to complicated machines under dynamic load The subjects of standardization and duplication of machine parts are given careful attention. Textbook: *Notes prepared for class.*

2·731. Machine Design. Lectures upon the applications of machine design to the airplane engine and the apparatus used in testing such motors. The fundamental study includes gears, shafts under combinations of bending and twisting, bolt and screw fastenings, journals, ball and roller bearings, couplings, clutches, and high speed disc wheels. Textbook: *Notes prepared for class and library research.*

2·732. Machine Design. An extension of 2·731 including an analysis of numerous stresses in parts of airplane engines with special stress calculations upon unusual machine elements. Textbook: *Library research.*

2·741. Machine Design, Advanced. A systematic application of the principles of applied mechanics to the design of machines of complicated character. The subjects of centrifugal effects, balancing, lubrication and combined stresses are treated at considerable length. Textbook: *Library research.*

2·742. Machine Design, Advanced. An extension of 2·741 with special reference to the stresses in turbine discs together with the design and action of brakes. Textbook: *Library references.*

2·743. Advanced Machine Design. A systematic application of the principles of mechanics applied to the design of machines of complicated character, centrifugal effects, balancing, lubrication, combined stresses as well as stresses in turbine discs are discussed and calculations carried along with the design.

2·75. Machine Design, Advanced. Arranged for Ordnance Design, United States Navy.

2·761. Machine Design. A thorough analysis of the stresses and factors of safety in the power plant of the naval torpedo, including bearings, gears, the action of combined bending and twisting and the distortion of parts. Textbook: *Library reference and notes prepared for class.*

2·762. Machine Design. An extension of 2·761 with a special study of the stresses in air turbine discs and the design of the necessary equipment for testing the power plants of torpedoes. Textbook: *Library reference.*

2·77. Engine Design. Lectures and drawing room exercises in the design of reciprocating engines for stationary plants. Typical engines are studied with reference to special requirements of the services in which they operate and to shop methods of construction, as well as to thermodynamic and mechanical principles, including engine balancing. A problem is assigned on the design of some type interesting to the student, and the principal parts are laid out on the drawing board.

2·781. Industrial Plants. A study of problems involved in the organization of a modern manufacturing plant and the planning, construction and equipment of the buildings required. The subjects included may be grouped as follows: (*a*) organization of the industry including the office and engineering departments, methods of superintendence, employment and cost of labor, and scheduling the work; (*b*) factors to be considered in selecting a suitable site for a given industry; (*c*) the construction of the foundations for an industrial plant; (*d*) the heating, ventilating and air conditioning of the factory; (*e*) the construction of a mill or shop of the three following types, — slow burning mill-steel frame and reinforced concrete. Textbook: *Notes prepared for class.*

2·782. Industrial Plants. An extension of 2·781 with special reference to the design of the structures and the distribution of power in mechanical processes. The mechanical equipment of the building including lavatories, stair-towers and safety appliances. Textbook: *Notes prepared for class.*

2·79. Gasoline Automobile. Covers the general principles of gasoline automobile construction and operation. Includes the engine and its accessories, carburetors, ignition, starting and lighting systems, storage batteries, lights; the chassis and its component parts, clutches, transmission, steering gear, axles, brakes, etc.

2·801, 2·802. Automotive Engineering. Fundamentals of automotive engineering are the bases of this course — engines and chassis; theoretical considerations of the general principles governing the action and design. It includes a study of the conditions within the cylinder, flame propagation, turbulence, detonation, lubrication and oil dilution, influence of shape and size of combustion chamber and valve arrangement, spark plug location, factors influencing m. e. p., manifold distribution, carburetion, cooling, sources of loss of efficiency, etc. A study is made of all important parts and procedure of design is outlined. In addition to the engine it includes clutches, gear-sets with calculation of bearing loads and choice of bearings, universal joints, rear axle drives with calculation of bearing loads, rear axles, front axles, steering gears, springs, brakes, etc.

2·811, 2·812. Automotive Design. The calculation and design of engines and chassis, supplementing the course in automotive engineering. All essential parts are carefully studied and drawings as well as the calculations are made. The student is given almost free choice of the type of machine for his individual design.

2·84. Heat Treatment. Conferences and laboratory work dealing with the effect of heat treatment on the physical properties of iron, steel and other metals.

2·841. Heat Treatment. Conferences and laboratory work dealing with the effect of heat treatment on the physical properties of metals of importance in torpedo or ordnance design. Open only to officers of the United States Navy taking torpedo design.

2·842. Heat Treatment. A continuation of 2·84, devoted to the study of the effect of heat treatment on the metals used in the automotive industry.

2·843. Heat Treatment. Lectures and laboratory work dealing with the constitution of metals used in construction and the effect of heat treatment on their physical properties. Open only to students in the Graduate Coöperative course with the General Electric Company.

2·850. Automatic Machinery. A discussion of a number of fully automatic machines representative of various classes of machinery, such as wire-working machinery, can-making and can-capping machinery printing machinery, weighing, package and wrapping machinery, labelling machines, fibre box machines, etc. Problems assigned include a motion diagram for a full automatic machine, analyses of indexing devices and designs for some of the simpler automatic mechanisms.

2·851. Fire Protection Engineering. The growing demand for men equipped with a knowledge of fire-proofing and fire-protective apparatus renders it necessary to make a special study of this branch of engineering. The erection, installation and operation of protective devices of all kinds are carefully studied. A number of problems are worked out on a drawing board, showing how modern shops and mills may be safeguarded against fire in the most effective manner. Textbook: *Crosby-Fiske-Forster, Handbook of Fire Protection.*

2·853. Locomotive Engineering. A study of the construction of modern locomotives from detail drawings, the general principles of locomotive design, the calculation of stresses in parts of the engine, balancing of driving wheels, superheaters, stokers, feed water heaters and their effect on the efficiency of the engine.

2·854. Mechanical Equipment of Buildings. Description and discussion of the general principles of construction of the mechanical equipment of large office buildings, including such subjects as elevators, pneumatic systems of dust collection, water supply systems, water-heating systems, sewage disposal, etc.

2·855. Steam Turbine Engineering. A study of the different types of modern steam turbines, by means of lectures and discussions. Their theory, construction and operation are taken up in sufficient detail to make the student familiar with the best practice. Problems illustrating simple design and the thermodynamics of steam turbines are worked out. Turbine economics and the special features of turbine auxiliaries are considered. Knowledge of the steam turbine and nozzle work taken in heat engineering of the third year is assumed. Textbook: *Steam Turbines, Moyer; or Church, Principles of Steam Turbines.*

2·856. Heat Treatment. Conferences and laboratory work dealing with 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.

2·857. Heat Treatment. Similar to 2·84.

2·858. Inspection Methods. A study of the principles of shop inspection, including shop measurements, measuring instruments and gauges, tolerances, dimensional standardization, calibration of shop standards, and analysis of production problems by means of measurement. Textbooks: *Library Research and Notes prepared for class.*

2·86. Heat Treatment and Metallography. A series of conferences and laboratory exercises dealing with the study of the heat treatment and metallographic testing of metals used in automotive construction.

2·861. Heat Treatment. Conferences and laboratory work dealing with the effect of Heat Treatment on the physical properties of metals of importance in Aero Engine Design.

2·87. Textile Engineering. Lectures on the machinery and processes employed in the production of textiles with special reference to mechanical fabrics. The process is studied from the bale of raw material to the finished cloth. In addition, thirty hours are applied to special work in the Textile Testing Laboratory, involving the determination of the strength twist, staple, elasticity, and moisture content of fabrics and yarn. The design of a yarn mill and weave shed is taken as a problem and a complete set of floor plans are calculated and drawn to fit the requirements. Textbook: *Notes prepared for class.*

2·88. Ordnance Engineering. Lectures and calculations on gun design, including stresses and strains in built-up and wire-wrapped guns; the design of recoil and counter-recoil mechanisms. 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 course.

2·891. Mechanics. Devoted to the study of the fundamental principles of Mechanics necessary for the solution of problems arising in the design of ordnance of various types.

2·892. Ordnance Problems. Devoted to the solution of problems arising in the design of ordnance; including recoil and counter-recoil mechanisms, the stresses in the parts of gun carriages and mounts of different types, the power for operating, elevating and traversing mechanisms, the stresses set up in the parts of projectiles, etc.

2·90. Forging. Systematic instruction in the use of each tool, the study of each material worked, with an explanation of its various grades and of the proper methods of working each, and the discussion of methods of making large forgings. The ground covered includes instruction in the building and care of fires, heating, drawing, forming, bending and twisting, upsetting, upsetting while bending, upsetting for square corners, punching, bolt making, welding, chain making, and the construction of hooks and ring bolts. The work in steel includes drawing, forming, welding, refining and tempering, and spring and tool making. Training is given in the use of the power hammer; and drop forging is also included.

2·901, 2·902. Forging. Similar to 2·90.

2·91. Foundry. A course dealing with the principles and practice of Foundry operation and the production of all classes of castings. Includes instruction by lecture, demonstration and practice in hand and machine molding and core making; mixing, melting and pouring metals. Castings are first made in white metal for practice, then in aluminum, brass and in cast iron, when the students are taught pouring and the running of metal furnaces. Illustrated lectures on floor, sweep, pit and loam molding; malleable iron and steel casting; permanent molds and die casting; heat treatment of castings; oxyacetylene and thermit welding; application of X-ray tests for internal defects in castings; foundry lay-out, equipment, safety methods and modern methods of progressive production. Textbook: *Notes prepared for class.*

2·911. Foundry. Covers part of 2·91.

2·912. Foundry. Similar to 2·91.

2·92. Pattern Making. Includes the elements of joinery and wood turning. Lectures, demonstrations and practice in hand and machine methods. Typical patterns and core boxes are constructed. The principles of molding are carefully considered. Illustrated lectures on the construction of solid, split, and loose-piece patterns; large, part, and skeleton patterns for floor, loam, and sweep work; master and metal patterns; mounting of patterns on plates and their preparation for use on molding machines. Textbook: *Notes prepared for class.*

2·921. Carpentry.

2·941, 2·942. Machine Tool Laboratory. Given by lectures and demonstrations. Includes laying out work, grinding tools, chipping cast iron, pneumatic chipping and drilling, filing and fitting cast iron and steel machine parts, alignment and babbitting of bearings, measuring hardness of metals with sclerescope, drilling, reaming, counterboring and tapping, grinding drills by hand and machine, belt lacing, soldering, electric and oxy-acetylene welding. Instruction is also given in 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.

2·951. Machine Tool Laboratory. Instruction in machine processes and the use of hand tools is given by lectures and demonstrations, supplemented by notes and textbooks. Each student is assigned problems involving laying out work, both hand and pneumatic chipping and drilling, filing and fitting cast iron and steel parts, alignment and babbitting of bearings, scraping machine slides, steam pipe fitting by hand and machine, hardness tests of metals with scleroscope, tapping, grinding drills and other tools by hand and machine; centering, squaring, straight and taper turning and fitting, screw cutting, finishing and polishing, gear cutting, mandrel making, hardening, tempering, grinding, and electric and oxy-acetylene welding. Special attention is paid to cutting angles and adjustments of cutting tools and cutting speeds for each material worked. The machines used are engine lathe, centering machine, milling machine, drilling machine and grinding machine. Textbook: *Advanced Machine Work, Smith.*

2·952. Machine Tool Laboratory. A continuation of 2·951. Includes planing flat and angular surfaces, keys and keyways, tool making, hardening and case hardening, oil and color tempering, grinding and lapping, making taps, milling cutters and cylindrical gages. The machines used are engine lathe, speed lathe, centering machine, milling machine, drilling machine, planer, shaper, cylindrical, cutter, and surface grinding machines, automatic gear cutting machine, gear shaper, thread milling machine and broaching machine. Instruction is given in the use of gages for the standardization of machine parts, standard precision measuring machine, contour measuring machine, lead test indicator and measuring with light waves. Textbook: *Advanced Machine Work, Smith.*

2·96. Machine Tool Laboratory. Covers part of 2·951 including instruction in mechanical processes, both hand and machine. Textbook: *Advanced Machine Work, Smith.*

2·961. Machine Tool Laboratory. Covers a small portion of 2·951. Textbook: *Advanced Machine Work, Smith.*

2·971. Machine Tool Laboratory. Covers a part of 2·951.

2·972. Machine Tool Laboratory. A continuation of 2·971 and includes boring, knurling, inside and outside screw cutting, cylindrical grinding, eccentric turning, tool making such as making mandrels, taps, hardening and tempering. Textbook: *Advanced Machine Work, Smith.*

2·98. Production Methods. Consists of a study of the production methods used by leading industries, manufacturing machines and appliances that are in general use such as electrical machinery, telephone apparatus, sewing machines, uses of aluminum and aluminum alloys in machine parts and appliances, die castings, pressed metal, tubing, pipe, pipe fittings and valves, machine tools, clocks, watches, cash registers, firearms, phonographs, radio apparatus, typewriters, conveyors, agricultural machinery, automotive construction. Estimating cost of production is considered.

2·981. Manufacturing Processes. Embraces methods of constructing automobiles, trucks, busses and tractors. Includes methods of machining automotive parts, such as cylinder blocks, pistons, connecting rods, crankshafts, camshafts, ball and roller bearings, axles, steering knuckles, drive shaft, rear axle housings, differentials, flywheels, universal joints, clutches, brake mechanisms, uses of carrier systems, unit and final assemblies such as steering columns, rear axles, engines, chassis, radiators and bodies.

2·99. Metrology and Dimensional Engineering Standardization. Includes first, a study of fundamental units of measure, measuring systems, and calibration of standards; second, the purpose of measurements in scientific and research work, engineering in general use; third, a study of conventional measuring instruments, their characteristics and methods of calibration; fourth, accuracy of measurements; fifth, analysis of measurements; sixth, shop measurements and analysis by means of measurement; seventh, dimensional engineering standardization; and eighth, inspection engineering. Textbooks: *Library Research, American Engineering Standards, S. A. E. Handbook, and Notes prepared for class.*

MINING AND METALLURGY
(Including Petroleum Production)

The study of Mining Engineering and Metallurgy covers such a large field of technical endeavor that the courses given cannot follow all the details of the several branches. The aim of instruction is to ground the student in the fundamental principles of the professional studies, and to train his mind and hand that he may be a close observer, a good reasoner and a conscientious worker.

Instruction is given by lectures and recitations by laboratory work and by summer schools. Work in the department covers studies in mining, ore-dressing, petroleum engineering, metallurgy, metallography and assaying. With these are interwoven auxiliary courses in physics, chemistry, mineralogy, geology, and in civil, mechanical and electrical engineering. All students in the department follow the same studies until the middle of the second year; differences in the options become marked in the third and fourth years.

There are three options. Option 1 covers the field of mining engineering, but its scope is sufficiently broad to enable the graduate to engage in the practice of those branches of metallurgy which commonly make a part of mining operations. Option 2 is designed for the metallurgist and emphasises the fundamental sciences and arts on which metallurgy depends. A short course in elements of mining is included, and electives allow the taking of lectures on geology and mineral deposits. Option 3 is devoted to petroleum production engineering, embracing prospecting, development, production and transportation of oil and gas. Opportunity is offered for advanced studies leading to the degrees of Master of Science and Doctor of Science.

Subjects 3·00 to 3·99 (see page 59).

3·01. Mining Methods. Includes a study of prospecting and exploring with applications of churn drilling, diamond drilling and magnetic surveying; mineral land titles; explosives, mining development, rock excavation, tunnelling and shaft sinking; support of ground and timbering; mine equipment and operation embracing air compressing, hoisting, drainage, ventilation, underground transport, shaft signaling, machine drills, shoveling machines; and surface plant, including head frames, aerial tramways and cableways. Textbook: *Peele, Mining Engineers Handbook.*

3·02. Mining Methods. A continuation of 3·01 including the study of such subjects indicated under 3·01 as have not been completed in the first term; also, mine production with description of underground mining methods and selection of the proper method; special types of mining, as: coal mining, steam shovel mining, dredge operations on alluvial deposits, hydraulic mining and petroleum, salt and sulphur wells.

3·03. Mining Economics. Embraces studies of mineral resources, metals, fuels and non-metals; the economic effects of geographic situation and of transportation facilities; sampling, selling and purchasing of ores, fuels and other mineral products; inquiry into the principles of smelting contracts. Textbook: *Finlay, Cost of Mining.*

3·04. Mining, Principles of. 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; also the consideration of health, welfare, safety, and accident prevention, mining regulations and employers liability insurance. Textbook: *Hoover, Principles of Mining.*

3·05. Mining, Elements of. Designed for students in metallurgy, geology, chemical engineering and others who are interested in ores or minerals, which may be the raw materials of their industries. The subjects treated in the lectures are mining methods, including exploring, sampling, development and production; mining equipment, as air compressors, hoists, machine drills, underground and surface transportation; and laws relating to mining. Textbook: *Young, Elements of Mining.*

3·061, 3·062. Mining Engineering, Advanced. Planned for graduate students who have had some experience in mining practice and mining engineering, and who desire to do advanced work in some branch of the subject not specifically covered by other courses scheduled. The student is expected to make his own choice of the special division of the subject 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 of 1927 will be spent in familiarizing the students with processes and operations in mining, crushing and concentrating with visits to various mines in the vicinity.

3·09. Mining Law. The history, interpretation and application of the United States mining law for graduate students who have had some experience in the practice of mining engineering. Readings and discussions. Textbook: *Lindley, On Mines.*

3·101, 3·102. Mine Valuation. 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. The study and analysis of the reports of mining 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.

3·21. Ore Dressing. 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 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. Textbook: *Richards and Locke, Textbook of Ore Dressing.*

3·22. Ore-Dressing Laboratory. Offers the student an opportunity to become familiar with the principles and actual operation of ore-dressing apparatus. The class usually makes two mill runs, one on gold ore, using stamps, amalgamated plate, vanner, classifier and canvas table, and the other on a lead ore using trommel, classifier, jigs and tables. In addition, individual tests are made on crushing machines, sizing screens, hydraulic classifiers, magnets and flotation machines. One very important part of this work carried out by the student 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. Lectures and laboratory; 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 cleaning up his products and preparing reports. Textbook: *Richards and Locke, Textbook of Ore Dressing.*

3·241, 3·242. Ore Dressing, Advanced. Somewhat variable in scope and time allotment. Devoted to lectures, conferences and assigned readings in continuation of 3·21 or 3·23.

3·251, 3·252. Theory and Practice of Flotation. 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 study of reagents, selective flotation, application to oxidized ores and the economics of flotation.

3·26. Ore Dressing, Economics. Conferences and problems involving the various factors of equipment costs, operating cost, efficiency of operation and profit.

3·271, 3·272. Ore Dressing, Design. Design of flow-sheets and lay-out of mills; usually includes a special problem of mill design to cover a set of stated conditions.

3·31. Fire Assaying. One lecture, one recitation and one four-hour laboratory exercise a week. In the lectures are discussed 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. Textbook: *Bugbee, Fire Assaying.*

3·32. Fire Assaying and Metallurgical Laboratory. A composite subject; consisting of elementary work in fire assaying followed by brief laboratory work in fire metallurgy.

Fire assaying covers only the assay of ores for silver, gold and lead. The work in fire metallurgy includes the roasting of copper ores and the refining of metallic copper. May not be given unless six or more apply. Textbook: *Bugbee, Fire Assaying.*

3·331, 3·332. Fire Assaying, Advanced. 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.

3·41. Metallurgy: Copper and Lead. Deals mainly with the production and refining of the metals. The principles of the subject are covered in thirty lectures. The remainder of the time is used in the library and laboratories. The laboratory work, which so far as possible is coordinated with the lectures, consists of various roasting, sintering, smelting, and leaching tests followed by a discussion of the economic application of the results obtained. Textbooks: *Hofman and Hayward, Metallurgy of Copper; Metallurgy of Lead.*

3·411. Metallurgy: Copper and Lead. The lectures are given simultaneously with 3·41. The time for laboratory and library work is shortened. Textbooks: *Hofman and Hayward, Metallurgy of Copper; Metallurgy of Lead.*

3·412. Metallurgy: Copper, Lead, Zinc, etc. The lectures on copper and lead are simultaneous with 3·41. In addition there are twenty lectures covering briefly zinc, aluminum, fuels and refractories. The laboratory work is confined to twenty-five hours. Textbooks: *Hofman and Hayward, Metallurgy of Copper; Hofman, Metallurgy of Lead; General Metallurgy, Zinc and Cadmium.*

3·42. Metallurgy: Gold and Silver. The principles of the subject are covered in thirty lectures. The laboratory work and problems are in connection with the lectures, and the results are discussed in weekly seminars.

3·43. Metallurgy: Iron and Steel. The physical and chemical properties of iron, steel and alloy steels, and the production and treatment of pig iron, cast iron, wrought iron, steel, etc. Stress is laid in the classroom mainly on principles; the processes being given in outline and studied in detail in assigned references to books and journals. The lectures are supplemented by plant visits which are covered by subsequent reports and seminars. Textbook: *Stoughton, Metallurgy of Iron and Steel.*

3·431. Metallurgy: Iron and Steel. The lectures are simultaneous with 3·43, but less time is devoted to library work and plant visits. This subject is recommended for army and navy officers requiring a knowledge of iron and steel for ordnance or structural purposes. Textbook: *Stoughton, Metallurgy of Iron and Steel.*

3·432. Metallurgy: Iron and Steel. The class work is simultaneous with 3·43. Library work and plant visits are omitted. Textbook: *Stoughton, Metallurgy of Iron and Steel.*

3·44. Metallurgy: General, Zinc and Minor Metals. 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 electro-metallurgical processes and considers typical metallurgical apparatus. In zinc and minor metals the work supplements that given in 3·412. Textbook: *Hofman, General Metallurgy, Zinc and Cadmium.*

3·45. Metallurgy, Heat Treatment of Steel. Takes up the heat treatment of steel and includes some discussion of furnaces and equipment. The lectures are supplemented by plant visits and library work covered by seminars and reports.

3·46. Metallurgy of Common Metals. Designed for engineering students who do not expect to practice metallurgy as a profession. It consists of three lectures per week and treats at varying lengths of iron and steel, copper, lead, zinc, aluminum, antimony, 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.

3·501, 3·502. Metallurgy: Iron and Steel, Advanced. 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.

3·511, 3·512. Metallurgical Plant Design. 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.

3·521, 3·522. General Metallurgy, Advanced. 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.

3·531, 3·532. Non-Ferrous Metallurgy, Advanced. Designed 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 number of hours 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 of this course is confined to production and refining. Those desiring to study the properties of metals and alloys should register for 3·651, 3·652.

3·541, 3·542. Gold and Silver Metallurgy, Advanced. For graduate students who desire to do advanced work in the metallurgy of the precious metals. May be extended to cover the metallurgy of the metals of the platinum group. Conferences, assigned reading, reports and special problems.

3·56. Metallurgical Plants. Drafting room, library and conference work. Details of apparatus, plant arrangement and operations are studied and presented at occasional seminars.

3·60. Metallurgical Plant Visits. 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 are 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 3·41, 3·411, 3·43 or 3·431.

3·61. 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. Practice in photomicrography is an essential part of the subject. Textbook: *Williams and Homerberg, Principles of Metallography.*

3·611. Metallography. Same as 3·61, but with less laboratory practice.

3·612. Metallography. Same as 3·611, but with less laboratory practice.

3·651, 3·652. Physical Metallurgy, Advanced. A series of conferences dealing with recent developments in physical metallurgy, accompanied by laboratory exercises in which brief research problems will be undertaken.

3·66. Applications of Metallography. Laboratory conferences, given in the graduate year, arranged to familiarize the student with the applications of metallography to industrial problems.

3·81, 3·82. Elements of Petroleum Engineering. 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.

3·85, 3·86. Petroleum Production and Utilization. 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 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. Consists of a five-day trip to the oil and gas fields of western Pennsylvania.

3·901, 3·902. Oil and Gas Land Valuation. Considers the factors entering into the valuation of oil and gas properties, given by the case system. The time is devoted to lectures, conferences, assigned readings, drawings, computations and written reports. Designed for graduate students who have had some experience in petroleum production.

3·911, 3·912. Advanced Petroleum Engineering. Planned for graduate students who have had some experience in petroleum production, and who desire to take advanced work in some branch of the subject not specifically covered by other courses 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.

3·92. Oil and Gas Law. Laws and legal forms relating to the acquisition of petroleum rights to production, storage and transportation of petroleum, natural gas and their products.

3·93. Oil Well Waters. Seminar topics relative to oil well waters.

ARCHITECTURE

The Department of Architecture offers two courses: Course IV, Architecture; and Course IV-A, Architectural Engineering; the former a five-year course, leads to the degree of Bachelor in Architecture; the latter covering four years, leads to the degree of Bachelor of Science in Architectural Engineering. The graduates of each course are equipped to assume their differing professional responsibilities entirely independent of one another, though modern practice will frequently bring them together with a better understanding of one another's problems than would have been possible without the background of subjects that they have taken in common.

The teaching of these two courses has steadily developed under the conviction that the ever-widening field of professional opportunity offered ample scope for each. It consequently has seemed fundamentally unsound to graduate students in either with the impression that they were qualified to assume the obligations of the other.

Certain subjects are obviously and properly taught in common, such as English and history, economics, drawing, mathematics and perspective; certain professional and semi-professional subjects, as history of civilization, art and architecture, philosophy of architecture, office practice, professional relations, and lectures on building construction. The more highly specialized subjects pertaining to the distinctive characteristics of the two courses are necessarily taught separately.

In all professional work the methods of instruction are so far as possible individual. Even in such subjects as architectural history and European civilization and art, which must be presented in the lecture room, written exercises and personal conferences keep the instructors in touch with the progress of each student. In the subjects of design and freehand drawing individual criticism and correction form to a very large extent, the basis of instruction.

As we believe that the function of the architectural school is to give training in fundamentals, our efforts are concentrated upon imparting to the student a very clear understanding of the general principles of the subject, and upon training his powers of analysis and application. It is believed undesirable, in fact dangerous, to spend too much time upon the hampering limitations of ordinary practice before the student has acquired sufficient knowledge of the subject to discriminate between the general and the special case.

Daily progress and attention to work are insisted upon, and the results of class exercises during the term are considered quite as trustworthy a measure of a student's development and power as are the formal examinations.

The student is strongly advised to spend a part of the summer vacation in an office. The experience that he gets there of practical problems and conditions will be a great aid to him in a clearer understanding of the value of his school work.

Subjects 4.00 to 4.99 (See page 59)

4·021, 4·022. Freehand Drawing. Includes drawing from the cast and architectural ornament in charcoal, pencil or pen and ink, also quick sketching direct from the human figure.

4·031, 4·032. Freehand Drawing. A continuation of 4·022. Drawing from the nude, memory drawing, and direct pen-and-ink sketching from the figure.

4·041, 4·042. Freehand Drawing. A continuation of 4·032. Drawing from the nude, memory drawing, and direct pen-and-ink sketching from the figure.

4·051, 4·052. Freehand Drawing and Decorative Design. Advanced work open only to students who have passed 4·042. The students make life-size drawings from the nude, and study the principles of decorative figure design.

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. Given by short lectures and individual classroom instruction.

4·061. Graphics. Intended for students in Course XVII. In this subject, which is the latter part of Graphics 4·06, the student becomes acquainted with Descriptive Geometry as applied to architectural problems.

4·071, 4·072. Modelling. Aims primarily to develop the student's sense of a third dimension in his study of architectural composition. Given by means of sketch exercises in modeling-wax upon a given program of an architectural character.

4·081, 4·082. Color, Theory and Exercises. Aims to familiarize the student with the various theories of color, both scientific and æsthetic, and to give him practice in the use of color. Given by lectures and problems.

4·091, 4·092. Color, Design and Application. A continuation of 4·081, 4·082, the problems being of a more architectural character.

4·10. Architectural Drawing. Intended to acquaint the students in Course XVII with the nature and production of architectural drawings. Special attention given to developing drawings from freehand sketches.

4·11. Shades and Shadows. Planned to give the fundamental knowledge necessary for casting the conventional shadows employed in architectural design. Given by means of 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. Textbook: *Notes on Shades and Shadows, H. W. Gardner.*

4·12. Perspective. Lectures and drafting-room exercises. The first part treats of the general theories of perspective and the methods of revolved plan and perspective plan. The latter part is devoted to practical work involving variations, short cuts and office manipulations.

4·13. Perspective. Lectures and classroom exercises. Consideration is given to the 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 subject is continued with 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. Textbook: *Principles of Architectural Perspective, Lawrence.*

4·20. Office Practice. Lectures and exercises in the drafting-room, to illustrate the principles governing the making of working drawings, details and specifications. Plans of executed work are examined and discussed, and, wherever practicable, visits are made to the buildings under discussion. The character and use of building materials are discussed, with special reference to their influence upon architectural design. This subject should enable a student without previous office experience to be of some value as a junior assistant in an architect's office during his vacation periods.

4·21. Office Practice. An analysis of the methods followed in architects' offices in the preparation of plans and specifications as well as details for a good building, accompanied by weekly visits to such a building under construction in or near Boston.

4·22. Office Practice. An analysis of working drawings and specifications used in the construction of buildings. Plans and specifications of a building under construction near Boston will be examined and discussed, frequent trips made to the building and written reports upon its construction required. Sufficient drafting of plans and details will be required to familiarize the students with the principles governing their preparation.

4·23. Office Practice. (Elective.) Offered to students who have passed the regular Office Practice courses and who wish to go on with the work and consider in more complete detail the preparation of working drawings, details, specifications and contracts; to students in other courses who desire instruction in the preparation of working plans, etc.; and to special students upon the recommendation of the head of the department. The character and scope of the course will depend upon the qualification of the student or his object in taking it. Arrangements as to schedule, etc., may be made with the instructor in charge of the course.

4·241, 4·242. Professional Relations. 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; also 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 documents that are issued by the American Institute of Architects. The students are encouraged to take part in the discussions and to express their personal opinions. Textbooks: *Handbook of Professional Practice, American Institute of Architects; Law of Architecture and Building, Clinton H. Blake, Jr.*

4·25. Estimating. Designed to give the students some knowledge of the methods used in making estimates of cost as applied to building.

4·311, 4·312. Theory of Architecture. Lectures supplementing the course in design and closely related to it.

4·321, 4·322. Theory of Architecture. Lectures supplementing the corresponding course in Design and closely related to it.

4·331, 4·332. Theory of Architecture. Lectures supplementing the corresponding course in Design and closely related to it.

4·411, 4·412. Architectural History. A series of lectures, illustrated by the stereopticon, covering the periods of Egyptian, Assyrian, Persian, Greek and Roman architecture. Supplemented by reference reading and sketching.

4.413. Architectural Drawing. Planned for students in the course in Building Construction.

4·421, 4·422. Architectural History. A continuation of 4·412 devoted to the periods of Byzantine, Romanesque, Gothic and Renaissance architecture. Reference reading and sketching are required.

4·461, 4·462. European Civilization and Art. Rise of civilization and of its westward expansion through the Mediterranean basin. The racial, economic, religious and political elements in this development are carefully traced, and upon the background thus gained the art of each successive epoch is studied and general æsthetic principles are discussed. As the students in Course IV have a specialized course in the history of architecture, attention is here particularly concentrated upon sculpture. The lectures are very fully illustrated by lantern slides, supplemented by collections of photographs and by reference to the original works and casts contained in the Boston Museum of Fine Arts. Textbook: *Breasted, Ancient Times.*

4·471, 4·472. European Civilization and Art. A survey of the civilization and art of the later Hellenic and Roman world. Method and apparatus as in 4·462 of which this forms a continuation. Textbooks: *Breasted, Ancient Times; Tarbell, Greek Art.*

4·481, 4·482. European Civilization and Art. Modern painting: a study of its development, problems, predominant influences, from the Renaissance to the present time.

4·49. History of Renaissance Art. A short consideration of its relation with mediaeval art and its consecutive phases in architecture, sculpture, and painting.

4·52. Philosophy of Architecture. A series of conferences in which architecture is considered from a theoretical rather than an historical point of view. It serves to supplement the drafting-room instruction in design in furnishing a résumé of the fundamental principles of architecture and its relationship to civilization and the other arts allied with architecture.

4·61. Town Planning. Intended to acquaint the student with the characteristic problems of the town planner, the purpose being to so equip the architect that he may the better coöperate with either engineer or landscape architect, as well as to acquaint him with the history and development of these arts. Lectures accompanied by reading and work at the drafting board.

4·712. Design I. The beginning of the study of the principles of architectural composition by means of problems. Given with individual instruction in the drafting-room and criticism of the student's work before the class. In combination with the lectures in theory of architecture, the student is made familiar with the elements of buildings derived from classic precedent. It also serves to teach the student the principles and methods of architectural drawing and rendering. Textbooks: *Esquié, Five Orders of Architecture; Gromort, Elements of Architecture.*

4·721, 4·722. Design II. A continuation of 4·712. Includes making preliminary sketches, in a period of nine hours for a given program, and developing these sketches to a final result in a period of from four to five weeks. Also includes sketch problem exercises of nine hours duration.

4·731, 4·732. Design III. A continuation of 4·722. Extends the instruction in the principles of architectural composition to buildings of simple requirements and varied character. Includes making preliminary sketches in a period of nine hours for a given program, developing these sketches to a final result in a period of from four to five weeks, and also sketch problem exercises of twelve hours duration.

4·741, 4·742. Design IV. A continuation of 4·732, the problems in composition being more advanced. The system of preliminary sketches, developed problems and sketch problems is continued. Includes the preparation of the thesis required for the degree of Bachelor of Science in Architecture.

4·751, 4·752. Design V. 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 Master in Architecture.

4·80. Building Construction. Lectures and discussion planned to give the student a general understanding of the different types of building construction, the typical forms of elementary structures, and some idea of arrangements and proportions imposed by the use of different material.

4·811. Constructive Design. Devoted to the 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. Textbook: *Mimeograph Notes.*

4·812. Constructive Design. A continuation of 4·811 including simple steel framing, the plate girder, and the elements of design in reinforced concrete. Textbook: *Mimeograph Notes.*

4·90. Structural Drawing. Intended to supply the preliminary knowledge of structural steel shapes and familiarity with the use of steel handbooks necessary for the study of structural design, and to give some practice in drawing. Some elementary computation on the properties of sections is also included. Advantage is taken of opportunities to view the work of the template and fabricating shops in one or more visits to a structural steel plant. Typical shop drawings of a structural steel building frame are made, including the details of a plate girder. Textbook: *Mimeograph Notes.*

4·911. Structural Design. A consideration of fundamental problems in structural design with emphasis on the analysis of such problems and the adaptation to their solution of principles already acquired in the study of mathematics and applied mechanics. Elementary forms in wood, cast iron and steel are studied. Textbook: *Mimeograph Notes.*

4·912. Structural Design. A continuation of 4·911 including the analysis and design of a wooden roof truss. Textbook: *Mimeograph Notes.*

4·921. Structural Design. Problems in architectural construction, including general steel framing, the design of plate and box girders, with a careful analysis of the stresses in a shallow girder. Textbook: *Mimeograph Notes.*

4·922. Structural Design. A continuation of 4·921 including a heavy riveted truss and some consideration of wind resistance.

CHEMISTRY

Instruction in general Inorganic Chemistry is given to all students in regular Courses except that of Architecture, throughout the first year. The subject is designed not only to impart a knowledge of the principles of the science and of the descriptive chemistry of the metallic and non-metallic elements, but to constitute an introduction to scientific methods of experimentation, observation and reasoning. Special effort is, therefore, made to impress upon the student the importance of neatness, accuracy and thoughtfulness in connection with his laboratory practice, and to point out the value for later professional work in all courses of intelligent observation and ability to interpret the meaning of observed phenomena.

The instruction in chemical subjects is continued in the Courses in Chemistry, Physics, Biology and Public Health and Geology, and in those of Mining, Sanitary, Electrochemical and Chemical Engineering and in Option 3 of the Course in Engineering Administration. It includes Analytical, Theoretical, Organic and Industrial Chemistry, as well as opportunity for elective courses in such specialized lines as gas, oil, air, water, food, sugar and proximate technical analysis and metallography. In all of these subjects classroom instruction is combined with laboratory work. Students in the course in Chemistry devote, as a rule, more time to these subjects than students in other courses, and their work is, accordingly, somewhat more advanced.

Opportunities for research work under the direction of the instructors in the various branches enumerated above are unusually extensive, and the general and special laboratories are well equipped for advanced work of this character.

The aim throughout all the courses of chemical instruction is to teach the student self-reliance, to inculcate habits of accurate thought and work, and to afford a scientific education that will fit him to cope successfully with new scientific and technical problems.

Subjects 5·00 to 5·99 (see page 59).

5·00. Chemistry (Entrance). Course consisting of lectures, recitations and laboratory work given during the summer covers the entrance requirement in Chemistry. (For description see page 80.)

5·01, 5·02. Chemistry. The fundamental principles of chemical science and the descriptive chemistry of the more common elements and their important compounds.

Those students who have elected courses in which chemical subjects are continued beyond the first year are given a laboratory course in synthetic inorganic chemistry, while students taking the other courses devote their time to a study of certain special applications of chemistry to engineering problems. Textbook: For the Chemical group: *Blanchard and Phelan, Synthetic Inorganic Chemistry.* For the Engineering group: *Norris, A Textbook of Inorganic Chemistry for Colleges.*

5.04S. Chemistry. Lectures on the fundamentals of inorganic chemistry. A study of the more common elements and of their compounds serves as a basis for discussion of the underlying principles of the science. Processes of manufacture of the more common chemical substances are discussed in detail. Covers in abbreviated form the subject matter of Chemistry 5.01 and 5.02. Textbook: *J. W. Mellor, Modern Inorganic Chemistry.*

5·06. Inorganic Chemistry. Aims to study in a comparative and systematic way the physical and chemical properties of the elementary substances and their more important compounds. Relationships indicated by the periodic system and the electromotive series are emphasized, and the effects which accompany change in valence are discussed. About half of the time is devoted to a consideration of the more important theories based upon recent investigations in inorganic chemistry.

5·08. Preparation of Inorganic Compounds. Some of the interesting compounds not usually mentioned in elementary courses on inorganic chemistry are discussed and prepared. Considerable attention is paid to Werner's Valence Theory and its adaptation to the electronic theory. In the conferences, students report on the methods of preparing typical substances and upon the theoretical aspects. Undergraduate students will be permitted to take the subject, if they desire.

5·09. Theories and Applications of Catalysis. The lectures will include a critical discussion of our present knowledge regarding the mechanism of catalysis and factors involved in the choice and use of catalysts for industrial and laboratory processes. Details may be obtained by consulting the instructor.

5·10. Qualitative Analysis. Intended to emphasize the principles involved in chemical analysis, to broaden the student's knowledge of inorganic chemistry, to develop deductive reasoning power and to give practice in manipulation. After a series of preliminary experiments, illustrating principles and giving practice in writing equations, the student is required to analyze unknown industrial products such as minerals, pigments, slags and alloys. The student reports not only upon his qualitative results, but also upon the proximate amounts of each element present. Not only is the educational value of the course broad, but it serves as a necessary introduction to the study of quantitative analysis. Textbooks: *Qualitative Analysis, A. A. Noyes; Analytical Chemistry, Vol. I, Treadwell-Hall.*

5·101. Qualitative Analysis. Similar to 5·10 except for reduction in the hours of laboratory exercise. Textbooks: Same as for 5·10.

5·11. Qualitative Analysis. Abridgment of 5·10 designed for students not specializing in chemistry. Textbooks: Same as for 5·10.

5·12. Elementary Quantitative Analysis. The work is regarded as a preliminary training for the more advanced work and the time is spent upon simple volumetric and gravimetric analyses which are typical of the subdivisions of the subject. Great stress is laid upon the accuracy, care and integrity necessary for successful quantitative work, and, as in the instruction in Qualitative Analysis, the chief endeavor is to promote thoughtful and intelligent workmanship. Special attention is given to stoichiometry and modern theories of solutions as applied to quantitative analysis. Textbooks: *Quantitative Analysis, Talbot; Calculations of Analytical Chemistry, Hamilton and Simpson; Analytical Chemistry, Vol. II, Treadwell-Hall.*

5·121. Quantitative Analysis. Similar to 5·12 with slightly increased time assignment. Textbook: Same as for 5·12.

5·13. Quantitative Analysis. A continuation of 5·12 dealing with the analysis of silicates, minerals, ores and alloys, and including volumetric, gravimetric, electrolytic and electrometric methods. The principles involved in the methods of analysis are discussed in detail and the application of these principles to problems other than those being carried out by the student in the laboratory are also considered. Textbook: Same as for 5·12.

5·131. Quantitative Analysis. Similar to 5·13 with slightly decreased time assignment and including some instruction in elementary gas analysis. Textbook: Same as for 5·12.

5·132. Quantitative Analysis. Abridgment of 5·131.

5·14. Industrial Applications of Quantitative Analysis. A lecture and recitation course designed primarily to fit the student to judge intelligently of the adaptability of certain quantitative methods to research and industrial work, to discuss the accuracy of the methods and to interpret the results, rather than to furnish detailed directions for specific analyses. Also to bring about a proper appreciation of the relation of Qualitative Analysis to Quantitative Analysis and for general instruction in sampling, specifications, control methods, costs of analysis and interpretation of results. Textbook: *Special Notes and References.*

5·16. Analytical Chemistry. Arranged for fourth year students who are admitted to X–A. The lectures give instruction in special analytical processes which are met with in plant practice. The laboratory work affords experience in rapid, accurate, commercial methods and is designed to train a small group of students to carry on efficiently a large number of analyses of the same kind without special or expensive apparatus, and to meet laboratory conditions of the practice school in X–A. Textbook: *Special Notes and References.*

5·17. Methods of Electrochemical Analysis. The theoretical and practical applications of electrochemical analysis, including electrolytic separations, conductometric and potentiometric determinations and some electrolytic syntheses.

5·18. Advanced Qualitative Analysis. Includes the testing of methods and procedures used in the detection of the less common elements, such as tungsten, vanadium, molybdenum, palladium, cerium, etc., which are not provided for in the usual schemes of qualitative analysis. Some commercial products containing these rarer elements are analyzed and particular attention paid to the interpretation of the results.

5·191. Chemical Literature. The purpose of the subject is to encourage the reading of current chemical literature in German and French. A textbook in German is used as a basis for most of the recitations and particular attention is paid to the chemical meanings rather than to the exact literal translation. Students are required to read current articles in both French and German periodicals and make reports on the chemistry involved. Some practice is given in looking up chemical topics in the literature.

5·192. Chemical Library Technique. Designed to acquaint the student with the journals, books, patents, government reports, etc., which are available to the chemist as sources of recorded chemical knowledge and to teach him how to use them efficiently and effectively. In addition to the survey of the literature of general, inorganic, organic, theoretical and industrial chemistry, instruction in modern library practice and methods of abstracting and indexing will be offered, illustrated with numerous practical problems to give opportunity for training in the actual use of library facilities.

5·20. Water Supplies. Laboratory practice in the chemical examination of potable waters and of sewages; and lectures in which the methods of analysis and the sanitary significance of the results are discussed. Textbook: *Woodman and Norton, Air, Water and Food.*

5·21. Industrial Water Analysis. A study of the methods of selection and treatment of water for industrial purposes. Special attention is given to the analysis and treatment of boiler waters.

5·22. Water Supplies and Wastes Disposal. The chemical problems involved in modern methods of selection and treatment of potable waters and the disposal and the purification of wastes. Textbook: *Woodman and Norton, Air, Water and Food.*

5·25. Chemistry of Foods. An introduction to the methods generally employed in determining the character, purity and nutritive value of common food materials. The fundamental basis of nutrition, as well as the extent, character and legal status of food adulteration are discussed, and analyses made of typical food products. Textbook: *Woodman, Food Analysis.*

5·251. Chemistry of Foods. Abridgment of 5·25.

5·26. Food Analysis, Advanced. Illustrates the manner of attacking the chemical problems arising in connection with State and municipal food control. In addition to the laboratory practice, each student is expected to present in conference a detailed written report concerning some particular food material, its forms of adulteration and the most rapid as well as systematic method of detecting them, accompanied by actual figures obtained in the laboratory. Some attention is devoted also to the system of food inspection and to a critical study of methods of food analysis. Textbook: *Woodman, Food Analysis.*

5·27. Chemistry of Plant and Animal Life. The physical and chemical properties of substances occurring in plants and animals, such as fats, carbohydrates, proteins, purin and pyrimidine derivatives, anthocyanins, and alkaloids will be considered, together with the chemical reactions by which these substances are synthesized and the changes of composition which they undergo. The physicochemical phenomena of osmotic pressure, of adsorption, of diffusion and of the colloidal condition will be discussed. Catalysis, neutrality of cell contents, chemical coördination, chlorophyll, hæmoglobin, fertilizers, chemotherapy, chemical structure and pharmacological action, the proximate analysis of plant and animal products, and the elements of toxicological analysis will also be considered. Reports on assigned topics will be required.

5·29. Optical Methods. Standardization of saccharimeters by quartz-plate readings; determinations of specific rotary power, double polarization, the quotient of purity; and practice in the calculations of optical analysis, with special reference to the use of the polariscope and refractometer as applied to sugars, starches, essential oils and the like. Textbook: *Rolfe, The Polariscope in the Laboratory.*

5·30. Proximate Analysis. The student selects a subject, consults the literature relating to it, presents the results of his reading before the class for criticism and suggestion, and then applies the method as thus worked up, in the laboratory. Among the topics studied are alkaloids, asphalt, oils of all kinds, paints, paper, inks, rubber, soaps, tanning materials and the like. The subject is designed to develop a critical spirit of investigation, rather than merely to study the technique of analytical methods.

5·31. Gas Analysis. Considers the qualitative and quantitative analysis of the various gases, the technical analysis of commonly occurring gaseous mixtures, such as illuminating and fuel gas, gases from acid chambers and chimney gas, and the consideration of losses due to waste gases. Textbook: *Gill, Gas Analysis for Chemists, or Gas and Fuel Analysis for Engineers.*

5·32. Gas Analysis. The analysis of gases, with the use of methods and apparatus which admit of a high degree of precision.

5·33. Study of War Gases. Embraces the manufacture and testing of the different war gases and of absorbents therefor.

5·34. Engineering Chemistry. Designed to give the engineer an insight into the chemistry involved in the production and use of illuminating gas, alcohol, paper, ink, leather, rubber, animal, vegetable and mineral oils, paints, varnishes, starch, sugar and explosives. See also G79. Textbook: *Rogers, Elements of Industrial Chemistry or Thorp, Outlines of Industrial Chemistry.*

5·35. Applied Chemistry. Properties, testing and applications of paints, oils, varnishes, lubricants and wood preservatives. Alloys, bearing metals, boiler scale and corrosion of metals are also discussed.

5·37. Chemistry of Road Materials. For civil engineers, dealing with the applications and tests of bitumens, tars, oils, paints and chemicals used in the preservation of roads and road structures. Textbook: *Blanchard, Highway Engineers' Pocket Book.*

5·38. Lubricating and Fuel Oil Testing. Covers the physical and chemical testing of the mineral, animal, and vegetable oils, to determine their applicability and safety, from the point of view of the user, the manufacturer and of the insurance underwriter. Distillation and other tests are applied to the motor fuels. The means of detecting the adulteration of different oils and their technology are also discussed. Textbook: *Gill, Handbook of Oil Analysis.*

5·40. Special Methods. Use of the microscope, polariscope and saccharimeter, refractometer, viscosimeter, turbidimeter, nitrometer and precision centrifuge, and a study of their application to problems in technical practice. *Neostyled Notes.*

5·50. Organic Chemistry. (Brief Course.) For students who will not pursue the study of organic chemistry further; includes a general discussion of the most important facts in the chemistry of the compounds of carbon. The typical methods of preparation and the chemical and physical properties of the various classes of compounds are presented, and a brief account is given of the source and technical preparation of the simpler substances of commercial importance. Textbook: *Moore, Outlines of Organic Chemistry.*

5·501. Organic Chemistry. Lectures same as for 5·50 but includes in addition one conference-recitation hour per week.

5·51, 5·52. Organic Chemistry I. An extensive course in which the general principles of organic chemistry and the properties of important compounds receive thorough discussion. The lectures are fully illustrated by experiments. Textbook: *Norris, Principles of Organic Chemistry.*

5·511, 5·521. Organic Chemistry I. Closely associated with 5·51 and 5·52 and differing only in the greater emphasis placed upon compounds of military importance.

5·531, 5·532. Organic Chemistry II. For admission to this subject students must have completed satisfactorily a year's work in organic chemistry. The important principles of the science are emphasized from a more mature point of view than is possible when the subject is approached for the first time.

5·54. Organic Chemistry III. Primarily a graduate course. Supplements the instruction received by students who have the equivalent of Organic Chemistry I. Important topics, varied from year to year, are presented in lectures accompanied by assigned reading and discussion. In 1927–28 the chemistry of the heterocyclic compounds will be treated.

5·55. Organic Qualitative Analysis. A laboratory course for advanced students in the use of systematic methods for the identification of organic compounds, given in one or both terms.

5·56. Industrial Organic Chemistry. A comprehensive survey of the industries in which organic chemistry is employed. The use of chemical literature in following the course of recent investigations will be considered. Details may be obtained by consulting the instructor.

5·57. Powder and Explosives. The various types of propellent powder are considered, their history, manufacture, properties testing and manner of use. Initiators and commercial and military high explosives are discussed, particular emphasis being given to their chemical reactions and properties with reference to current theories of explosives.

5·571. Chemistry of Medicinal Products and Allied Topics. Brief discussion of the physiological effects of representative compounds for the purpose of aiding chemists and chemical engineers in exercising care when handling toxic materials. The constitution and methods for preparing important medicinal and pharmaceutical products will be described. Given in summer session only.

5·581. Synthetic Methods in Organic Chemistry. Advanced Organic Chemistry, a course in correlation designed to produce a familiarity with the kinds of phenomena exhibited by organic compounds.

5·582. Chemistry of Dyes. Illustrated lectures on the organic chemistry of the synthetic dyestuffs and their intermediates. Synthetic methods, physical, chemical and tinctorial properties, structure, classification, and the development of the color industry are systematically treated.

5·583. Catalytic and Electrochemical Methods in Organic Chemistry. The experiments include the preparation of organic compounds to illustrate most of the important types of catalysis, including oxidation, hydrogenation, dehydration, hydration, dehydrogenation, chlorination, polymerization, molecular decompositions, etc. Typical syntheses by the use of the electric current will also be carried out, with emphasis on the significance of factors such as the choice of electrodes, solvents, current density, etc. Directions for the experiments will furnish a brief account of the theoretical principles involved and the industrial significance of the reactions. Given in Summer Session only.

5·601, 5·602. Journal Meeting in Organic Chemistry. The instructing corps and graduate students in organic chemistry meet once a week to discuss current publications.

5·61, 5·62. Organic Chemical Laboratory. Includes practice in: (*a*) ultimate analysis — quantitative determinations of nitrogen and of carbon and hydrogen by the Dumas and Liebig combustion methods and the use of the Carius procedure in analyses for halogen; (*b*) organic preparations, which are designed to give familiarity with important syntheses and methods of manipulation; the application of theory to the work in hand is constantly emphasized by written study questions, oral quizzes and regular conferences with individual students; (*c*) identification of organic compounds — this work having a similar educational value to that afforded by qualitative analysis in the inorganic field; (*d*) the preparation of an important compound by means of a series of syntheses described only in chemical journals or reference books, this part of the course giving drill in the use of chemical literature and the planning of experiments.

5·611, 5·621. Organic Chemical Laboratory. These subjects are closely associated with 5·61 and 5·62, respectively, and differ from the latter only in the emphasis laid upon compounds of military value and in the time required.

5·612, 5·622. Organic Chemical Laboratory. In 5·612 the student performs a carefully planned course of experiments in which a detailed laboratory study of the typical reactions associated with each class of organic compounds is accompanied by synthetic work involving the preparation of some representative of each class. Course 5·622 is devoted to a systematic study of the methods for the identification of organic compounds both pure and mixed. In both courses the individual laboratory instruction is supplemented by a regular program of class conferences on the laboratory work.

5·613, 5·623. Organic Chemical Laboratory. Closely associated with 5·612 and 5·622 respectively and differs from it only in the emphasis laid upon substances of military value.

5·614, 5·624. Organic Chemical Laboratory. Laboratory practice illustrating both synthetic and analytical organic chemical methods, accompanied by conferences for discussion of work.

5·615. Organic Chemical Laboratory. Laboratory practice based upon theoretical instruction given in 5·50. The kind and quantity of work is widely varied, according to the professional course which the student is pursuing.

5·631, 5·632. Advanced Organic Laboratory Practice. Special methods. Synthesis. Includes catalytic reduction and dehydration, triphenyl methyl, use of ultra violet, micro experiment, etc. Illustrates principles discussed in 5·52. Questions are based on references to the literature.

5·64. Recent Advances in Organic Chemistry. An informal discussion of the history of organic chemistry during the twentieth century, particular attention being given to dominant tendencies in research and in theory.

5·651, 5·652. Chemical Principles I. Only the more important general principles of chemistry are considered, but these are treated with great thoroughness, and are illustrated by applying them to a variety of problems, which the students are required to solve. These problems are discussed in detail, the aim being to develop power to use the principles, rather than merely to impart a knowledge of the phenomena. The topics considered in the course are the pressure-volume relations of gases, the kinetic theory, the energy relations of gases, the properties of solution related to molal composition, the conduction of electricity in solutions, the ionic theory, the mass-action law applied to the rate and equilibrium of chemical changes, heterogeneous equilibrium from the phase-rule standpoint, and thermochemistry. The laboratory course serves to emphasize the principles of the subject, rather than to teach physicochemical methods of measurement; and for this reason it is closely correlated with the classroom work. The principles are, however, illustrated by the determination of physicochemical constants; for example, of vapor-density and molecular-weight, vapor-pressure, freezing-point, transference-numbers, conductivity and ionization, of rates of reaction, of the equilibrium-constants of reactions between gaseous, dissolved, and solid substances, and of thermochemical constants. In the case of students in Course X certain subjects may be dealt with more briefly, and the time thus gained devoted to the consideration of the maximum work obtainable from chemical changes and its relation to the equilibrium conditions of such changes. Special emphasis is placed upon the effect of temperature on chemical equilibrium. Textbooks: *Noyes and Sherrill, An Advanced Course of Instruction in Chemical Principles; Sherrill, Laboratory Experiments on Physico-Chemical Principles.*

5·66. Chemical Principles. A continuation of 5·652, conducted in the same general way. The principles of electrochemistry and of thermodynamic chemistry are developed from the free-energy viewpoint. The topics considered in electrochemistry are: the electromotive force of voltaic cells and the separate electrode and liquid potentials which constitute it; electrode-potentials in relation to the equilibrium of oxidation and reduction reactions; electrolysis in relation to electromotive force; and concentration and gas polarization. In thermodynamic chemistry the free-energy decrease attending isothermal chemical changes, or the maximum work obtainable from them, is considered in relation to the equilibrium conditions of such changes; and from the effect of temperature on free energy is derived its effect on chemical equilibrium. Textbooks: *Noyes and Sherrill, An Advanced Course of Instruction in Chemical Principles; Sherrill, Laboratory Experiments on Physico-Chemical Principles.*

5·671, 5·672. Chemical Principles. Open only to graduate students from other colleges who have already taken a descriptive course in physical chemistry, which is not accepted as the equivalent of 5·652. Especial emphasis is placed on the practical application of principles, as illustrated by problems, which the students are required to solve. The subject matter corresponds to that described under 5·651, 5·652 and 5·66, but is adapted to the more advanced viewpoint of the graduate student. Textbook: *Noyes and Sherrill, An Advanced Course of Instruction in Chemical Principles*

5·68, 5·681. Thermochemistry and Chemical Equilibrium. The more important principles of physical chemistry. The topics considered are the pressure-volume relations of gases, solutions, elements of thermochemistry, the phase rule, the mass-action law applied to homogeneous and heterogeneous equilibria, the effect of pressure and of temperature on chemical equilibria, the elements of electrochemistry and the energy obtainable from chemical change. These principles are illustrated and emphasized by numerous problems.

5·69. Surface and Colloid Chemistry. The physical and chemical characteristics of gas-liquid, gas-solid, liquid-liquid, and liquid-solid interfaces are studied from the points of view of thermodynamics and of molecular orientation. The kinetic theory and the surface properties of colloids are studied.

5·701, 5·702. The Logic of Scientific Inquiry. The seminar is devoted to a discussion of the methods which are used in making an inquiry into the phenomena of nature, to a discussion of the uses of reasoning and of the relations between logic and experiment. Members of the group are admitted to the course after consultation with the instructor in charge.

5·71. Physical Chemistry Seminar. The classes are of an informal nature and include discussion of the assigned reading. Many topics are brought up to date by assignments in the current literature. Certain topics chosen entirely outside of the text are considered in relation to physical chemistry as a whole. The subject is given only in case a sufficient number of students apply in time to arrange for it. Textbook: *Taylor, Treatise on Physical Chemistry.*

5·721, 5·722, 5·723. Thermodynamics and Chemistry. Mainly for students taking physical chemistry as a major. A good command of elementary physical chemistry pre-supposed. The laws of thermodynamics are applied to develop equations for the treatment of chemical reactions, and of equilibria in chemical systems. Especial attention is drawn to Maxwell's relations and to Gibbs' chemical potential. Considerable practice is given in the manipulation and interpretation of the differential equations by the solution of problems.

In the second term (5·722, 5·723) the Gibbs theory is further developed with applications to surface tension, effects due to a gravitational field, and to the effect of pressure on chemical equilibria of real gases. The phase rule is discussed in its theoretical and experimental aspects and applied to various types of heterogeneous equilibria. Special attention is given to phase diagrams of binary mixtures, and to the Gibbs surface. Reference books: *Gibbs, Thermodynamics; Roozeboom, Die heterogenen Gleichgewichte; van Der Waals, Thermodynamik.* Textbook: *MacDougall, Thermodynamics and Chemistry.*

5·73. Free Energy. Planned especially for graduate students who do not take physical chemistry as a major. A systematization of the free energy changes attending the formation of chemical substances in different states at a given temperature is developed through a consideration of the laws of thermodynamics, including the constant entropy principle (or so-called third law of energy). The practical use of such free energy values in determining the equilibrium conditions of chemical reactions at different temperatures is illustrated by definite problems. There is also included a brief consideration of the ion-attraction theory of strong electrolytes. Textbooks: *Neostyled Notes; Lewis and Randall, Thermodynamics and the Free Energy of Chemical Substances* (for supplementary study).

5·741, 5·742. Kinetic Theory of Gases, Liquids and Solids. Those ideas and theories are discussed which seek to account for the physical properties of substances from a kinetic point of view. Given every alternate year. (Will be offered in 1927–28.) Textbook: *J. H. Jeans, Dynamic Theory of Gases.*

5·75. Atomic Structure. The indications concerning the nature of the atom, shown by researches in radiation, radioactivity and allied fields are outlined in an essentially non-mathematical manner.

5·761, 5·762. Sub-Atomic Chemistry. Extends throughout the year and considers the structure of the atom and the classification of the physical and chemical properties of substances in terms of atomic structure.

5·771, 5·772. Conference on Physical Chemistry. The investigations in progress in the Research Laboratory of Physical Chemistry, and the current literature in physical chemistry, are presented and discussed by students and members of the laboratory staff.

5·78. Thermodynamics. The principal general equations of thermodynamics from the entropy point of view are developed. The aim throughout is to emphasize the fundamental and general aspects of thermodynamics.

5·79. Radiation Chemistry. A brief course in atomic structure based on the nature and behavior of radiations emitted by atoms either spontaneously (as in radio-active decomposition) or when suitably excited by some physical agency. Definite problems serve to emphasize the quantitative aspects of the subject. Textbooks: *Neostyled Notes; Crowther's Ions, Electrons and Ionizing Radiations* (for supplementary study).

5·81. Organic and Explosives Laboratory. Organic chemistry closely associated with 5·62 and in the preparation and testing of explosive substances. Analysis of black powder and smokeless powder, preparation of picric acid, TNT, tetryl, etc., heat-test, etc. The subject familiarizes the student officers with the chemical and physical properties of explosives and with the methods by which the properties are examined.

5·82. Physical Chemistry. Elementary work in which special emphasis is placed upon selected topics in physical chemistry which are of interest to engineers; such as the application of X-rays to crystalline structure, metallography. Textbook: *Millard, Physical Chemistry for Colleges, second edition.*

5·83. Elements of Chemical Theory. (A brief course for biological students.) Rather than to present a mass of detail, the primary aim is to present the fundamental concepts and principles of physical chemistry so as to enable the student to gather and to interpret further needed material, by intelligent self-study. Certain special topics, however, are discussed in detail: such as the numerical solution of physical-chemical equations, criteria for detecting chemical change, hydrogen electrode and indicator applications and the Donnan Equilibrium. Notation of the differential calculus will be used without requiring technical skill in the use of mathematics.

5·84. Quantum Theory Applications. The historical development and applications of the quantum theory to problems in physics and chemistry. Material for discussion will be taken from the text named below, supplemented by various articles and monographs. Given in alternate years. Textbooks: *Sommerfeld's Atomic Structure and Spectral Lines; Crowther's Ions, Electrons and Ionizing Radiations.*

5·85. Theory of Solutions. A study of recent attempts to relate the properties of solutions to those of the components with special emphasis on solutions of strong electrolytes. Given in alternate years. Not offered in 1927–28.

5·91. Organic Physical Chemistry. Lectures and discussions on the application of physical measurement to problems in Organic Chemistry.

5·93. History of Chemistry. An historical study of the development of the science and of the life and work of the great men who have contributed to this development. The student is required to do extensive reading and to make reports upon the details of classic investigations.

5.951, 5.952. Research Problem and Thesis. The laboratory problems assigned are of the nature of minor researches, which are intended to give the student an opportunity to test his ability to do work of an original character. In connection with this work carefully written reports are required for the journal literature relating to the topic in hand, and a formal record of results obtained in the laboratory must be presented for acceptance. The student may select a problem in inorganic, organic or physical chemistry, as he may prefer.

5·96. Thesis Reports. Classroom exercises at which students are required to report upon the progress of the investigations upon which their theses are to be based. These reports are subject to criticism and suggestion from members of the class and of the instructing staff.

5·98. Research. The research required as a part of the requirements for any of the advanced degrees may be taken in any of the following divisions of the Department: inorganic, physical or organic chemistry.

5·991, 5·992. Research Conferences in Physical and Organic Chemistry. The investigations in progress in the department are presented for discussion.

ELECTRICAL ENGINEERING

The instruction in Electrical Engineering aims to give a foundation in those principles of electricity and magnetism upon which rest the development and the advancement of the electrical arts. Coördinated with this instruction in the theory of electricity and magnetism, and enforcing it, are courses on the larger problems of engineering, together with the work in the laboratories, embracing a study of the instruments, methods, and plant used in modern electrical engineering practice, special emphasis being laid on a study of sources of error, economy of time, and precision of results.

The unusually extensive equipment of the Augustus Lowell Laboratory of Electrical Engineering makes it possible to familiarize the undergraduate student with the various types of apparatus and the engineering methods with which he will be brought into contact in his later professional work, and also affords opportunity for graduate students to carry out original investigations. The latter opportunities are enhanced by the large libraries and research laboratories of the Department.

Excursions to important industrial works with which the vicinity of Boston abounds keep the students in touch with present practice in electrical engineering.

In Course VI-A the instruction and experience in shop processes and shop management are added to the scientific instruction of Course VI.

The Option in Electrical Communication is exhibited on page 94.

Subjects 6·00 to 6·99 (see page 59).

6·00. Principles of Electrical Engineering (Electric, Dielectric and Magnetic Circuits). Recitations and problems. Fundamental concepts of electrical engineering and the laws of the electric, dielectric and magnetic circuits. Textbook: *Timbie and Bush, Principles of Electrical Engineering.*

6·01. Principles of Electrical Engineering (Direct-Current Machinery). Recitations and supervised problem work. Mathematical and physical interpretation of the principles underlying the design, construction and performance of Direct-Current Machinery. Textbooks: *Langsdorf, Principles of Direct-Current Machines.*

6·01T. Principles of Electrical Engineering. (Direct Current Machinery). Recitations and supervised problem work. Principles underlying the construction and performance of direct-current machinery.

6·02. Principles of Electrical Engineering (Alternating Currents and Alternating-Current Machinery). Recitations and supervised problem work. Mathematical and physical interpretation of Alternating Currents and Alternating Current Machinery, including vector representation, use of complex quantities, effective values, power, non-sinusoidal waves, series circuits, single-phase alternating currents, polyphase alternating currents, and the transformer. Textbooks: *Lawrence, Principles of Alternating Currents; Lyon, Problems in Electrical Engineering; Lawrence, Principles of Alternating-Current Machinery; Lyon, Problems in Alternating-Current Machinery.*

6·021. Electrical Engineering Principles. First half of 6·02.

6·023. Electrical Engineering Principles. Last half of 6·02 and all of 6·031.

6·03. Principles of Electrical Engineering (Continuation of Alternating Current Machinery, Electrostatic Circuit). Recitation and supervised problem work. Discussion of the different types of alternating-current machinery for the generation and distribution of power. Last five weeks: principles of electric power transmission and distribution. Recitations and supervised problem work. General statement of problem, statistics, calculation of line constants, and solution of short line problems. Textbooks: *Lawrence, Principles of Alternating-Current Machinery; Lyon, Problems in Alternating-Current Machinery; Woodruff, Principles of Electric Power Transmission and Distribution.*

6·031. Electrical Engineering Principles. Recitations and supervised problem work. Study of the synchronous generator, the synchronous motor, and parallel operation of synchronous generators. Textbooks:

Lawrence, Principles of Alternating Current Machinery; Lyon, Problems in Alternating Current Machinery.

6·04. Principles of Electrical Engineering (Electric Power Transmission and Distribution). Recitations and supervised problem work. 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. Textbook: *Woodruff's Principles of Electric Power Transmission and Distribution.*

6·043. Principles of Electrical Engineering. Lectures and recitations. Brief review of the transformer, the synchronous generator, the synchronous motor and the induction motor. Study of electric power transmission and distribution, including calculation of line constants, skin effect, corona, insulator stresses, solution of short and long line problems, inductive interference. (Open only to students at the General Electric Company.) Textbook: *Woodruff's Principles of Electric Power Transmission and Distribution.*

6·06. Principles of Electrical Engineering (Electric and Magnetic Circuits). Recitations and supervised problem work. Fundamental concepts of electrical engineering and the laws of electric and magnetic circuits. Textbook: *Timbie and Bush, Principles of Electrical Engineering.*

6·07. Principles of Electrical Engineering (Direct-Current Machinery and Alternating Currents). Recitations and supervised problem work. Principles underlying the construction and performance of direct-current machinery, and an introduction to the theory of alternating currents. Textbooks: *Langsdorf, Principles of Direct-Current Machinery; R. R. Lawrence, Principles of Alternating Currents; W. V. Lyon, Problems in Electrical Engineering.*

6·08. Principles of Electrical Engineering (Alternating-Currents and Alternating Current Transformer). Recitations and supervised problem work. Theory of single and polyphase alternating currents and of the alternating current transformer. Textbooks: *R. R. Lawrence, Principles of Alternating Currents and Principles of Alternating-Current Machinery; W. V. Lyon, Problems in Electrical Engineering and Problems in Alternating-Current Machinery.*

6·09. Principles of Electrical Engineering (Alternating-Current Machinery and Electric Transmission). Recitations and supervised problem work. Continued study of alternating-current machinery and problems involving local distribution networks carrying heavy currents. Textbooks: *Lawrence, Principles of Alternating Current Machinery; Lyon, Problems in Alternating Current Machinery.*

6·105. Principles of Electrical Engineering (Alternating-Current Principles). First part of 6·03. Given at works of coöperating company.

6·106. Principles of Electrical Engineering (Alternating Current Machines, Transmission). Last part of 6·03 and first part of 6·04.

6·107. Principles of Electrical Engineering (Transmission). Last part of 6·04. Given at the works of the coöperating company.

6·115. Principles of Electrical Engineering (Alternating Current Machines). Last part of 6·03.

6·116. Principles of Electrical Engineering (Transmission). First part of 6·04. Given at the works of the coöperating company.

6·117. Principles of Electrical Engineering (Transmission). Last part of 6·04.

6·121. Principles of Electrical Engineering. A part of 6·03, concluding Alternating-Current Machinery.

6·122. Principles of Electrical Engineering. Equivalent to a part of 6·03.

6·123. Principles of Electrical Engineering. A part of 6·03, concluding Alternating-Current Machinery.

6·20. Power Transmission Equipment. Construction and characteristics of the equipment employed in the transmission of electric power and application to transmission line design.

6·21. Industrial Applications of Electric Power. Lectures on electric motor drive, electric lighting and electric heating in industrial plants and for industrial purposes. Problems involve handling of materials and machining of metals, with consideration of duty cycles and economics of motorization.

6·221. Central Stations. Lectures dealing with the theoretical electrical principles and economic considerations influencing the generation of electric power. The generating station is studied as regards influence of bus layout and reactor location on synchronizing power, limitation of short circuit currents, maintenance of bus voltage and transfer of power under normal operating conditions; the operation of synchronous machinery under short circuit conditions; principles of relay selection and applications for generating stations; factors influencing selection of electrical equipment.

6·222. Central Station Design. Lectures dealing with thermal principles and economic considerations influencing the generation of electric power. The generating station is studied with regard to those factors which influence the energy consumption per unit of electrical energy output; the layout and calculation of heat balance and flow diagrams; the economic considerations affecting the selection of site and machinery and arrangement of plant; the physical layout of the electrical bay, turbine plant and boiler plant; the layout and design of the cell structure for the electrical equipment; study of load curves; and analysis of the cost of electric energy and studies of rate schedules.

6·23. Electrical Equipment of Buildings. Lectures on the design of electric wiring, lighting and elevator systems for buildings. Textbook: *Cook, Interior Wiring.*

6·24. Electric Railways. An introductory course of lectures and recitations covering the application of electric power to local and trunk line transportation. Essential calculations are made, such as speed-time curves, energy consumption and simple distribution layouts. Various systems, service requirements and existing electrifications are also discussed from economic and engineering viewpoints.

6·251. Electric Machinery Design. Direct-current machines and alternating-current transformers. Materials of construction, methods of construction, and the influence of the various factors of design on manufacture and operation of machines are considered.

6·252. Electric Machinery Design. Design of synchronous and induction machinery, primarily a continuation of 6·251 but also complete within the term.

6·27. Illumination. Lectures and discussions, dealing with production, measurement and utilization of light together with a survey of the bearing of lighting on industrial production, sanitation and factory welfare, industrial codes, street lighting and headlighting. Textbook. *Cady and Dates, Illuminating Engineering.*

6·281. Principles of Wire Communication. The problem of transmission over long lines with distributed constants in the steady state, including composite and loaded lines. Exchange area and toll transmission, repeaters, balancing networks, elementary filters and carrier telephony.

6·282. Principles of Radio Communication. Elementary theory underlying radio-communication. Circuits under free and forced vibrations are discussed with special emphasis upon their applications to radio. High-frequency power sources are described and some attention is given to the thermionic oscillator as a power source. Detection and amplification by present methods are studied in some detail. Some time is spent on general applications of thermionic tubes.

6·29. Storage Batteries. Theory, construction, care and application of storage batteries. Fifteen lectures. Given in one term of fourth year if applied for by six or more students.

6·301. Principles of Electrical Communication. Principal systems of telephony in practical use with reference to the principles and modes of operation. Steady state transmission over lines with uniformly distributed coefficients.

6·302. Principles of Electrical Communication. Intended to familiarize the student with the fundamental problems of telegraphic and radio-communication. Covers in a general way the behavior of various types of telegraph circuits such as the simplex, duplex, diplex, multiplex and composite. Emphasis is placed upon the behavior of elementary circuits in the transient state with special reference to the conditions met with in signalling. It covers in an elementary way the radio-transmitting set, its purpose and operation, and the receiving set, its purpose and operation. Some time is spent on general elementary net-work theory and upon electrostatics and systems of electrical units as a preparation for the more advanced subjects to follow.

6·311. Principles of Electrical Communication. General treatment of the principles of ionic conduction in gases and in vacua. A comprehensive study is made of the characteristics of thermionic tubes and of gaseous conduction tubes in use today with special emphasis upon their engineering applications and limitations as circuit elements.

6·312. Principles of Electrical Communication. Alternating-current steady state transmission over uniform unloaded, loaded and composite lines; reflections; exchange area and toll transmission, repeaters, balancing networks, elementary filters, carrier telephony and inductive interference.

6·32. Principles of Electrical Communication. The general circuit theory as related to radio. Some time is spent in the discussion of high-frequency sources which is followed by a discussion of antennæ and radiation as related to electric wave propagation. Amplification and detection are treated in continuation of the studies in 6·311. The theory of radio measurements is discussed.

6·330. Communication Electrical Laboratory. Equivalent to 6·331.

6·331, 6·332. Communication Electrical Laboratory. Offers problems in the manipulation and study of various apparatus with a view to intimately associating the theoretical deductions with actual measured data. Among other things, it includes measurements on artificial lines and cables, and the determination of transmission equivalents of networks, measurements on filters, as well as on thermionic and gaseous conduction tubes, also radio-frequency measurements of resistance, inductance and capacitance extending to networks. Textbook: *Communication Laboratory Notes, Bowles.*

6·342. Electrical Communications, Principles of. Equivalent to last part of 6·302.

6·343. Electrical Communications, Principles of. First part of 6·312.

6·353. Electrical Communications, Principles of. Last part of 6·302 and first part of 6·311.

6·354. Electrical Communications, Principles of. Last part of 6·311.

6·355. Electrical Communications, Principles of. Similar to 6·312, but more comprehensive.

6·40. Elements of Electrical Engineering. Recitations and problems. Applications of the general principles of the electric and magnetic circuit to the generation, distribution and utilization of direct and alternating-current power. Textbook: *Hudson, Engineering Electricity.*

6·41. Elements of Electrical Engineering. Recitations and problems. Applications of the general principles of the electric and magnetic circuit to the generation, distribution and utilization of direct and alternating-current power. Textbook: *Hudson, Engineering Electricity.*

6·42. Elements of Electrical Engineering. Recitations and problems. 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. Textbook: *Hudson, Engineering Electricity.*

6·43. Generation and Distribution of Electric Energy. Lectures and problems dealing with the thermal, economic and electric principles of electric generating stations, the electric principles and economic considerations affecting the distribution of electric energy and an analysis of the cost of electric energy.

6·44. Electric Transmission and Distribution of Energy. Lectures and problems relative to an analysis of the electric circuit and the theoretical principles and economic considerations influencing the transmission and distribution of electric energy.

6·451, 6·452. Alternating Currents and Alternating-Current Machinery. Principles of alternating currents and alternating-current machinery with special reference to mechanical and naval problems. Given especially for students in Course XIII-A and adjusted each year to meet the requirements of these students. Textbook: *Electrical Engineering* (1925) *C. V. Christie, Reference Book; A Course in Electrical Engineering, Vol. II, C. L. Dawes.*

6·46. Industrial Applications of Electric Power. Similar in material to 6·21, but with considerably less outside preparation required.

6·47. Central Stations. Lectures and problems dealing with the thermal, economic and electric principles of steam electric generating stations and the electric principles and layout of hydro-electric generating stations.

6·501, 6·502. Electrical Engineering Seminar. A series of papers and conferences of the junior instructing staff and of students who are candidates for advanced degrees in electrical engineering, held for the purpose of reviewing the development of the arts and sciences relating to electrical engineering, and studying the trend of their advancement and particularly the effect of scientific research.

Much attention is given to the reactions observable between scientific discoveries and the practice of design, manufacture, operation and management and also the reactions observable between scientific and social development.

A collateral object of the subject is to impress upon the members of the seminar the most effective methods of collecting, analyzing, and presenting data and conclusions in a comprehensive technical subject.

6·511. Electric Circuits. Methods of solving problems concerning power networks. The theory of multi-circuit transformers. Treatment of unbalanced circuits by the method of symmetrical components with applications. The introduction and effect of harmonics with particular reference to the harmonics caused by transformers. A comprehensive graphical treatment of transmission systems, particularly in a steady state.

6·512. Electric Circuits. The problem of the maintenance of synchronism in, and the behavior of the machines connected to, a transmission system during disturbances. A comprehensive exposition of analytical and graphical methods for the determination of power limits and stability. Analysis of transients in lumped circuits with constant and variable parameters. Discussion of some of Heavyside's, Wagners' and Carson's formulæ. Traveling waves on lines, over-voltage due to surges, reflections at junctions and terminals, and other matters relating to transients on long lines.

6·521. Advanced Alternating Current Machinery. Application of the method of symmetrical phase components to the study of synchronous and induction machines when operating in the steady state under unbalanced conditions. Determination of the heat loss developed in conductors embedded in slots when carrying alternating currents. The effect of stranding and of special shapes of conductor.

6·522. Advanced Alternating Current Machinery. Application of harmonic analysis to the synchronous and induction machine, particularly in regard to the distribution of flux in the air gap and its effect upon the generated e.m.f., the power developed, the iron losses and in causing vibration. Behavior of alternating current machines in the transient state under both balanced and unbalanced conditions. The effect of sudden changes in the terminal potential, such as produced by short circuit. Also the effect of sudden changes in the load torque.

6·531, 6·532. Organization and Administration of Public Service Companies. Lectures associated with a large amount of reading, studying of financial and operating statistics and forms of organization, and further associated with written dissertations by the students on important topics. The characteristics of corporations, their utility to society and the reasons for adopting this form of organization for public service companies. The general problems of the public service companies of various classes, including their best internal organization; the comparative features of operating companies and holding companies; the financial conditions in public service companies compared with those in ordinary businesses with which the general public is more familiar; the relations of assets; the turnover of capital, risks in the business, and available rewards to owners and employees; rates of charge for service, valuation of property limitations on rate of return to capital, the relation of financial reserves to investment in plant; the influence of the character of the organization and its personnel on economics of operation, on excellence and reliability of service, the duties of public utility companies and their public relations.

The intention is to give the students a knowledge of the characteristics, the place held in the national life by public service companies, to the extent needed by electrical engineers and others who have to do with engineering and administration in association with such companies.

6·541, 6·542. Power Stations and Distribution Systems. The theoretical principles and economic considerations relating to electric power generating stations and distribution systems; the limitation of short circuit currents, maintenance of voltage and stability; general theories and calculation of short circuit currents; the control and transfer of power under normal operating conditions as influenced by the bus layout of the generating station and sub-stations and the electrical layout of the system; principles of relay characteristics and their selection and application; secondary distributing networks; commercial economy of high pressure steam, reheating, regeneration and the use of mercury vapor and steam in conjunction; feed water heating for maximum thermal economy; layout and calculation of heat balances; considerations influencing station economy.

The theoretical work is supplemented by studies of electric power generating station and distribution system practice with regard to physical layout of the electrical bay of the generating station with three phase and isolated phase arrangement; indoor switching and transforming substations, and outdoor switching and transforming substations; layout and design of cell structure for electrical equipment; layout of turbine and boiler plant.

6·551, 6·552. Railroad Electric Traction. Aims to give thorough technical grounding in the fundamentals of railroad electric traction, with sufficient economic background to insure an appreciation of transportation in general and electrification in particular. Stress is laid on current developments at home and abroad.

The subject covers the equipment, operation and mechanical design of rolling stock; energy consumption and economy; study of distribution systems; preliminary estimates and proposition work involving the application of the principles discussed throughout the year. Specialized details of design are necessarily omitted.

6·561, 6·562. Principles of Electrical Communication. The first term covers the theory of electric filters, their design and application. Some time is spent introducing the subject in order to emphasize general network theory and to show the relation of such filters to their parallels in acoustics and optics.

The second term covers the more advanced study of electron tubes and their associations with electric circuits and apparatus. Emphasis is placed upon the graphical solution of certain typical problems.

6·57. Illumination. Reading and discussion of advanced problems in illumination.

6·58. Operational Calculus. A study of circuits by means of the Heaviside Operational Calculus with particular application to the problem of traveling waves on transmission lines, their attenuation, distortion, reflection and refraction.

6·591. Principles of Electrical Engineering (Electric Circuits). A graduate subject covering the last part of 6·04 and first part of 6·511.

6·592. Principles of Electrical Engineering (Electric Circuits). A graduate subject covering the last part of 6·511.

6·593. Principles of Electrical Engineering (Electric Circuits). A graduate subject covering the first part of 6·512; given at the works of the coöperating company.

6·601. Principles of Electrical Engineering (Electric Circuits). A graduate subject covering the first part of 6·511. Given at works of coöperating company.

6·602. Principles of Electrical Engineering (Electric Circuits). A graduate subject covering the last part of 6·511. Given at the works of the coöperating company.

6·603. Principles of Electrical Engineering (Electric Circuits). A graduate subject covering the first part of 6·512.

6·661 and 6·662. Principles of Electric Machine Development. Design of direct-current and alternating-current machines. The fundamental principles of the magnetic circuit, the circuits of heat flow and of air flow as exemplified in such machines. Predetermination of characteristics. The relation of changes in design to changes of the inductance of machines, and of the starting and pull-out torques of motors. The effect of shape of the pole face in alternating-current and direct-current machines. Methods of applying machine characteristics to the calculation of short-circuit currents. Methods of predetermining losses. Special construction to minimize losses. Special types of armature and field windings of direct-current machines (interpole windings, pole face windings, multiplex windings, and other special windings). Commutation. Regulation. Speed variation in motors. Various formulas are compared, their derivation studied, their agreement with tests investigated and rational improvements analyzed.

6·70, 6·71, 6·72. Electrical Engineering Laboratory. Study of technical electrical measurements and dynamo-electric machinery. For purposes of administration, the work is divided into two parts: (a) Technical Electrical Measurements. — The work in technical electrical measurements consists of ten exercises in the first term of the third year, seven in the second term of the third year and three in the first term of the fourth year (for 1927–28 only). Particular attention is given to tests to determine the character and behavior of the materials of electrical engineering under various circumstances and to the study of electrical measuring instruments. The laboratory exercises are supplemented by a series of conferences in which the general subject of technical electrical measurements is discussed. (b) Dynamo-Electric Machinery. — The work in dynamo-electric machinery consists of ten exercises in the first term of the third year, seven in the second term of the third year and eleven in the first term of the fourth year (for 1927–28 only). The tests in the third year include the determination of the characteristics, efficiency, regulation, and heating of direct-current machinery and transformers. In the fourth year tests for efficiency, heating, regulation and the like are made on alternating-current machines. The laboratory exercises are supplemented by conferences. Preliminary reports prepared in the classroom at specially assigned hours are submitted by students before performing each experiment in the laboratory. Textbooks: (a) *Laws, Electrical Measurements; Special Directions for Measurements Division.* (b) *Instructions for Students in Electrical Engineering Laboratory, Fifth Edition,* 1926; *Ricker and Tucker, Electrical Engineering Laboratory Experiments.*

6·73. Electrical Testing, Advanced. Opportunity is offered to advanced students to obtain additional training in electrical testing through the solution of special problems selected to meet the needs of the individual student.

6·74. Electrical Engineering Laboratory. The work is laid out in accordance with the needs of the individual student. It covers a variety of special problems on direct- and alternating-current machinery and transformers. Students are permitted to work out, if they choose, original problems approved by the instructor in charge.

6·75, 6·76, 6·77, 6·78. Electrical Engineering Laboratory. Laboratory exercises devoted to the study of technical electrical measurements and dynamo electric machinery. The subject matter is similar to that of 6·70, 6·71, 6·72. Textbooks: Same as for 6·70, 6·71, 6·72.

6·771. Electrical Engineering Laboratory.

6·772. Electrical Engineering Laboratory. Substantial equivalent of 6·71a and 6·72a.

6·782. Electrical Engineering Laboratory. A course of twelve experiments in alternating current machinery.

6·80. Electrical Engineering Laboratory. Intended for those students who desire to do more than the regularly required amount of undergraduate work in the Electrical Engineering Laboratory. The experiments are arranged to suit the requirements of the individual student.

6·81, 6·82, 6·83. Electrical Engineering Laboratory. Laboratory exercises devoted to the study of technical electrical measurements and dynamo-electric machinery. The subject matter is similar to that in 6·70, 6·71, 6·72.

6·85. Electrical Engineering Laboratory. Ten exercises designed to familiarize students with the elements of technical electrical measurements and with the characteristics and operation of the ordinary types of electrical machinery. Textbooks: *Ricker and Tucker, Electrical Engineering Laboratory Experiments; Instructions for Students in Dynamo Laboratory, Fifth Edition,* 1926.

6·86. Electrical Engineering Laboratory. Six laboratory exercises similar in subject matter to that of 6·85.

6·871, 6·872. Electrical Engineering Laboratory. Twelve experiments designed to illustrate the operating characteristics of the common forms of alternating current machinery and the execution of some of the more important acceptance tests. Textbooks: *Ricker and Tucker, Electrical Engineering, Laboratory Experiments; Instructions for Students in Electrical Engineering Laboratory, Fifth Edition,* 1926.

6·88. Electrical Engineering Laboratory. Study of electrical measurements and the testing of dynamo machinery. In electrical measurements the students calibrate portable indicating instruments of the types later used in the testing of dynamo machinery. Watt-hour meters and instrument transformers are also calibrated. The oscillograph is used to determine the wave forms in various circuits.

In the dynamo machinery laboratory, operating tests are made on shunt, series, compound and interpole motors, on shunt and compound generators singly and in parallel, on the balancer set and the three-wire system. The operating characteristics of the above are determined by means of load and no-load runs. Heat run acceptance tests are made. Transformers, alternators, induction and synchronous motors as well as other types are tested for performance characteristics.

Each laboratory exercise is preceded by a conference, and a preliminary report is prepared by the student. In the final report the student is required to analyze and explain the results obtained in the tests. Textbooks: *Ricker and Tucker, Electrical Engineering Laboratory Experiments; Instructions for Students in Dynamo Laboratory, Fifth Edition,* 1926.

6·89. Electrical Engineering Laboratory. Eight laboratory exercises similar in subject matter to that of 6·85. Textbooks same as 6·85.

6·901 to **6·905. Manufacturing Practice.** These numbers cover the manufacturing subjects taken by the coöperative students at the various plants of the General Electric Company. The major portion of the assignments are to the Lynn works and the remainder to the Schenectady, Pittsfield and Erie works of this company. 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

Machine Shop Training Room, Assembling and Inspecting. Armature Winding.

Drafting and Design, including work on Motors, Transformers and Turbines.

Foundry Practice.

Standardizing Laboratory and Meter Testing.

Direct-Current Motor Test.

Alternating-Current Motor Test.

Illumination Department.

Transformer Test.

Turbine Test.

Factory Production.

Air Compressors.

Power Plant.

Research in various departments including the Thomson Laboratories and Schenectady Research Laboratories.

These courses also include a series of weekly lectures on Manufacturing Methods given by the various heads of departments. Each student is required to submit a report on each lecture and these reports are read by the lecturer and by the English Department of the Institute.

6·901. Manufacturing Practice. First term's work at plant of General Electric Company.

6·902. Manufacturing Practice. Second term's work at plant of General Electric Company.

6·903. Manufacturing Practice. Third term's work at plant of General Electric Company.

6·904. Manufacturing Practice. Fourth term's work at plant of General Electric Company.

6·905. Manufacturing Practice. Fifth term's work at plant of General Electric Company.

6·911 to **6·935. Public Utility Practice.** The courses in Public Utility Practice are given by the Edison Electric Illuminating Company, the Boston Elevated Railway Company and Stone & Webster, Inc. The various departments to which the students are assigned are listed below in the approximate order in which the work is given.

Edison Electric Illuminating Company of Boston

Electrical Engineering Office.
Maintenance of Line Departments.
- Repair and Testing of Transformers.
- Locating and Repairing Trouble in Low and High Tension Lines, both Overhead and Underground.

Steam Division of Generating Department.
- Boiler Room, Repairs, Firing, Tests, Turbine Work and Operating.

Electrical Division of the Generating Department.
- Operating and Repairing Electrical Generating Equipment.

Sales Department.
- Office Methods.
- Rate Computing.
- Power Estimating and Commercial Engineering.

Installation Department.
- Testing and Repair of Meters.
- Maintenance of Street Lighting System.
- Installing and Maintaining Service to Customers.

Supply Department.
- Purchasing, Receiving, Inspecting and Shipping.

Standardizing and Testing Departments.
- Standardizing the various types of Electrical Equipment.
- Steam and Chemical Tests.
- Electrical Tests on Power House and Substation Equipment.
- Transmission Lines and Electrical appliances of all kinds.
- Scientific Research and Study covering the many Public Utility Problems.

Boston Elevated Railway Company

Department of Rolling Stock and Shops.
- Car House Pits.
- Rapid Transit Shops.
- Armature Shop.
- Machine Shop.
- Truck Shop.

Maintenance Department.
- Engineering Division.
- Architectural Division.
- Everett Car Shop.
- Tie Plant and General Yard.
- Accounting and Inspection.
- Surface Lines Division.
- Repairs, Installation and Welding, etc.
- Rapid Transit Lines.
- Track, Steel Maintenance and Erection Division.
- Signal Division.
- Building Division.

Transportation Department.
- Switchman, Conductor, Motorman.
- Time Table and Traffic.

Power Department.
- Wire and Conduit Division.
- Power Station and Substation.
- Electrical Engineering.

Miscellaneous Work.
- Civil Engineering.
- Mechanical Engineering.
- General Manager's Office.
- Special Work.

Stone & Webster, Inc.

Boston Office.
- Messenger Service.
- Drafting — Electrical, Steel, Mechanical, Concrete and Architectural Drawings.

Construction Department.
- Surveying, Foundations, Concrete Construction, Steel Work, Mechanical and Electrical Installations.

Statistical Department.
- Analyzing and Tabulating Data of Various Construction and Operating Projects.
- Cost Accounting.

Operating Department.
- Operation of Gas Plants, Electrical Power Plants, Experience in Boiler House, Generating and Switching Departments.

Special Assignment.
- Final Assignment will be in that department of the Company in which the student desires to specialize.

6·911. Public Utility Practice (Edison). First term's work at the plant of the Edison Electric Illuminating Company of Boston.

6·912. Public Utility Practice (Edison). Second term's work at the plant of the Edison Electric Illuminating Company of Boston.

6·913. Public Utility Practice (Edison). Third term's work at the plant of the Edison Electric Illuminating Company of Boston.

6·914. Public Utility Practice (Edison). Fourth term's work at the plant of the Edison Electric Illuminating Company of Boston.

6·915. Public Utility Practice (Edison). Fifth term's work at the plant of the Edison Electric Illuminating Company of Boston.

6·921. Public Utility Practice (Elevated). First term's work at the plant of the Boston Elevated Railway.

6·922. Public Utility Practice (Elevated). Second term's work at the plant of the Boston Elevated Railway.

6·923. Public Utility Practice (Elevated). Third term's work at the plant of the Boston Elevated Railway.

6·924. Public Utility Practice (Elevated). Fourth term's work at the plant of the Boston Elevated Railway.

6·925. Public Utility Practice (Elevated). Fifth term's work at the plant of the Boston Elevated Railway.

6·931. Public Utility Practice (Stone & Webster). First term's work at the plant of Stone & Webster, Incorporated.

6·932. Public Utility Practice (Stone & Webster). Second term's work at the plant of Stone & Webster, Incorporated.

6·933. Public Utility Practice (Stone & Webster). Third term's work at the plant of Stone & Webster, Incorporated.

6·934. Public Utility Practice (Stone & Webster). Fourth term's work at the plant of Stone & Webster, Incorporated.

6·935. Public Utility Practice (Stone & Webster). Fifth term's work at the plant of Stone & Webster, Incorporated.

6·941 to 6·945. Communications Practice. These numbers cover the Communications work taken by the coöperative students at the various plants and laboratories of the Bell Telephone System. About one-third of the time is spent in the Western Electric Company's plant at Kearny, N. J., and with the installation department in or near New York City, one-third with the New York Telephone Company, and one-third in the Bell Telephone Laboratories in New York City. The various assignments include the following.

Manufacturing:
- Shop Planning
- Scheduling Production
- Manufacturing Layouts and Rate Setting

Telephone Switchboard Installation

Telephone Operations:
- Testing and Maintenance of Switchboard and Station Equipment

Transmission, Testing and Maintenance

Traffic Engineering:
- Equipment and Building Engineering
- Development Studies and Design of Apparatus and Circuits for Wire and Radio Communication

Research Engineering Investigations and Laboratory Trials

6.941. Communications Practice. Manufacturing: Shop Planning, Scheduling of Production, Manufacturing Layouts and Rate Setting. Telephone Switchboard Installation.

6·942. Communications Practice. General View of Telephone Operations. Testing and Maintenance of Switchboard and Station Equipment. Transmission Testing and Maintenance.

6·943. Communications Practice. Traffic Engineering. Equipment and Building Engineering.

6·944. Communications Practice. Development Studies and Design of Apparatus and Circuits for Wire and Radio Communication.

6·945. Communications Practice. Research Engineering. Investigations and Laboratory Trials.

BIOLOGY AND PUBLIC HEALTH

The Department aims to prepare men for the following fields of professional work:

Public Health and Sanitation.	Food Technology.
Public Health Administration.	Fisheries Technology.
Industrial Hygiene.	Biochemistry and Fermentations.

In the professional work of this Department fundamental knowledge of chemistry and physics is indispensable by way of preparation, and the aim of the first two years is to supply this basic training as well as courses of a general cultural character. In the second year general biology is given, followed by zoölogy and botany, while in the third and fourth years, instruction in professional subjects is provided, chiefly for students of biology and public health, industrial biology, chemistry, sanitary engineering, geology, and general engineering. The subjects fall somewhat naturally into four groups: First, the *general biological*, including the fundamental subjects in biology, botany, zoölogy, anatomy, physiology and biochemistry; second, the *bacteriological* group, including general bacteriology and its professional and technical applications in the laboratory; third, the *public health* group, in which broad applications to community life and public and social welfare are considered. The fourth group includes the technical subjects of most importance in *food conservation* and manufacture. The aim of the instruction in the lower years is to give a solid foundation; in later years, to develop professional attainment.

The first option, public health, stresses the application of biology and bacteriology to individual and community health. It forms an excellent preparation for the varied and highly technical types of service in the municipal and state departments of health or in the great non-official health agencies; for research or technical positions in laboratories or in the manufacture of biologic products and for teaching. This course is especially recommended as a foundation for the study of medicine and gives excellent preparation for the best Class A medical schools.

The second option, industrial biology, is designed especially for those who wish to enter the broad field of food engineering or fermentation. Rapid development is taking place in fisheries, food preservation and fermentation industries, and bacteriology and biochemistry are essential subjects for men entering these fields. In the curriculum for Option 2, the subjects designated *a* meet the requirements of the fishery industries, while those marked *b* serve to prepare students for technical careers in the fermentation and packing industries in general. In this option, the departments of mechanical engineering and economics supply the necessary engineering and business subjects to fit men thoroughly for the industries to be served.

Subjects 7·00 to 7·99 (see page 59)

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. Textbooks: *Textbook of Zoölogy, Galloway and Welch, fourth edition; Textbook of Botany, Coulter-Barnes-Cowles, Vol. I.*

7·011. Methods of Teaching General Biology. Designed to give a fundamental knowledge of Biology as illustrated by the study of a simple plant and animal in contrast with a complex plant and animal. The course will briefly survey the plant and animal kingdoms by the actual study of carefully selected types.

In addition, excursions will be planned to near-by points rich in biological material.

The general plan followed is one which has been used with great success in Boston schools, and is designed especially to give teachers of biology suggestions and specific illustrations of the materials and the methods which have been found most satisfactory in high school teaching. Given in Summer Session only. Textbooks: *Brown, "Textbook of Botany, Ginn and Company*; *Hegner's College Zoölogy, Macmillan,* or any standard college textbooks.

7·03. Theoretical Biology. 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 morphogenesis. Special reading assigned. Textbook: *Castle, Genetics and Eugenics.*

7·06. Botany. Beginning with the lowest forms of vegetable life, the various groups of algæ and fungi are systematically studied and afterwards, higher cryptogams. Some attention is also paid to the structure and development of flowering plants. Textbook: *Coulter, Barnes and Cowles. Textbook of Botany, Volume I.*

7·07. Mycology. Many decomposition processes are caused by the attacks of fungi of various kinds. This course provides a brief survey of the principal types of molds and related fungi of technical interest especially in the decomposition of foods, the wet and dry rots of timbers and in the mildewing and weakening of fabrics, or of fibres used in the textile and cordage industries. The isolation of fungi and their cultivation is taught. Experimental studies on mildewing of cotton and fabrics, and on methods for its prevention make up a part of the laboratory work of the course.

7·08. Parasitology. Invertebrate zoölogy with special reference to the parasitic forms and their relation to disease in man and the domestic animals. Lectures with demonstrations. Textbook: *Chandler, Animal Parasites and Human Disease. Ed. 3.*

7·09. Parasitology, Advanced. Advanced work in parasitology 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. Zoölogy. A systematic study of the invertebrate animals, considering their form, structure, distribution, and economic value. Textbook: *Galloway and Welch, Textbook of Zoölogy.*

7·11, 7·12. Anatomy and Histology. Comparative anatomy of vertebrates, including man, together with the development of the body and the microscopical anatomy of each of the principal organs. An important feature is practice in embryological and histological technique. Each student makes a series of preparations for his own use. Affords a sound basis for the subsequent study of human anatomy, physiology, personal hygiene and public health. Textbooks: *Wilder, History of the Human Body, New Edition; Kingsley, Guides to Dissection, the Dogfish; Bigelow, Directions for Dissection of the Cat; Jordan, Textbook of Histology; Harman, Laboratory Outlines for Embryology.*

7·13. Cytology. For students who have had a laboratory course in histology. May be arranged as a seminar course on special topics in the literature of the subject or as a laboratory course of special methods and research.

7·14. History of Biology. A survey of the development of biology and the principal theories which have led to our present knowledge. The lives and works of the great biologists will be studied chronologically in order to give an historical picture of the growth of the science.

7·18. Technical Aspects of Entomology. 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. The functions of living things are studied from the point of view of causative factors. Energetics of muscle action, conduction, excitation, excretion, metabolisms are discussed with lectures, laboratory and outside reading.

7·22. Personal Hygiene and Nutrition. 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. Required reference book: *Bulletin 28, United States Department of Agriculture, American Food Materials.*

7·23. Applied Nutrition. 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.

7·25. Physiological Basis of Nutrition. For specially qualified students of nutrition. Reports and discussions of outside reading on the science of nutrition, practical studies of nutritional requirements, and exercises in determining diets in sickness and health. Such subjects as Basal Metabolism, maintenance requirements, adequate and inadequate diets for men, women and children may be taken up. The work is largely individual and can be arranged to meet the needs of each case separately.

7·28, 7·29, 7·291. Biology and Bacteriology. Deals with the fundamental principles of biology, the behavior of living matter, growth, etc., and the general relation of microörganisms to chemical changes such as fermentation, putrefaction and disease. (Courses V and IX–A in second term have less work in Water Bacteriology.) Textbooks: *Shull, Principles of Animal Biology; Prescott and Winslow, Elements of Water Bacteriology.*

7·301, 7·302. Bacteriology. Fundamental work in the biology of the bacteria. Thorough study of selected types. Special study of the bacteriology of water, sewage, air and foods. Textbooks: *Park and Williams, Pathogenic Microörganisms; Prescott and Winslow, Elements of Water Bacteriology, Wiley,* 1915; *Tanner, Bacteriology and Mycology of Foods, Wiley,* 1919; *Standard Methods of Water and Sewage Analysis.*

7·31. Bacteriology. Lectures, with conferences and demonstrations presenting the salient facts of structure, distribution and behavior of bacteria, their relation to disease, to water purification and waste disposal, and to problems of food preservation, spoilage, etc., which might be encountered in the administration of military camps and similar operations.

7·321, 7·322. Bacteriology, Advanced. Lectures, seminars and minor research problems involving the more difficult points of bacteriological technique, the study of the metabolism of microörganisms, the theory and practice of testing disinfectants, of unusual character and the study of representative types of the higher bacteria. In general, the subjects are approached from the biochemical viewpoint.

7·34. Microscopy of Waters. Aims to give first-hand knowledge of the organisms commonly found in waters of varying quality. The treatment of water by copper sulphate, aeration, etc., is also discussed. Methods of microscopical examination are taught and practical laboratory work is required. Textbook: *Whipple, The Microscopy of Drinking Water.*

7·35. Planktonology. Takes up a consideration of those animals and plants which drift about in the water, unattached. They are the greatest single source of fish food, either directly or indirectly. Some, as the medusæ, are enemies of young fish. The identification, life-history and distribution are particularly considered.

7·361. Industrial 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, as are also enzymes and their technical applications. Textbooks: *Marshall, Microbiology; Blakiston*, 1921, *Fuhrmann, Einfuhrung in die Grundlagen der technischen Mykologie.* Numerous other books for collateral reading.

7·362. Industrial Microbiology. A continuation of the preceding with more detailed laboratory investigation on a semi-commercial scale.

7·371, 7·372. Industrial Microbiology. 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.

7·39. Zymology. Lectures, reviews of current literature and laboratory experimentation on enzymes. The distribution and special chemical behavior of these biochemical agents, and their relation to the theory and practice of different types of digestion and fermentation, is discussed in detail. Textbook: *Waksman and Davison, Enzymes; Williams and Wilkins*, 1927.

7·421, 7·422. Food Fishes. Lectures, recitations or conferences, and laboratory work on economically important fishes and shell-fish; including the natural history of food fishes, and their relations to oceanic and fresh-water environment, fishing methods and equipment, and the protection of fishing grounds against pollution and other destructive agencies. In the laboratory, students acquire knowledge of the structure and developmental stages of selected types of fish and shell-fish, and practice in determining species. Visits to fish wharves and vessels with taking of notes and writing of reports will form an important part of the work.

7·43. Fish Culture. Two lectures a week on the rearing of fresh water and marine fish, clams, oysters, and lobsters; including methods of taking and fertilizing the eggs, design, construction and management of hatching apparatus, and the care and transportation of the young fry.

7·441, 7·442. Technology of Fishery Products. The methods of handling, curing and preservation of fishery products. Refrigeration, dehydration, salting and canning are studied from the bacteriological, chemical and nutritional aspects. The examination of special processes, of treatment packaging, and transportation, as well as the utilization of by-products will also be considered. Textbook: *Tressler, Marine Products of Commerce, Chemical Catalog Co.*, 1925.

7·50. Infection and Immunity. 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. Textbooks: *Park and Williams, Pathogenic Microörganisms, Lea and Febiger; Hiss and Zinsser, A Textbook of Bacteriology, D. Appleton and Company.*

7·52. Industrial Hygiene. The various prejudicial effects of factory life upon health, including occupational accident, industrial poisoning and the effects of defective ventilation and of dusty and otherwise dangerous trades upon the health of the worker. Special attention is given to industrial fatigue, factory sanitation, and to the problems of health administration in industry. Textbook: *Hockett, Health Maintenance in Industry.*

7·53. Plant Sanitation. A consideration of the application of the general principles of sanitation, water supply, waste disposal, etc., to plants or factories utilizing decomposable materials, with special reference to the food industries.

7·541, 7·542. Public Health Administration. 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. A systematic study of the procedures of official public health agencies.

7·551, 7·552. Public Health Laboratory Methods. Practical methods in use in state and municipal bacteriological laboratories are considered. Training is given in the cultural diagnosis of diphtheria, examination of specimens for tuberculosis, the Widal reaction in typhoid fever, the microscopical diagnosis of malaria, the Wassermann test, the Kahn test, etc. Textbooks: *Park and Williams, Pathogenic Microorganisms, Lea and Febiger; Hiss and Zinsser, A Textbook of Bacteriology, D. Appleton and Company.*

7·553. Public Health Laboratory Methods. A practical course in diagnostic methods and other procedures employed in public health laboratories. Training is given in laboratory diagnosis of diphtheria, tuberculosis, typhoid fever, malaria, and certain other communicable diseases and in the Wasserman and Kahn tests. This course is valuable for physicians, laboratory technicians and those preparing for administrative positions in public health. Given in Summer Session only.

7·56. Public Health Surveys. A discussion of the methods employed in studying the health of a community, the factors considered and the interpretation of accumulated data. A critical study of well-known surveys will also be made. Textbook: *Horwood's Public Health Survey.*

7·57. Municipal Sanitation. Lectures and problems dealing with the general principles of sanitation as applied to the community, and including water supply, sewerage and sewage disposal, collection and disposal of refuse, street cleaning, housing, school sanitation, sanitation of food, stores and restaurants, etc. Textbook: *Phelps, Public Health Engineering.*

7·58. Vital Statistics. Lectures, recitations, and problems by which the student acquires a working knowledge of statistical methods, consideration of errors, and the preparation, graphic representation and critical analysis of data. Textbook: *Whipple's Vital Statistics.*

7·59. Health Records and Statistical Procedure. Deals particularly with record-keeping, together with the organization and presentation of health statistics in the work of school departments, private agencies and health departments. The problems of Public Health Nursing Organizations will receive special consideration. Offered at the suggestion and with the endorsement of some of the national health organizations in the belief that it will assist health agencies in improving, standardizing and making more useful the records of their activities. It will be in the nature of a seminar with both lectures and discussion. It is expected that the students will be persons in charge of public health record-keeping and that a set of satisfactory and adaptable health records will be developed as a part of the work. Given in Summer Session only.

7·60S. Hygiene of the School Child. Presenting the fundamental scientific facts upon which Health Education is based, with consideration of the recent discoveries in nutrition, heleotherapy, the health value of posture and related phases of personal hygiene. Important points in the lectures and assigned reading will be illustrated by laboratory demonstrations, a number of which will be designed with the view of their being repeated in the Health Education classroom of the public schools. If this subject is taken for credit, no other subject may be taken for credit simultaneously.

7·601, 7·602. Health Education. 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 to allow the student an opportunity to study and participate in these activities.

7·603. Health Education Methods. Designed for teachers and for school nurses who have teaching responsibilities. Begins with a brief statement of the organization and administration of school health work, but devotes most of the time to a detailed consideration of the subject matter and procedure in health teaching through the various grades. New methods of health teaching as they have been developed in experimental work by the instructor and by other health workers in various parts of the country will be described. These methods include teaching with the aid of motion pictures, story telling, scrap books, competitions, weight records, etc. Observation and practice work in the Greater Boston schools will occupy fifteen hours. If this subject is taken for credit no other subjects may be taken for credit simultaneously. Given in Summer Session only.

7·61. Health Education Administration. Classroom exercises with required reading considering the principles of health education with special reference to the administrative procedure of Health Departments and School Departments.

7·62. Health Surveys and Statistics. A critical examination of the method and content of standard health surveys, with a consideration of community health score cards and suggested satisfactory schemes of organization for municipal health activities. Analysis, discussion and interpretation of the morbidity and mortality statistics of disease, and their relationship to current public health problems. A portion of the work will consist of original problems and reports which will be discussed in a seminar.

7·63. Public Health Field Work. Conferences and actual 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 actually carried out in the neighborhood of the metropolitan district.

7·64. Public Health Problems. 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. The specialized study of the dangers, and of the principles of industrial hygiene 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.

7·66. Epidemiology. 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, sewerage 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, cerebro-spinal meningitis is included.

7·67. Communicable Disease Control. Conferences, chemical and laboratory exercises on the control of the common communicable diseases. A large part of the work is done at the South Department of the Boston City Hospital.

7·68. Pathology. The principles of general pathology, with some attendance at clinics and extensive laboratory studies on prepared material.

7·701, 7·702. Technology of Food Supplies. Lectures, discussions and reports on the 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.

7·711. Technology of Food Products. Detailed discussion of the methods of food preservation and manufacture of special food products. The packing house, flour, fishery, canning, confectionery, and food specialty industries are discussed, from the bacteriological, chemical and nutritional aspects.

7·712. Technology of Food Products. A continuation of 7·711, with laboratory studies on selected phases of certain industries.

7·80. Biochemistry. Lectures, laboratory, and assigned reading on the chemistry of biological processes in plants and animals. The laboratory work will include such practical technique in analytical and organic manipulations as is required for biochemical assays and investigations. The chemistry of proteins and their cleavage products, bodily secretions and excretions, urine analysis, etc., will be taken up. The use of vacuum apparatus and special extractors, the preparation of glandular substances, ferments, vitamine preparations, sugars and other concrete industrial applications of biological chemistry will be taken up in class as completely as time permits.

7·821, 7·822. Biochemistry, Selected Topics. Conferences, laboratory, and assigned reading on individual selected topics. Such topics as body fluid neutrality, enzyme action, autolysis, radiations, cell physiology, and other problems involving the applications of 7·80 are available for selection. Extra hours may be arranged. A course of directed original investigations.

7·83. Serology. Lectures and seminar discussions, supplemented by such laboratory work as will aid in clarifying the more important theories and practical applications of the subject. A comparative study is made of the older and the more recent theories of immunology, with special attention given to the physical and chemical aspects of immunity. The application of serological methods to special problems is discussed.

7·91, 7·92. Biological Colloquium. A weekly meeting of the staff and fourth year and graduate students. Each student presents from time to time reports of his own investigations or digests of current scientific literature, and receives friendly criticism as to his conclusions or his manner of presentation or both.

7.93. Biological Seminar. All candidates for higher degrees are required to prepare digests on assigned topics for presentation and discussion at meetings of the staff and graduate students.

The following subjects are offered as General Studies. For description of courses see Division of General Studies, page 237.

G71. Principles of Biology and Heredity.

G72. Technical Aspects of Bacteriology.

G73. Sanitary Science and Public Health.
G75. Physiology and Embryology of Reproduction.

PHYSICS

(Including Theoretical and Industrial Physics and Electrochemical Engineering)

The course in physics is designed to give a sound fundamental training in theoretical and experimental physics intended to prepare such physicists as are needed in educational institutions and in research laboratories of larger industries and scientific organizations.

A large proportion of students in physics plan to take graduate work. The facilities for graduate instruction enable them to extend their theoretical, experimental or industrial development in one or another direction, according to their qualifications and desires.

By collaboration with a staff actively engaged in theoretical and industrial physical research, the graduate student is effectively initiated into the method of pursuing a definite research problem, selected as much as practicable along the line of his specialization.

A weekly Physics Seminar keeps undergraduate and graduate students in touch with recent fundamental developments in physics, while acquainting them with current physical literature.

Electrochemical Engineering

The course in electrochemical engineering aims to provide a fundamental training in the principles of electrical engineering together with a broad knowledge of chemistry, upon which as a foundation the more specialized work of theoretical and applied electrochemistry is based. The demand for men with a training along the above lines is steadily increasing as electrochemical and electric furnace operations become more and more general. The large industrial research laboratories also offer excellent opportunities for electrochemical engineers.

The instruction in electrochemistry extends throughout the third and fourth years. A large amount of time is devoted to laboratory work for which purpose two laboratories, established in connection with the Rogers Laboratory of Physics, have been especially equipped for performing all types of electrochemical and electric furnace operations. Owing to the limited capacity of these laboratories, however, the number of students who can be admitted is necessarily restricted. In the senior year students in Course XIV are allowed considerable option in the choice of studies in the Departments of Electrical Engineering, Chemical Engineering and in Metallurgy.

Subjects 8·00 to 8·99 (see page 59)

8·00. Physics. (Entrance). Recommended to candidates for admission to the first year class who are in doubt as to the adequacy of their preparation for the entrance examination in September. It is also open to students who have not previously studied Physics. The ground covered corresponds to the entrance requirements in Physics. Students passing the course are not required to take the entrance examination. No laboratory work will be given. Textbook: *Practical Physics by Black and Davis, Revised Edition.*

8·01. Physics (Mechanics). Lectures, laboratory and recitations devoted to a discussion of the statics of a particle and of a rigid body, the general conditions of equilibrium, composition and resolution of vectors, moments and couples, the kinetics of a particle, laws of accelerated motion,

motion of particles in plane curves, motion of projectiles, friction, work energy and power, angular velocity and acceleration, moment of inertia, dynamics of rotation, elasticity, gravitation. Free use is made of trigonometry and elementary calculus. Textbook: *Exercises in Mechanics, Drisko.*

8·012. Physics (College Class). Given during the first ten weeks of the first term for the benefit of 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 before transferring. In cases where the previous laboratory training has been sufficient to warrant, the laboratory requirement of this course will be waived. The work includes a discussion of energy and power, angular velocity, angular acceleration, moment of inertia with calculus derivations, universal gravitation, hydraulics, periodic motion, harmonic motion, and wave motion. Calculus is used to a considerable extent.

8·02. Physics (Mechanics and Optics). Lectures, laboratory and recitations. The first part of the subject is devoted to a discussion of vibratory and harmonic motion, hydrostatics, hydraulics, and wave motion. The latter part is devoted to optics including a discussion of reflection, refraction, total reflection, lenses and mirrors, spherical and chromatic aberration, achromatism, optical instruments, interference, diffraction and the diffraction grating, wave length measurement, radiant energy, spectrum analysis, ultraviolet and infra-red radiation, color, polarization, light production and distribution. Textbook: *Exercises in Mechanics and Light, Drisko.*

8·03. Physics (Electricity). A quantitative study of Ohm's Law, Joule's Law, electromagnetic induction and the magnetic circuit, galvanometers and meters. Free use is made of the calculus, and many types of problems assigned and discussed. Textbook: *Special Printed Notes and Problems.*

8·034. Physics (College Class). Given during the first ten weeks of the first term for the benefit of 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 before transferring. In cases where the previous laboratory training has been sufficient to warrant, the laboratory requirement of this course will be waived. Among the topics studied are the electrostatic field, capacitance, electromagnetic induction, and the behavior of circuits carrying variable currents. Free use is made of the calculus, and particular emphasis is laid upon fundamental alternating current and oscillatory current circuit phenomena.

8·04. Physics (Electricity and Heat). Electricity: Continuation of 8·03 with special emphasis on sinusoidal induced e.m.f.'s and simple alternating current circuits and phenomena. Electrical resonance, free and damped oscillations, pulsating currents, and electronic conduction are discussed. Many problems are assigned for solutions.

Heat: The general theory of heat and laws of conduction and of radiation are discussed. Methods of measurement of temperature and other thermal constants are taken up in the laboratory and the lectures, and many important applications to industrial processes are emphasized. Textbook: *Special Printed Notes and Problems.*

8·05. Sound, Speech and Audition. A study of the dynamics of sound, vibrating systems, strings, membranes, pipes, resonators, etc. Also a study of speech and audition.

8·06. Acoustics, Illumination and Color. A discussion of topics of especial interest to students of architecture.

8·07. Precision of Measurements. A discussion of the principles underlying the treatment of experimental data and the planning of investigations involving measurements. Textbook: *Goodwin's Precision of Measurements and Graphical Methods.*

8·10. Heat Measurements. Laboratory experiments and lectures on heat of combustion, thermal conductivity and temperature measurement.

8·11. Heat Measurements. The theory and practice of heat measurements, particularly for industrial problems.

8·12. Heat Measurements. Enlargement of 8·11.

8·13. Heat Measurements. The various means of measuring temperatures, thermal conductivity of materials of construction, heats of combustion of coals, petroleum and gas will be studied theoretically and by experiments. The effect of radiation in true measurement of temperature and loss of heat from furnace walls will be considered in detail.

8·14. Heat Measurements II. 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.

8·15. Photography. Lectures on the theory and practice of photography with special emphasis on its scientific applications.

8·151. Photographic Laboratory. Exercises in photographic manipulation, determination of the characteristics of photographic materials, color sensitivity and use of filters, telephotography, micro-photography, the making of lantern slides, etc. Should be taken after or simultaneously with 8·15.

8·16. Photography Seminar. A discussion of important problems in advanced photography such as the theory of photographic sensitivity, the physics, chemistry and physical-chemistry of the process, etc.

8·161. Aerial Photography. Lectures covering the military and commercial aspects of aerial photography. Among the topics considered will be, aerial cameras, photographic materials and dark room manipulation, interpretation of aerial photographs, map-making, stereoscopic and oblique aerial photography, etc. Textbook: *Ives, Air Plane Photography.*

8·17. Geometrical Optics. The theory of image formation by mirrors, prisms, and lenses, the design of optical systems, theory of stops, photometry of optical systems, etc.

8·171. Geometrical Optics (Ordnance). (Not to be offered in 1927–28). An extension of 8·17 with special study of the optical instruments used in military service.

8·18. Physical Optics. Lectures and laboratory exercises on the wave-theory of light, interference, diffraction, reflection, refraction, polarization, spectroscopy, photometry, spectrophotometry and colorimetry. Textbook: *Houstoun, A Treatise on Light.*

8·191. Microscope Theory and Photomicrography. Theory of the microscope with laboratory work in photomicrography.

8·192. Optics, Advanced. Lectures, assigned reading, and laboratory work in physical and geometrical optics. Among the topics treated may be mentioned the design, construction and testing of optical instruments, refractometry, colorimetry, photometry, spectrophotometry, radiometry and spectro-radiometry, polarimetry, etc.

8·201. Electricity. Intermediate work in electricity and electrical measurements, in continuation of 8·03 and 8·04. Emphasis is placed on the fundamentals of electrical theory, and the usual theorems of the electrostatic field are developed. A careful study is made of the properties of the electric circuit, including resistance, inductance, and capacitance, and relations developed whereby these constants may be evaluated for special cases. Some attention is given to the method of "dimensions" and to the inter-relations of the several systems of units. Textbook: *Starling, Electricity and Magnetism.*

8·202. Electricity. A continuation of 8·201. A detailed study of the behavior of circuits carrying varying currents is followed by some practice with alternating current circuits, including a brief discussion of three-phase circuits. This is followed by an introduction to transmission line theory and allied topics. The remainder of the course has to do with ionic and electronic conduction in gases at low pressures, and various applications to commercial devices. The student in this course is placed more and more upon his own initiative, in preparation for his undertaking of some special investigation as a thesis in his fourth year. Textbook: *Starling, Electricity and Magnetism.*

8·21. Elements of Electron Theory and Electron Apparatus. The fundamentals of the modern theory of electrons are presented, and the varied lines of experimental evidence on which the theory is based are discussed. The latter includes Millikan oil drop experiments, the phenomena of conduction in gases, thermionic emission, photoelectric effects, etc. In the latter part of the course, the various specific tubes which depend for their operation on electron conduction in space are taken up. Textbook: *Crowther, Ions, Electrons, and Ionizing Radiations.*

8·211. Electron Theory. The fundamentals of the modern theory of electrons are presented and the varied lines of experimental evidence on which the theory is based are discussed. The latter includes methods of determining the charge and the mass of the electron, the phenomena of conduction in gases, thermionic emission, photoelectric effects, etc. The relation of electrons to the constitution of matter is considered incidentally. The kinetic theory of gases is discussed briefly, as far as it is necessary to understand the processes in gas-filled and vacuum tubes. In the latter part of the course, the practical details of commercial and other apparatus, which depend for their operation on electron conduction in space, are discussed. These include the kenetron, the tungar rectifier, the three electrode radio tube, the cathode-ray oscillograph, etc. In connection with these tubes the modern methods of producing and measuring high vacua are discussed. Given in Summer Session only.

8·212. Gaseous Conduction. Arcs, sparks, and glow discharges. A study of the theory of gaseous conduction in relation to electrical engineering problems. Insulator flashovers, corona, arc rectifiers and allied matters.

8·221, 8·222. Advanced Physics I. Designed to give a thorough training in the main topics of theoretical mechanics as a basis for subsequent work in advanced physics. The work begins with the general kinematics and dynamics of the mass point introducing the potential function, the principles of conservation of energy, the principles of internal displacement in holonomic and nonholonomic systems and d'Alembert's equations of dynamic equilibrium. Following the study of periodic and aperiodic free and constrained motion, conservative and dissipative, and its applications to the linear and spherical pendulum — general dynamics of a system of material points continued as far as Hamilton's principle, the Lagrangian and canonical equations of motion. Finally the study of mechanics of rigid bodies and of continuous media, including the principle of hydrodynamics and elasticity.

8·231, 8·232. Advanced Physics. II. The first part of the course includes the theory of heat conduction with a discussion of various initial and boundary conditions leading to solutions in terms of Fourier's Series and Integrals, Cylindrical and Spherical Harmonics. A brief course in Thermodynamics follows, including the First and Second Laws and their application to various problems in Physics and Chemistry, concluding with the subject of chemical affinity and Nernst's Heat Theorem. This is followed by a mathematical treatment of the electric and magnetic fields, the electromagnetic field and Maxwell's equations, Poynting's vector, electromagnetic waves, radiation from an electron, the electromagnetic theory of light, theories of reflection, refraction, dispersion, absorption and scattering. Magneto and electro-optics. Elementary presentation of the nature of white light and its propagation.

8·241. Electromagnetic Theory. The fundamental ideas of Maxwell's theory, covering the following topics: the electrostatic field, dielectrics, energy and mechanical forces in the electrostatic field, the electric current, the electromagnetic field, induction, the fundamental circuital laws and the Poynting vector.

8·242. Electromagnetic Wave Propagation. A continuation of 8·241 covering: plane waves in isotropic homogeneous dielectrics and in imperfect dielectrics; penetration of electromagnetic waves in metals, the complex Poynting vector and theory of skin-effect; the propagation along parallel wires and cables, general theory of propagation of electromagnetic disturbances and Hertz's solution. Applications to the theories of propagation of electromagnetic waves along the surface of the earth and of radiation from antenna systems.

8·25. Practical Spectroscopy. Instruction will be by lecture and laboratory work ending with simple research problems. The principles, practice and applications of spectroscopy without using advanced mathematics and covering the following topics will be discussed: prisms and grating spectrographs for infra-red, visible, and ultra-violet; their construction and adjustment; interference methods, purification of organic compounds; the analysis and interpretation of their absorption spectra. Emission spectra of elements and compounds in arc and spark; their identification and estimation. Precision wave length determinations. Refractive indices in ultra-violet and photometry of spectra. Textbook: *Baly's Spectroscopy, Longmans, Green & Co.*

8.26. Dielectric and Magnetic Molecular Properties. Molecular explanation of the phenomenological constants of gases and liquids and their dependence on pressure and temperature. Debye's theory of dielectrics, Kerr effect, anomalous dispersion, Born's theory of the migration speed of ions, Langevin's theory of magnetism, the magneton, electrocaloric and magnetocaloric effects and related problems. (Not given 1927–28.) Textbook: *P. Debye, Theorie der elektrischen und magnetischen Molekulareigenschaften.*

8·29. Lattice Theory of Rigid Bodies. The methods and results of crystallography and the X-ray investigations of rigid bodies will be discussed. The following topics will be considered: Homeopolar and heteropolar crystals; Born-Madelung's theory of heteropolar lattices; Elastic constants and breaking stress; Surface tension; Dielectric constant and magnetic susceptibility; Piezoelectricity; Double refraction and optical activity; Thermal expansion and pyroelectricity, specific heat of crystals; Hund's theory of crystal types. Textbook: *M. Born, Problems of Atomic Dynamics; Atomtheorie des festen Zustandes.*

8·301, 8·302. Atomistic Theories. A comprehensive study of the theories of atomic structure and constitution of matter, including: a systematic development of statistical mechanics starting from the Hamilton canonic equations of motion, a study of ergodic and quasiergodic systems with applications to the classical Maxwell-Boltzmann molecular theory of gases, Boltzmann's H-theorem and the concept of entropy, and an introduction to the quantum theory from the statistical viewpoint. This is followed by a study of the modern theories of atomic structure including the Bohr theory, its accomplishments and difficulties, and the later work of Born, Heisenberg and Schrodinger. The theories of fine structure of band spectra, and of the Stark, Zeeman and Paschen-Back effects are given. Emphasis is laid on the fundamental philosophical and mathematical methods of attack and not on the descriptive side which is assumed familiar to the student. Reference books: *Cl. Schaefer, Einfuhrung in die theoretische physik. Bd. 2; A. Sommerfeld, Atomic Structure and Spectral Lines.*

8·31. Celestial and Atomic Mechanics. A general introduction to the Hamilton-Jacobi theory and the calculus of perturbation, including: the *n*-body problem, the Newcomb-Lindstedt and Bohlin expansions of the perturbation function, Poincaré's periodic solutions, and the theorems of Poincaré and Bruns. Next, a brief survey of Bohr's semi-classical atomic dynamics is given, the reasons for its breakdown are discussed and an introduction to the new atomic mechanics of De Broglie, Schrodinger, Born, Heisenberg, are given, concluding with a study of the relation between these different theories and the macromechanics of Galileo and Newton. The topics vary considerably from year to year. Reference books: *E. T. Whittaker, Analytical Dynamics; C. V. L. Charlier, Mechanik des Himmels; M. Born, Problems of Atomic Dynamics,* and original articles in the literature.

8·33. X-rays and Radiology. Lecture and laboratory work dealing with the theoretical considerations of X-ray emission and absorption followed by a discussion of the applications to scientific and industrial problems.

8·36. Radiation Measurements (Laboratory). Aims to familiarize the student with modern instruments and methods for quantitative measurement and analysis of ultra-violet, visible and infra-red radiation.

Determinations of the transmissions of various glasses, analysis of the radiation from such sources as the quartz mercury arc, carbon arc, incandescent lamp, etc., and determinations of surface radiation coefficients will be made by means of the filter-radiometer, radiation potentiometer, and spectro-radiometer, using thermopiles, photoelectric cells, selenium cells, etc.

8·37. General Theory of Radiation. (Offered in alternate years.) Selected topics from the following: Kirchhoff's law, black-body radiation, the pressure of radiation, Stefan-Boltzmann's and Wien's laws, entropy and temperature of a monochromatic radiation, energy-distribution in normal spectrum according to the classical theory and to the quantum theory, pure cavity radiation. Textbook: *M. Planck, Wärmestrahlung.*

8.38. Theory of Relativity. Restricted and general relativity covering the following topics: the Galilean principle of relativity, relativity of space and time, the Lorentz transformation and its geometrical and mechanical consequences; Minkowski's electrodynamics, matter and energy, the principles of equivalence; relativity and Riemann's geometry, the fundamental equations of general relativity, Einstein's theory of gravitation, the static-symmetrical gravitational field with applications, cosmological consequences of the theory of relativity. Weyl's theory and gauge invariance. The newly discovered relations between relativity and quantum theory will also be discussed. Reference books: *A. S. Eddington, The Mathematical Theory of Relativity; W. Pauli, Relativitätstheorie.*

8.431. Applied Elasticity. Covers the principles of the theory of elasticity giving the necessary theoretical foundation to the students taking the laboratory work in photoelasticity or intending to do further specialized work in theoretical and applied elasticity. The following topics are covered: the general theory of stress and of strain up to the stress equations and the strain equations in cartesian coordinates, the general Lame's stress-strain relations assuming the generalized Hook's law and their simplification in isotropic solids to the more usual stress-strain relations involving two elastic constants. The relation between the mathematical theory of elasticity and technical mechanics is discussed, and the scope and limitations of the mathematical theory of elasticity are examined. Textbooks: *A. E. H. Love, Mathematical Theory of Elasticity; Prescott, Applied Elasticity.*

8·432. Photoelasticity. Combined lecture and laboratory course on the analysis of problems of elasticity, mechanical and structural design, by means of the photoelastic method of stress analysis, based upon the temporary double refraction due to stress. The principles of the method are studied and the apparatus described. The laboratory work includes the solution by the photoelastic method of well-known classical problems for instruction in the method, followed by original research in the field of engineering chosen by the student or upon which the staff and graduate students are engaged at the time.

8·44. Applications of X-Ray and Photoelasticity. A joint lecture and laboratory course in the applications of the X-ray and photoelastic methods of examination of engineering materials and structures. The work in X-rays includes the theory and practice of radiography and crystal analysis. The work in photoelasticity covers the theory and practice of stress analysis by means of polarized light.

8·451, 8·452. Physics Colloquium. Papers and conferences by visiting lecturers, members of the instructing staff and students pursuing graduate work in physics for the purpose of reviewing problems of theoretical and applied physics and discussing research problems and noteworthy papers in current physical literature.

8·46. Industrial Radiology. Lectures and laboratory work covering the theory and practice of industrial radiology, including the examination of opaque materials by means of X-rays and the analysis of crystal structure.

8·801, 8·802. Principles of Electrochemistry. The fundamental principles of physics and chemistry underlying electrochemical phenomena are discussed from the standpoint of thermodynamics and kinetics. The instruction is by lectures, recitations and the solution of problems. The ground covered is that in *Washburn's Principles of Physical Chemistry* which is used as a textbook, together with a more extended treatment of thermodynamics.

8·82. Electrochemistry. The electron theory, electrical conduction in liquids, solids and gases, theories of the voltaic cell, polarization and electrolysis, the principles involved in the corrosion, electro-deposition, and refining of metals, and the energy relations underlying the mutual transformations of chemical and electrical energy. No single English textbook covers the subject as presented. Reference: *Thompson's Theoretical and Applied Electrochemistry.*

8·83. Electrochemistry, Advanced. The mechanism of electrode potential phenomena is studied in detail. This includes the experimental data on overvoltage and the theory of overvoltage; the mechanism of oxidation and reduction potentials; and electro-capillary phenomena and absolute potential. Abstracting and criticizing journal articles on these subjects is included in the assigned work.

8·84. Photochemistry. Elements of the quantum theory of spectra, application of the same to photochemical reactions in gases, liquids and solids, kinetics of photochemical reactions, temperature coefficients of reactions, catalysis, photoelectrochemical reactions, energy relations underlying transformations of radiant and chemical energy, production and practical uses of ultra-violet radiation, and principles of radiometry. The instruction is by lectures, informal discussion, problems and reports. Textbook: *Special Notes.*

8·851, 8·852. Applied Electrochemistry. Consideration of the industrial applications of electrochemistry. The subjects discussed include the theory and construction of different types of electric furnaces, electrometallurgical processes, accumulators and primary batteries, and the electrolytic production of chemical compounds. The work of the last part of the second term consists in working out the details of design of one or more electrochemical plants for specific processes. Textbook: *Thompson, Theoretical and Applied Electrochemistry.*

8·86. Electrochemical Laboratory. Carried on in conjunction with 8·82. The work is strictly quantitative and includes measurements of electrical conductance, single potentials, decomposition voltages, overvoltages, polarization, and practice in electro-analysis. *Admission will be limited to the capacity of the laboratory.* Textbooks: *Special Notes; Ostwald-Luther's Physiko-Chemische Messungen.*

8·871, 8·872. Applied Electrochemical Laboratory. Affords practice in the use of various types of electric furnaces together with efficiency tests on their output. Arc, resistance, and induction types of furnace are provided. The production of steel, ferrosilicon, calcium carbide, carborundum and aluminum are among the processes studied. Efficiency tests on technical processes involving electrolysis in aqueous solutions are also included, *e.g.*, the production of hypochlorite, chlorate, etc. *Admission limited to the capacity of the laboratory.* Textbook: *Neostyle notes.*

8·89. Electric Furnaces. 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. Descriptive lectures on electric furnace operation accompanied by a selected number of laboratory exercises described under 8·872. Textbook: *Thompson, Theoretical and Applied Electrochemistry and Neostyle notes.*

8·90. 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. The laboratory work consists in the electric furnace experiments of 8·87. Textbook: *Thompson, Theoretical and Applied Electrochemistry.*

8·93. Colloquium. Students present before the class for discussion reviews of current articles on electrochemistry appearing in the English and foreign journals, and memoirs on assigned topics in modern physics.

8·94. Precision of Measurements. A series of lectures and classroom discussions on the scientific method of attacking experimental research problems and on the reduction and discussion of experimental data. Textbook: *Precision of Measurements and Graphical Methods, Goodwin.*

8·98. Glass Blowing. Students are taught how to manipulate glass and make such simple apparatus, electrodes, etc., as are likely to be needed in electrochemical research. Given during either term, and offered only to fourth-year and special students in Course XIV.

GENERAL SCIENCE, ENGINEERING AND MATHEMATICS

Courses IX-A, IX-B, IX-C

General Science IX-A

This course, largely elective in the senior year, is planned to offer first, a substantial education along scientific lines, and to provide subsequently, through its electives, for a more intensive training in some one branch of science or in closely inter-related sciences. There is, also, an opportunity to elect a substantial amount of such humanistic studies as English, Modern Language, History, Economics and Social Science.

It offers, in other words, an opportunity for a broad training in science without sharp specialization. Such a course possesses many advantages in view of the ever increasing inter-relations of the various sciences, and should prove particularly valuable to those who have not fully decided upon any particular line of specialization, or to those who intend to specialize in graduate work later.

The choice of electives in the third and fourth years must in all cases be approved by the committee in charge of Course IX.

General Engineering IX-B

This course is designed to meet the needs of those who desire a training in fundamental engineering subjects, and who either do not wish to specialize in any particular branch of engineering to the extent demanded by one of the regular courses, or who may wish to follow out some line or lines of work not provided for by the schedule of any particular engineering course.

A schedule, except for that portion listed as elective, has been prepared and is offered as one suitable for a broad training in engineering. There is also opportunity for the election of economic and business subjects, or of courses in literature and modern languages.

In all cases the choice of electives must be approved by the committee in charge of Course IX.

Mathematics IX-C

The Institute offers exceptional opportunities for the study of mathematics particularly as applied to scientific and engineering work.

The schedule outlines a course of study leading to the Bachelor's Degree for students who desire to specialize in applied mathematics. It is a course well adapted to serve as a preparation for later specialization in pure mathematics, in mathematical-physics, or along lines of experimental physics or engineering requiring a high degree of proficiency in mathematics.

Considerable latitude in the choice of subjects is provided for in the electives of the junior and senior years in order that the student shall be able to take, if he so desires, a considerable amount of work in general studies, or in scientific and engineering subjects in which mathematics play an important part, in addition to his purely mathematical subjects. For example, he may elect courses in Thermodynamics, Mechanics, Electricity, or in Physical Chemistry.

While a definite schedule for the second year is offered, any student who has completed satisfactorily the work of the first two years in any of the professional courses of the Institute, or their equivalent, provided always that a creditable record has been obtained in mathematics and physics, may be admitted to the work of the third year in this course.

CHEMICAL ENGINEERING

The course in Chemical Engineering is designed to give the student a thorough foundation in chemistry and in the elements of mechanical and electrical engineering, followed by training in the special field of chemical engineering, *i.e.*, in the solution of the engineering problems of chemical industry. The instruction of the first two years is therefore wholly in other departments, and of the third year mainly so. The professional instruction within the department begins with industrial chemistry in the third year and is followed by chemical engineering and laboratory work in the fourth.

Because of the composite character of the course, it is impossible to include in the undergraduate instruction material other than the fundamentals required in professional work. On this account, special attention is given to post-graduate courses, and the student who hopes to attain professional leadership should plan for at least one post-graduate year leading to the Master's Degree.

Laboratory instruction in chemical engineering is carried out mainly in the School of Chemical Engineering Practice, located in seven industrial plants in Buffalo, New York; Bangor, Maine; and Everett, Mass. This school has facilities for only a limited number of students and its privileges are restricted to those whose work at the Institute has, in the opinion of the Department, shown marked promise of professional success. The work of the Practice School may be taken either as a part of a post-graduate program leading to the Master's Degree (X–A) or as the last part of the undergraduate course (X–B).

The function of the Research Laboratory of Applied Chemistry is to afford special training in industrial research. The student cannot profitably undertake such work without a thorough theoretical foundation. Normally this will require a Master's Degree or its equivalent. The laboratory is able to give financial assistance to a limited number of men of unusual capacity in research.

Students interested in post-graduate work should consult the bulletin on Graduate Study and Research.

Subjects **10·00** to **10·99** (see page 59).

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.

10·12. Plant Engineering. A series of daily conferences, supplemented by laboratory work in which are taken up the stoichiometric methods of computation of industrial processes, the technique of securing and interpreting the laboratory data necessary for evaluating the industrial potentialities of processes, and the principles underlying and the description of the mechanical operations of chemical industries.

10·13. Plant Engineering. A continuation of the preceding course in which is taken up Flow of Heat and Flow of Fluids, particularly as relating to chemical industries, and the quantitative relationships of chemical engineering processes.

10·14. Applied Chemistry. Devoted to the development of the technique of quantitatively applying the underlying principles of chemistry to the solution of the types of problems involving the problems which are most frequently encountered in industrial work.

10·15. Thesis Reports. A series of reports by the students on the progress of their theses, presented before the rest of the students and the instructing staff.

10·191. Chemical Engineering Literature. Readings in technical literature in both French and German, including searches in reference books and journals.

10·192. Chemical Engineering Literature. Continuation of 10·191.

10·20. Industrial Chemistry. The more important industrial chemical processes, including metallurgy, 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 and one hour a week of memoirs presented by individual students upon important topics. Textbook: *Thorp, Outlines of Industrial Chemistry.*

10·201. Industrial Chemistry. Identical with 10·20 except for omission of memoirs.

10·202. Industrial Chemistry. Identical with 10·20 except that especial emphasis is laid on ordnance and chemical warfare topics, particularly in memoirs.

10·203. Industrial Chemistry. Similar to 10·202.

10·206. Industrial Chemistry. A modification of 10·20 designed particularly to meet the requirements of Chemical Warfare Officers.

10·21. Industrial Chemistry. A continuation of 10·20. Devoted to those industries which deal with amorphous solids, including glass, ceramics, leather, paints, textiles, paper, rubber, etc. Textbook: *Thorp, Outlines of Industrial Chemistry.*

10·211. Industrial Chemistry. Identical with 10·21 except that memoir work of 10·20 is included.

10·212. Industrial Chemistry. Identical with 10·21 except that the mechanical operations of chemical industry are taken up in place of memoirs.

10·213. Industrial Chemistry. Continuation of 10·202.

10·214. Industrial Chemistry. Similar to 10·21 modified to meet the needs of R. O. T. C. students.

10·22. Industrial Chemistry. Continuation of 10·20.

10·224. Industrial Chemistry. Similar to 10·22 modified to meet the needs of R. O. T. C. students.

10·25. Industrial Stoichiometry. Stoichiometric calculations connected with the processes of chemical industry. The subject matter is an expansion of the problem work of 10·20. Intended especially for college men who have had descriptive industrial chemistry.

10·26, 10·27. Industrial Chemical Laboratory. 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.

The process is first examined in the light of available literature, and is analyzed as to the probable factors which enter into its successful operation. Commencing with the preparation of the raw material it is next carried out in a quantitative manner in the laboratory on as large a scale as is consistent with reasonable accuracy and despatch. Each chemical operation is analytically controlled, rapid methods of the requisite accuracy being employed. The physical properties of the solutions, precipitates, and final products are critically observed and the choice of the apparatus to be recommended is based upon quantitative experimentation carried out in the laboratory. Finally, each student submits an informal report upon the process and plant, with plant layout and estimate of costs. Questions of labor, depreciation, interest, and insurance are discussed in the class, and so far as is possible are involved in the students' reports.

10·31 — 10·36. Chemical Engineering. These subjects cover the basic principles underlying the unit operations of chemical industry. Because most of these operations involve fundamental problems in flow of heat and flow of fluids, these topics are 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. Throughout the course, emphasis is laid on quantitative relationships and these are illustrated by the solution of numerous problems. Textbook: *Walker, Lewis and McAdams, Principles of Chemical Engineering.*

10·31. Chemical Engineering (Dynamics of Fluids, Flow of Heat, Evaporation and Distillation).

10·311. Chemical Engineering. Similar to 10·31, modified to meet the needs of R.O.T.C. students.

10·32. Chemical Engineering (Humidity, Humidification, Drying and Subdivision, and Separation of Solids).

10·321. Chemical Engineering. Similar to 10·31, modified to meet the needs of R.O.T.C. students.

10·33. Chemical Engineering (Dynamics of Fluids, Flow of Heat, Evaporation and Distillation).

10·331. Chemical Engineering.

10·34. Chemical Engineering (Humidity, Humidification, Drying and Subdivision, and Separation of Solids).

10·341. Chemical Engineering.

10·35. Chemical Engineering.

10·36. Chemical Engineering.

10·37. Chemical Engineering Laboratory. Trains the student to plan and conduct tests, and to interpret and correlate the results. The apparatus tested includes filters, evaporators, driers, scrubbers, etc.

10·41—10·54. Special Topics in Chemical Engineering. The purpose of each of this group of subjects is to study thoroughly and in detail one special phase of chemical engineering. Each subject starts with a brief review of the underlying principles as taken up in 10·31 and 10·32. The more advanced phases are then discussed in detail. To illustrate the general applicability of these principles to the design and operation of industrial plants, numerous problems are solved quantitatively.

10·41. Distillation. A quantitative study of the basic principles of distillation, as applied to binary mixtures, both of complete and limited miscibility and to multicomponent systems. Typical 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. Textbook: *Special notes and problems.*

10·42. Drying. A detailed study of the basic principles of drying. Quantitative problems dealing with driers of the rotary, tunnel, loft, compartment and drum types. Textbook: *Special notes and problems.*

10·43. Evaporation. A detailed study of the various factors involved in evaporation, such as heat transmission, entrainment and frothing. Considerable attention is paid to multiple effect operation, both with parallel and reversed flow of steam and vapor. Vapor compression evaporation is also considered. Textbook: *Special notes and problems.*

10·44. Combustion.

10·45. Mechanical Separation.

10·46. Extraction I. (Gases by Liquids.) 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. Textbook: *Special notes and problems.*

10·47. Extraction II. (Gases and Liquids by Solids.) 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. Textbook: *Special notes and problems.*

10·50. Heat Transmission. Includes a study of the individual or film coefficients of heat transfer for evaporating, condensing, warming and cooling, followed by application in the design of stills, condensers, heat exchangers, etc. Special attention is paid to the correlation of data by the methods of dimensional analysis, and to the inter-relationships between heat transfer, fluid friction, and absorption. For problems involving the batch warming and cooling of solids, the Fourier equations are applied graphically. Textbook: *Special notes and problems.*

10·51. Furnace and Retort Design.

10·53. Chemical Engineering Design. This course is open only to students who have taken the field work of the School of Chemical Engineering Practice. The problems given involve the design of a complete plant, from the viewpoint of both chemical engineering and economics. Textbook: *Special notes and problems.*

10·54. Economic Balance in Chemical Industry. A course of lectures and conferences planned to develop original power in the solution of problems in chemical industry. The problems chosen cover a wide range of topics, but in each case the various factors under the control of the designer are analyzed quantitatively, in order to determine the optimum design from the viewpoint of cost and economic return. Textbook: *Special notes and problems.*

10·61. Corrosion. Presents the general theory of corrosion and the specific characteristics of the more important metals.

10·62. Applied Chemical Thermodynamics. Presents and illustrates those elements of thermochemistry and thermodynamics of most importance in the field of chemical engineering.

Special Topics in Industrial Chemistry 10·69, 10·79. A series of graduate courses covering in detail the following subjects:

10·69. Tanning and Allied Subjects.
10·691. Leather and Rubber.
10·70. Sulphuric Acid.
10·71. Glass, Ceramics and Refractories.
10·72. Iron and Steel.
10·73. Starch and Cellulose.
10·74. Petroleum.
10·76. Nitrogen Fixation.
10·77. Rubber.
10·78. Wood Distillation.
10·79. Paints, Oils and Varnishes.

10·81. School of Chemical Engineering Practice — Bangor Station 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. Given during the summer and first term and may be taken only in conjunction with 10·82 and 10·83.

10·82. School of Chemical Engineering Practice — Boston Station. At the Boston Station primary emphasis is placed on the study of filtration, handling of corrosive materials, materials of construction and plant layout, flow of heat and absorption. Stress is also placed on the chemistry and chemical engineering involved in the manufacture of heavy chemicals, such as sulphuric acid, nitric acid, hydrochloric acid, glauber salts, etc. This work is carried out at the South Wilmington plant of the Merrimac Chemical Company which manufactures heavy chemicals; and at the Revere Sugar Refinery, Charlestown, Massachusetts. Given during the summer and first term and may be taken only in conjunction with 10·81 and 10·83.

10·83. School of Chemical Engineering Practice — Buffalo Station. The work at the Buffalo Station deals primarily with flow of fluids, flow of heat and combustion, the work extending over a wide field. Heat balances and efficiency tests are 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, Lackawanna, New York. Given during the summer and first term and may be taken only in conjunction with 10·81 and 10·83.

10·84. School of Chemical Engineering Practice — Bangor Station. Same as 10·81. Given during the second period of the academic year. May be taken only in conjunction with 10·85 and 10·86.

10·85. School of Chemical Engineering Practice — Boston Station. Same as 10·82. Given during the second period of the academic year. May be taken only in conjunction with 10·84 and 10·86.

10·86. School of Chemical Engineering Practice — Buffalo Station. Same as 10·83. Given during the second period of the academic year. May be taken only in conjunction with 10·84 and 10·85.

10·87. School of Chemical Engineering Practice — Bayonne Station. Students may elect 10·87 by substitution for one of the other stations, 10·81, 10·82, 10·83.

10·90. Experimental Research Problem.

10·911, 10·912. Research Conferences. Regular conferences are held with research students by the Staff of the Research Laboratory of Applied Chemistry and of the Laboratories of Chemical Engineering in which the work is conducted.

10·921, 10·922. The Applied Science of X-rays. Lectures and conferences presenting especially the chemical applications of the new theories of the structure of matter, and of X-rays and ultra-violet rays. Industrially important chemical reactions are considered from the viewpoint of the dynamic models of atoms and molecules and of valence. Emphasis is placed upon the methods, results and practical value of X-rays in the examination of the actual fine structures of many materials — chemicals, colloids, ceramics, metals, alloys, films, plastic materials, cellulose, rubber, varnishes, catalysts, plasters, adhesives — and in relating these properties to the details of manufacturing technique. Apparatus research methods and experimental results are demonstrated. Open to graduate students generally and to seniors upon permission of the instructor.

10·93. Automotive Fuel Problems. A discussion of the principles of the design of internal combustion engines from the standpoint of fuels, with particular reference to the reactions in the cylinders and distributing systems. Among the problems taken up are the influence of volatility in carburetion and distribution, the probable causes and methods of elimination of detonation in internal combustion engines, etc.

10·931. Automotive Fuels. A study is made of automotive fuels with particular reference to reactions in the engine cylinders, detonation and doping. It also includes physical and chemical testing of fuels to meet specifications.

10·94. Organization and Methods of Industrial Research. The methods of attack used in industrial research are considered. Specific problems of industrial importance are submitted to each member of the class who is asked to outline in detail for criticism of the class the method of attack suggested for its solution.

10·941. Technical Organization. A modification of the preceding course particularly designed to meet the needs of Chemical Warfare Officers.

10·95. Applied Colloid Chemistry. A study of the application of colloid chemistry to various chemical industries, including a brief survey of the general principles of colloidal chemistry with special reference to their industrial application, a discussion of various colloid problems involved in the industries, and a consideration of the important research problems in applied colloid chemistry now pressing for solution.

10·951. Applied Colloid Chemistry Laboratory. An opportunity is given to carry out selected experiments. Apparatus is available for surface tension measurements, ultra-microscopic studies, etc.

10·952. Experimental Problems in Applied Colloid Chemistry. Designed primarily for graduate students interested in the field of applied colloid chemistry, to offer an opportunity for research along these lines. The time may be arranged to suit the convenience of the individual and is dependent on the nature and scope of the problem being investigated. Only a limited number of students can be accommodated.

10·991, 10·992. Seminar in Chemical Engineering. A series of talks by members of the staff and others on timely subjects in chemical engineering.

SANITARY AND MUNICIPAL ENGINEERING. Course XI.

(See description under Civil and Sanitary Engineering, page 142.)

GEOLOGY

This Department offers courses which lead to the degree of Bachelor of Science in Geology, Master of Science, Doctor of Philosophy and Doctor of Science.

The growth of economic geology is a comparatively recent development. There exists now a broad demand for men who have made a special study of the practical application of geology to metal mining, to non-metallic products like clay and building stone, to petroleum and coal, and to engineering works and hydrology. Such men must have an education in engineering subjects along with their geological training, and it is just this which is provided for in this course. Among its graduates are many of the most prominent practical geologists of the present day.

For a long time there has existed a demand for teachers in the various branches of geology and for those who desire to devote themselves to teaching, the degree of Bachelor of Science in Geology is a stepping stone to the higher degrees necessary for such work.

The subjects in Course XII, during the first and second years, do not differ from those arranged for Mining Engineering (Course III), but in the third and fourth years the studies diverge. Mineralogy, petrography, geology in all its branches, including physiography, geological surveying and economic geology, are included in the curriculum. In view of the growing importance of the geology of coal and petroleum special lecture courses are established for this branch of the science. The examination, sampling and valuation of ore deposits are also emphasized.

Ample provision is made for graduate studies for candidates desiring to obtain the higher degrees and for special students. The subjects for this advanced work include microscopic analysis, mineralogy and crys-

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tallography, chemical mineralogy, advanced petrography, advanced economic geology, geology of North America and of Europe, geology of igneous rocks, paleontology and organic evolution.

A beneficial coöperation in graduate studies has been established with the Department of Geology of Harvard University by which advanced students are allowed to attend Harvard courses in subjects not regularly given at the Institute and vice versa. Among such Harvard courses open to advanced students are geometrical crystallography, geology of igneous rocks, physiography and climatology offered respectively by Professors Charles Palache, Reginald A. Daly and R. DeC. Ward.

The subjects offered in this department to students of other branches of engineering may be divided in four sections.

1. Students in Course III (Mining Engineering), Options 1 and 3, are instructed in mineralogy, petrology, geology (dynamic, structural and historical), geological surveying and economic geology. Students in Metallurgy, Option 2, receive instruction in mineralogy.

2. Students in Courses I and XI (Civil and Sanitary and Municipal Engineering) take dynamic and stratigraphic geology and field geology.

3. Students in chemistry and physics are offered courses in mineralogy, crystallography and microscopic analysis.

4. Students in all Courses except I, $III_{1,3}$ and XI may select, among their general studies, a course in general geology or evolution.

Subjects 12·00 to 12·99 (see page 59).

12·01. Mineralogy. Principally a laboratory study of about one hundred and twenty of the most common minerals. Textbooks: *Rogers, The Study of Minerals and Rocks*; *Warren, Determinative Mineralogy*; *Dana, Manual of Mineralogy.*

12.02. Mineralogy. A continuation of 12·01, for students in Course XII and others desiring further work in mineralogy. A number of additional minerals are studied and the elements of crystallography are reviewed. In the lectures the minerals are described and the mode of formation of a number of mineral groups is considered. Textbook: *Dana-Ford, Textbook of Mineralogy, 3d edition.*

12·03. Mineralogy. Designed as an option for students in Courses V and X and for others desiring a short course in mineralogy. A general determinative study of about sixty common and important minerals. Crystallography is given as part of this subject. Textbooks: *Rogers, Study of Minerals and Rocks; Warren, Determinative Mineralogy.*

12·04. Mineralogy (Advanced). Detailed study of many common and some of the rare minerals by means of optical, blowpipe, and other methods. In the lectures and seminar hours the chemical composition of mineral groups is treated. The laboratory work will include the preparation and use of immersion liquids, specific gravity separations, etc.

12·05. Mineralogy (Advanced.) A shorter treatment of 12·04. It differs only in that fewer minerals are considered.

12·151. Petrography. Introduction to the study of minerals and rocks by means of the petrographic polarizing microscope. The optical properties of a number of important minerals are reviewed and the study of igneous rocks is begun. Textbook: *Dana-Ford, A Textbook of Mineralogy; Neostyle Notes.*

12·152. Petrography. The study of igneous rocks is continued; later, sedimentary and metamorphic rocks are taken up. Textbook: *Harker, Petrology for Students.*

12·161, 12·162. Petrography (Advanced). Study of selected suites of rocks, reading of petrographic literature, and the preparation of a written report on at least one suite of rocks.

12·20. Optical Examination of Chemical Precipitates. A short course of instruction in the use of the polarizing microscope in the identification of crystalline substances. It gives the student the ability to identify precipitates even though the amount available be exceedingly minute. The method is particularly helpful in the case of mixtures and has a wide range of application in industrial and research problems. This course is a shorter and more elementary treatment of the subject given in 12·211.

12·211. Optical Crystallography. Study of the optical properties of crystals with special reference to their determination with the aid of the polarizing microscope. It is designed for the instruction of those students not interested in mineralogy or petrology who wish to use the instruments in some other branch of technical work.

12·212. Optical Crystallography. A continuation of 12·211 for students desiring further work in this subject.

12·22. Optical Ceramics. Primarily a laboratory subject in which the methods of petrography are applied to the study of ceramic products, such as cement, glass, porcelain, chinaware, refractories, tile, terra cotta, and brick.

12·30. Geology. General dynamical geology. Textbook: *Shimer, Introduction to Earth History.*

12·31. Geology. Continuation of 12·30. Historical geology, and laboratory work on the study of geologic structures and maps and also geologic field trips. Textbook: *Shimer, Introduction to Earth History.*

12·321, 12·322. Geology. Geology adapted to the needs of engineers. Textbook: *Ries and Watson, Elements of Engineering Geology.*

12·33. Field Geology. Designed to teach practical methods of geologic mapping in the field.

12·331. Geology. Similar to G60.

12·34. Geological Surveying. The students are assigned field problems upon which they are required to prepare a detailed report.

12·351, 12·352. Geological Surveying (Advanced). Field investigation and mapping of assigned areas with research in connected problems. Also excursions to areas of special interest.

12·36. Field Geology. Consists of excursions in the vicinity of the summer mining camp at Dover, N. J., to typical and interesting geological exposures illustrating phenomena of intrusion, folding, and faulting.

12·37. Field Geology. A short series of field trips to supplement 12·322.

12·38. Physiography. A study of the characteristics and development of land forms and the methods of interpretation of topographic maps.

12·40. Economic Geology. Lectures on the occurrence and origin of ore deposits. Textbook: *Lindgren, Mineral Deposits.*

12·41. Economic Geology Laboratory. The student is trained in the determination of complex ores.

12·42. Applied Economic Geology. Describes methods of examination and valuation of ore deposits and placers.

12·431, 12·432. Economic Geology Laboratory (Advanced). Laboratory study of specimens or suites of specimens from mineral deposits; metallographic or petrographic work, structural problems.

12·433, 12·434. Economic Geology Seminar (Advanced). Seminar including reading and reports based upon the literature of ore deposits.

12·44. Economic Geology of Fuels. The origin and the geological occurrence and utilization of deposits of natural gas, petroleum, and coal.

12·46. Economic Geology of Non-Metallic Deposits. Designed to give students in mining and geology a fairly complete orientation in the occurrence of clays, cements, abrasives, fertilizers, barite, and other non-metallic deposits. Includes a certain amount of laboratory work.

12·47. Economic Geology of Non-Metallic Deposits (Advanced). Consists mainly of laboratory work on non-metallic deposits.

12·48. Engineering Geology and Hydrology. Relations of geologic processes and structures to engineering problems. Also includes the study of underground waters from the standpoint of the engineer and the geologist.

12·49. Geology of Materials. For students of architecture who have had no previous work in geology. Describes the character and mode of occurrence of materials of construction.

12·50. Historical Geology. An extension of 12·31, including a study of the more common fossils. Textbook: *Grabau, Historical Geology.*

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. Textbook: *Shimer, Introduction to the Study of Fossils.*

12·521, 12·522. Paleontology (Advanced). Consists largely of laboratory work and assigned reading upon some aspect of index fossils, or the evolution of fossil or living forms.

12·53. Index Fossils. The determination of the geologic age of rock formations through a study of their included organic remains. Textbook: *Grabau and Shimer, North American Index Fossils.*

12.54. Micropaleontology. A study of fossil microscopic plants and animals, especially foraminifera.

12·55. Organic Evolution (Advanced). Reading and discussion upon various phases of organic evolution.

12·591, 12·592. Stratigraphy (Advanced). Consists largely of laboratory work and assigned reading upon some subject of stratigraphy.

12·621, 12·622. Geological Seminar. Reading and reports based upon various phases of geologic literature.

12·631, 12·632. Geological Seminar (Advanced). Reading and reports based upon various phases of geologic literature. For graduate students.

12·64. Geology of North America. The physiography, stratigraphy igneous bodies and general geologic structures of North America.

12·65. Geology of Europe. Similar in plan to 12·64, but dealing with the continent of Europe.

12·80. Geology of Coal and Petroleum. Presents in detail the geological occurrences of petroleum and coal deposits and the methods of investigating petroleum and coal properties.

12.82. Chemistry Applied to Ore Deposition. The application of the principles of physical chemistry to ore deposition.

The following subjects are offered as General Studies. For description see Division of General Studies, page 237.

G60. Geology.

G64. Organic Evolution.

NAVAL ARCHITECTURE AND MARINE ENGINEERING

Naval architecture and marine engineering (option 1) is intended for those who expect to be ship-designers, shipbuilders, or marine engine builders or who desire to enter allied industries. The special work of the regular course is given in the form of lectures and recitations, and drawing and computation, during the second, third and fourth years.

The option in ship operation is intended for students who wish to enter the fields of ship operation and management or to engage in other maritime pursuits, such as marine insurance, admiralty law, and the various branches of marine transportation. This course is a combination of engineering, economics, and business studies, especially prepared to train men for activities in this field.

The Department also offers a graduate course in Naval Construction (XIII-A) for Naval Constructors of the United States Navy.

Subjects 13·00 to 13·99 (see page 59).

13.00. Yacht Design and Model Making. Lectures on yacht design, yacht construction, and the care and sailing of yachts. Instruction given in drawing and cutting of models, each student making one or more wooden models. Given in summer session only.

13·01. Naval Architecture. General theory of naval architecture; units of measurement employed, methods of quadrature exact and approximate; principles of flotation including displacement stability and trim. Preparation of ship's lines for required conditions. Geometry of ship forms.

13·011. Naval Architecture. General theory of naval architecture; ship forms and coefficients, displacement, stability, trim, rolling and pitching.

13·02. Naval Architecture. Continuation of 13·01, including grounding, docking, launching, tonnage, freeboard, steering and theory of sea waves.

13·021. Naval Architecture. The resistance and powering of ships, influence of forms and coefficients on resistance, models and model tanks; powering and propulsion, propeller design, influence of hull on action of propeller; steering and maneuvering; longitudinal strength.

13·03. Naval Architecture. Rolling, pitching and heaving motions, methods of controlling same. Resistance and propulsion of ships by paddle wheels, screw propellers, and sails. Methods of making power and speed trials, torsion meters, model experiments of hulls and propellers, effect of shallow water on speed and power.

13·11. Theory of Warship Design. An historical account and a discussion of the evolution of modern warships. General design comprising the determination of the principal elements of design, stability and behavior in a seaway. Textbooks: *Modern History of Warships, Hovgaard, Spon, London*; *General Design of Warships, Hovgaard, Spon, London.*

13·12. Theory of Warship Design. Completion of the lectures on general design comprising construction of lines, preliminary weight calculations, watertight subdivision, buoyancy and stability of submarines, troop transports and oil tankers; final weight calculations. Artillery, development, distribution and installation; ammunition; stowage and transport; torpedo and mine installations. Protection against artillery fire, submarine attack and air bombs. Conning towers. Textbooks: *Modern History of Warships, Hovgaard, Spon, London; General Design of Warships, Hovgaard, Spon, London; Speed and Power of Ships, D. W. Taylor, Wiley, N. Y.*

13·13. Theory of Warship Design. Structural design of warships, comprising materials used in hull construction, strength calculations of the entire hull as well as of its various members and a discussion of riveted joints used in shipbuilding. History of development of machinery; preliminary design and installation of boilers, engines and propellers, as far as this work concerns the naval architect; coaling and coal stowage; oil fuel. Rudders and steering gear. Drainage, ventilation and heating of warships. Textbooks: *Structural Design of Warships, Hovgaard, Spon, London; Modern History of Warships, Hovgaard, Spon, London.*

13·14. Theory of Warship Design. Structural design of warships completed, comprising a discussion of the design of the main structural features; plating, framing, decks, bulkheads, stem and sternpost. Anchors and anchor gear; towing and warping gear. Boats and boat handling appliances. Advanced lectures on stresses in gun-turrets; effects of underwater explosions and protection against such attack; strength of submarines. Docking stresses. Riveted joints. Textbook: *Structural Design of Warship, Hovgaard, Spon, London.*

13·21. Warship Design. Construction and fairing of a set of lines from approximate offsets. Calculation of displacement and stability by ordinary methods used in commercial shipbuilding.

13·22. Warship Design. Preparation of a complete preliminary design of a warship.

13·23, 13·24. Warship Design. Preparation of a complete preliminary design of a warship.

13·31. Ship Construction. Yachts and vessels of wood construction; historical and technical development of wood construction as applied to small boats, yachts, and merchant vessels.

13·32. Ship Construction. Introduction of iron and steel and development of the metal hull in detail, with special regard to the requirements of the registration societies.

13·321. Ship Construction. Similar to 13·32 but dealing with steel constitution of merchant vessels of the present time.

13·33. Ship Construction. Continuation of 13·32 dealing with carpenter and joiner work, plumbing, ventilating, heating and lighting.

13·331. Ship Construction. A course similar to 13.33 but omitting the work on shipyard methods and equipment.

13·37. Merchant Shipbuilding. Deals with the design and construction of merchant vessels with special reference to their employment as auxiliaries during war time, and re-conditioning for their original work when the war service is completed.

13·38. Shipyard Organization. Division of authority and responsibility of the various officials; their duties and necessary qualifications; the efficient handling of labor and materials; the sequence of work; recording of wages, materials and costs, also methods of estimating costs for tendering.

13·39. Shipyard Practice. Lectures dealing with industrial organization, management, operation, equipment, and practice of ship and navy yards as applied to warship construction and repair.

13·41. Ship Drawing. Instruction in the principles of yacht design, drawing and fairing of yacht forms, and in the use of the special drawing instruments. The student is given the opportunity to make a half model of his design of yacht.

13·411. Ship Drawing. Instruction in drawing and fairing lines, layout of midship section from rules of registration societies, structural drawings of ships.

13·42, 13·43, 13·45, 13·46. Ship Design. Further instruction in drawing lines, calculations for displacement, curves of form, and stability calculations. Calculation of launching problem, laying out inboard, people and deck plans, midship section with scantlings. Calculations of weight, trim, strength, etc. Special plans of details. The student is required also to make a half model of this design with such assistance being given as he may require.

13·47. Ship Design. Lectures and drawing room exercises for students in ship operation. Each student works up the preliminary design of a merchant ship, and determines the dimensions, co-efficients, displacement, freeboard, power and propeller requirments, and stability under various conditions of loading. In the drawing room he lays outboard and inboard profile, arrangement plans, etc., and fairs up a preliminary set of lines to meet the requirements of his design.

13·48. Model Making. Includes 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.

13·51. Marine Engineering. An introductory course in Marine Engineering; fuels, combustion, boilers, reciprocating engines, turbines, auxiliary machinery and power plant layouts. Numerous practical problems. Textbook: *Chapman, The Marine Power Plant.*

13·52. Marine Engineering. Describes the design of marine engines and boilers, with special reference to the evidence of trouble in operation at sea. Textbooks: *Marine Engines, Peabody; Marine Power Plant, Chapman.*

13·53. Marine Engineering. Includes the determination of stresses and the methods of proportioning the parts of reciprocating machinery. The vibration of ships, balancing of engines, inertia forces and other interesting problems of the marine engine designer are treated.

13·58. Marine Engineering. Deals with the design of propellers, boilers, and machinery for naval vessels. Textbook: *F. W. Sterling, Marine Engineers' Handbook.*

13·61, 13·62. Marine Engine Design. Computations and drawings for a marine engine, a propeller, a boiler and the layout of the machinery space for a merchant steamship. The design of riveted joints, simple machine parts, choice and advantage of different engineering materials are also discussed. Textbook: *Marine Engineer's Handbook; Sterling.*

13·63, 13·64. Marine Engine Design. The calculations and drawings for the propellers, boilers and machinery for naval vessels. Textbook: *Marine Engineer's Handbook, Sterling.*

13·66. Marine Engineering Design. Calculations for the size of the boilers and auxiliaries of a merchant ship; layout of machinery arrangement and important piping systems; various actual machinery layouts discussed and compared; calculations and drawing of propeller for an assigned ship.

13·70. Marine Steam Turbines. Following a brief preliminary resume of nozzle and blade design, the dimensions of several turbines are computed and the effect of variation in steam conditions is considered. Descriptions of the turbines accompany these thermodynamic calculations. Mechanical features of turbine design such as shaft critical speed, disc wheel strength, and blade strength are discussed. A description of the marine helical reduction gear and electric drive is also included.

13·71. Steam Turbines. Descriptions and methods of designing steam turbines, especially as applied to the proplusion of naval vessels. Textbook: *F. W. Sterling, Marine Engineers' Handbook.*

13·72. Marine Diesel Engines and Auxiliaries. A detail study of Diesel engines and motorship auxiliaries; fuel injection, valve gears, reversing, types of engines, Diesel fuels; Diesel-electric drive, the Still engine and calculations for auxiliaries for motorships.

13·81, 13·82. Ship Operation. The engineering and economic aspects of ship operation; 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 owners' point of view, economical operation of propelling machinery and auxiliaries, inter-relation of power plant and hull design on operating efficiency; repairs, upkeep, maintenance.

13·83. Terminal Facilities. A study of ports and port layouts, the handling of ship's cargoes, piers, transit sheds, warehouses, railroad facilities, pier equipment, influence of turn-around on ship operation.

AERONAUTICAL ENGINEERING

The course in aeronautical engineering is designed 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. Following the usual preliminary work in the subjects fundamental to all engineering, part of the time in the third year and most of that in the fourth is devoted to professional subjects, lectures being supplemented by drafting room practice and by laboratory work both in the methods of aeronautical research and in the operations of maintenance of airplanes in the field.

While a graduate in aeronautical engineering is especially prepared for work in the engineering department of a company manufacturing airplanes, the subjects taught are not so specialized as to go beyond the proper and necessary interest of any man entering any part of the aeronautical field. In particular, it furnishes a sound basic training for those desirous of associating themselves with enterprises engaged in the operation of aircraft, whether their primary concern is with the selection of equipment or its maintenance or with traffic management.

Subjects 16·00 to 16·99 (see page 59).

16·01. Airplane Design. General theory of the design of airplanes, including calculations of stresses and performance and the study of stability and control. Textbooks: *Warner, Airplane Design, Vol. I; Niles, Airplane Design.*

16·015. Airplane Design. Part of 16·01. Textbooks: *Monteith, Simple Aerodynamics and the Airplane; Niles, Airplane Design.*

16·04. Advanced Airplane Design. Special topics in stability and control and performance calculation, and advanced points in lay-out of airplanes for specific purposes are considered.

16·06. Advanced Airplane Structures. Examination of new methods in structural analysis and original work on analyses of greater refinement than those ordinarily made. Particular attention is paid to the applications of the generalized three-moment equation and the method of least work.

16·11, 16·12. Airplane Design Practice. Identical with 16.13 but given in two terms. Textbook: *Niles, Airplane Design.*

16·115. Aeronautics. Continuation of 16·785, completing 16·78 and 16·11.

16·13. Airplane Design Practice. Actual practice in design. Each student carries through the design of a training airplane.

16·14. Airplane Design Practice. A continuation of 16·13 with a more complete study of detail design and with more opportunity for the display of initiative by the student.

16·21. Airship Theory. A study of the theory of aerostatics and aerodynamics as applied to lighter-than-air craft, including discussion of the properties of aerostatic gases and of the stability and control of airships. (Not given in 1927–28.)

16·22. Non-Rigid Airship Design. Theory and practice of the design and construction of non-rigid airships, including stress calculations for envelope, suspension and car. (Not given in 1927–28.)

16·24. Non-Rigid Airship Design Practice. Actual practice in design, including stress calculations. Each student carries through the design of a non-rigid airship. (Not given in 1927–28.)

16·26. Rigid Airship Design. Theory and practice of design of rigid and semi-rigid airships including stress calculations for the hull. (Not given in 1927-28.)

16·28. Rigid Airship Design Practice. Drafting room practice in the layout of a rigid or semi-rigid airship. (Not given in 1927-28.)

16·30. Aerial Propellers. Theory and practice of propeller design by several methods, including the study of propeller stresses. Textbook: *The Design of Screw Propellers for Aircraft, H. C. Watts* (*Longman*).

16·32. Aerial Propeller Design Practice. Drafting room practice in the calculation and design of a propeller for specific aircraft.

16·35. Aircraft Instruments. Discussion of the use of instruments in the navigation of aircraft, with analysis of the theoretical and practical problems entering into their design.

16·41. History of Aeronautics. History of the airplane and airship, with special reference to the technical development. (Not given in 1927-28.) Textbook: *History of Aeronautics, Vivian and Lockwood-Marsh.*

16·42. Aerial Transport. A discussion of the technical, economic and legal problems attending the operation of air lines for the carriage of passengers, express, and mail. Textbook: *A. E. C. Survey of Civil Aviation* (*McGraw-Hill*).

16·48. Aircraft Armament. A general discussion of the types of machine gun, aircraft cannon and bomb releasing gears used on airplanes, together with a general treatment of the theory of sighting and operation of aircraft armament, and in particular of the especial equipment necessitated by the difference between the conditions of aerial and ground operation. Open only to officers of the United States Army, Navy and Marine Corps.

16·51. Rigging and Maintenance of Aircraft. Devoted to actual work on the assembly, disassembly, alignment, and adjustment and minor repair of airplanes. Methods of maintenance work will be studied and maintenance operations actually practiced on one or more airplanes of conventional type.

16·54. Airplane Construction. Lectures discussing the methods used in constructing airplanes, either experimentally or in large production, the tools and other equipment needed, and the estimation of costs.

16·62. Aero Laboratory. An abbreviation of 16·65 and 16·67. Includes both lectures on the methods and equipment used in aeronautical research and experience in the making of tests in the Institute wind tunnels.

16·65. Aeronautical Research Methods. Lectures on aeronautical laboratories and their equipment and on methods of free-flight testing.

16·67. Aeronautical Laboratory. Training in the use of wind tunnels, especially as applied to problems of airplane and airship design.

16·68. Conduct of Aeronautical Research. A continuation of 16·65. Devoted chiefly to the design of equipment, the discussion of general research methods, and the planning of the methods of attack on specific new problems.

16·69. Aeronautical Seminar. Intended primarily for students conducting theses in aeronautics. Consists of a series of meetings with discussions of current research work by graduate students and members of the wind tunnel staff.

16·72. Propellers and Airships. A brief discussion of the theories of design of aerial propellers and their application and of the design and construction of various types of lighter-than-air craft. Intended primarily to give students who are prospective airplane specialists a broadened knowledge of the aeronautical field as a whole.

16·76. Aeronautics. Airplane design and the general principles of flight.

16·78. Aeronautics. A comprehensive course containing material on airship design, aerial propeller design and theory, and aeronautical laboratory methods. Intended to be supplementary to 16·76.

16·785. Aeronautics. Continuation of 16·015, completing 16·01, and part of 16·78. Textbook: *Warner, Aerostatics.*

16·82. Aero Engines. The design and construction of modern aeronautical engines is taken up from the point of view of the airplane designer and operator. Textbook: *Aircraft Power Plants by Jones, Insley, Coldwell and Kohr.*

16·83. Airplane Engine Design. Covers the thermodynamics, mechanics, materials and methods of construction from the point of view of the designer, followed by a study of the methods of designing the various mechanical parts of the engine, in accordance with the requirements of modern aeronautical practice.

16·84. Airplane Engine Design. Includes a study of carburetion, induction, ignition, lubrication, cooling, supercharging, accessories, and the potentialities of new forms of power plants.

16·85. Airplane Engine Design Practice. This is made up of a number of drafting room exercises covering certain fundamental problems in aircraft engine design.

16·86. Airplane Engine Design Practice. In this course the student chooses, under certain necessary limitations, a definite type and size of aircraft engine which he uses as the basis for a complete design. As far as possible, the design methods used are representative of modern practice in the aircraft engine industry.

16·90. Aeronautical Engine Laboratory. Study of aeronautical engines, laboratory test equipment, and tests procedure. Performance tests run on aero engines using different type dynamometers and test equipment. Textbooks: *The Testing of High Speed Internal Combustion Engines, by Judge; S. A. E. Data Sheets and Test Forms.*

BUILDING CONSTRUCTION

The subject of "Building Construction," included in the schedule for the second, third and fourth years is an intensive and detailed study of the assembly of the materials of building. Instruction will be given simultaneously with the development of the structure and, in so far as possible, the student will apply the scientific and professional training of the other parts of the Course to the problem in hand.

Subjects 17·00 to 17·99 (see page 59).

17·21. Building Construction. Problem I, Dwelling House. The student draws the plans and elevations of a dwelling house, to scale, with principal dimensions indicated. A progressive detailed study is then made of the development of the structure and the assembly of the materials of building in their proper sequence, including excavations; concrete, rubble and block foundations; waterproofing; baloon, braced and veneered frames; stucco; roof framing and roofing materials; chimney design; plumbing, heating, etc. Instruction is given by lectures and demonstration from models and samples, after which, the student makes scale details of all the important structural features, embodying materials in general use in dwelling house construction, with an analysis of quantities and costs as applied to the specific problem in hand.

17·22. Building Construction. Problem II, Industrial Building. The same procedure is followed as described for Problem I, but with special reference to timber, slow burning construction and reinforced concrete and the structural details commonly met within industrial buildings.

17·31. Building Construction. Problem III, Office Building-Above Grade. The same procedure is followed as indicated in Problem I, but with special reference to structural steel; stone brick and terra cotta masonry, fireproof construction, floor finishes, plumbing, heating and ventilation, electrical equipment, etc. Includes a study of the chemistry of the materials of building; cements, plasters, paints, explosives; waterproofing compounds, roofing materials, etc.

17·32. Building Construction and Materials. Problem III. Office Building — Above Grade. A continuation of 17·31.

17·41. Building Construction. Problem IV. Office Building-Below Grade. This is a continuation of the work of Problem III, and involves a study of the various types of foundations required for steel structures under varying conditions, together with instruction in earth and rock excavation; the use of explosives; shoring, sheet piling and underpinning, and the use of mechanical tools, derricks, compressors, drills, pumps, mixing machinery, etc.

17·42. Building Construction. Problem IV. Office Building — Below grade. A continuation of 17·41.

17·50. Job Management. A series of lectures on the management and control of an operation in the field, with particular reference to rapid construction in cities and congested localities. 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; discipline; and the various systems of job accounting payrolls and their distribution; requisitions, job receipts; materials survey, cost tabulations, etc.

DRAWING

The work of this division includes preparation in mechanical drawing, and descriptive geometry which leads to the various courses in applied drawing offered by the professional departments.

The course in mechanical drawing is concerned largely with the technique and principles of graphical representation and includes as a basis for the work which follows, practice in accurate pencilling, in the inking of instrumental construction and irregular curves, and in lettering and tracing. It also includes practice in making dimensioned sketches from simple machine parts, from which are laid out finished working drawings.

Special importance is attached to the study of descriptive geometry, both as embracing the principles of the graphical representation of objects and the solution of geometrical problems, and as a means of developing the imagination and the power to visualize. Illustrations of the practical application of its principles are afforded by the solution of problems taken from engineering and architectural practice.

Subjects D1 to D99 (see page 59).

D11. Mechanical Drawing. Instruction in the correct use of drafting instruments and materials. Drawings are made in pencil and in ink, on paper and on tracing cloth. Practice is given in lettering. Neatness and accuracy are required. Isometric and oblique projection are included. Textbook: *Mimeograph Notes.*

D12. Working Drawings. Gives the elementary instruction required for the courses in machine drawing. Includes simple perspective projection, the construction of conics and rolled curves, the making of dimensioned freehand sketches from machine parts and of accurate detail drawings from the sketches.

D21. Descriptive Geometry. Short lectures and individual classroom instruction. Especial emphasis is placed upon the ability to visualize the problems and the processes of solution.

Includes a study of the fundamental conceptions of orthographic projection and fundamental problems on lines, planes and solids. Textbook: *Kenison and Bradley, Descriptive Geometry.*

D22. Descriptive Geometry. A continuation of the work of the first term through the more complex phases of the science, including sections, developments, tangent lines and planes, and intersections of surfaces of revolution. Textbook: *Kenison and Bradley, Descriptive Geometry.*

D23. Descriptive Geometry (College Class). Intensive work covering in one term the complete requirement in first year descriptive geometry, open to students transferring from other colleges with advanced standing. Students with failures in descriptive geometry will not be admitted. Textbook: *Kenison and Bradley, Descriptive Geometry.*

D31. Descriptive Geometry. A continuation of D22 providing additional practice and applications and covering in greater detail, the study of tangent planes, intersection of surfaces of revolution. Includes some consideration of warped surfaces. Textbook: *Kenison and Bradley, Descriptive Geometry; Mimeograph Notes.*

D311. Descriptive Geometry (College Class). Covers the same ground as D31 and primarily intended for college transfer students of Course I who have taken the College Course (D23) of the first term.

ECONOMICS

In this Department is grouped the instruction given in general economics to students in all courses, and also the more specialized subjects provided for the course in Engineering Administration (XV). All courses, except XV, take political economy (Ec31, 32) in the third year, and opportunity will also be given to select general studies in the field of economics, such as political and social problems, and banking and finance.

Students in Course XV begin political economy in the second year, but owing to the requirements of subsequent studies in business economics, devote but one term, instead of two, to this preliminary course.

The courses in Accounting Ec50, Cost Accounting Ec51, Banking Ec37 Statistics Ec65, Corporate Organization Ec56, Corporate Finance and Investments Ec57, Industrial Relations Ec46, Business Management Ec70, 71 and 72, and Business Law Ec61 and 62 are designed particularly for students in Engineering Administration, and should not be applied for without permission of the Department.

Subjects Ec1 to Ec99 (see page 59).

Ec21. Political Economy. Less extensive in its scope than Political Economy Ec31, 32. More emphasis is placed upon fundamental principles, and less time devoted to such subjects as money, banking, trusts, labor problems, etc., which are covered by special subjects in Course XV.

Ec31, Ec32. Political Economy. 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. Special attention is given in Ec32 to fundamental business processes including principles of accounting, corporate organization and finance, credit and banking, labor problems, and business management.

Ec35. Political Economy. Given for students in Course XIII-A. Covers Ec31 and part of Ec32.

Ec37. Banking. Credit instruments, credit documents, national banks, state banks, trust companies, savings banks, different kinds of loans, securities for loans, credit statements, the bank statement, the money market, relation of the treasury and crop movement to money market, clearing house, domestic and foreign exchange.

Ec46. Industrial Relations. Intended to familiarize the student with the more important problems which arise out of the relation of employer and employee under present conditions of industry. In addition to a consideration of the organizations and policies of the parties to the contract of employment, it deals with matters of public policy such as labor legislation and social insurance.

Ec471, 472. Personnel Management. An intensive study of the principles and technique of personnel work, sometimes called human engineering. Particular attention will be given to the problems that arise in practice in recruiting, training, and maintaining a labor force. Comparative studies of the different methods and practices in selection, including mental and trade tests; placement, promotion and transfer; education and training; job analysis and specifications; the measurement and control of turnover, regularization of employment; absenteeism and tardiness, and other specific problems will be undertaken. Other topics for investigation will include methods of wage payment; benefit plans, including pensions, insurance and assignment of stock; health and welfare work; housing; labor legislation, including safety supervision and workmen's compensation.

Ec50. Accounting. Systematic and logical recording of financial data is a requisite of modern business. The purpose is accomplished through the mechanism of double entry bookkeeping. But more important than the assembling of such data is analysis aiming toward useful generalizations and conclusions. Analysis of this sort is beneficial for management, stockholders, and the general public. Instruction therefore, deals with assets and liabilities, balance sheets, profit and loss statements, surplus, depreciation charges, reserves, financial ratios indicating trends and present conditions, and other kindred problems. In so far as possible, cases based upon actual corporation reports and records are studied.

Ec51. Cost Accounting. Methods of determining costs of materials, processes of labor and machines; the distribution of direct costs and overhead expenses; cost data to test management and to show the particular sources of profits or losses; shipping orders; inventories; recording and payment of wages.

Ec53. Building Finance. Describes the financing of new building projects as well as the financing of the building constructor. The topics studied include the valuation of real estate, method of appraisal, depreciation, financing by first and second mortgages, mortgage companies, building and loan associations, construction loans, bank credit and the administration of finance. Special attention will be devoted to those aspects of building finance which are connected with the problem of securing new business for the building constructor.

Ec541, 542. Manufacturers' Accounts. Application of cost accounting principles to specific problems in industry through the use of case material and preparation of a thesis. Readings in cost procedure for those manufacturing activities into which the individual student is planning to enter. Study of some miscellaneous topics serving to clarify various accounts of the manufacturer not necessarily directly connected with the computation or application of costs.

Ec55. Tax Returns and Accounts. Lectures, readings and problems illustrating accounting principles underlying income taxation, the accounts which should be kept, and the preparation of tax returns. Emphasis will be given federal taxation as being of more widespread interest, but some attention will be given to the income taxes of two or more commercially important states.

Ec56. Corporate Organization. The organization and control of corporations with some attention to other forms of business. Consideration is given to procedure and problems of incorporation, relationships of the parties in the corporation, and combinations of corporations in our large industrials. Public utility corporations are studied briefly with the purpose of presenting the relations of public service corporations and the public.

Ec57. Corporate Finance and Investments. Covers fundamental principles of financial organization and management. The various types of corporate securities are examined, the financial problems of the promoter, the incorporators and the later financial management are studied and illustrations are drawn from concrete cases. The latter part of this subject considers more specifically the different kinds of investment securities with exercises in investment analysis, and a discussion of the methods of the exchanges, brokerage and speculation. Lecturers from investment houses assist in this branch of the subject.

Ec581, 582. Financial Administration of Industry. Deals primarily with financial problems of the ordinary sized establishments. The problems covered include: initial working capital requirements, mortgaging the plant, choice of banking facilities, budgetary control, duties of the treasurer and procedure with relation to bankrupt debtors.

Ec591. Public Utility Management and Finance. Deals with the theoretical and practical phases of public utility management. The subject matter will include a brief study of corporate organization and management in general, followed by the application of the general principles of finance and management to public utility enterprises. Emphasis will be placed upon problems of capitalization, holding company organization and certain phases of accounting which bear upon the financial policies of these companies.

Ec592. Public Utility Management and Finance. A continuation of Ec591 including public relations, rate making, valuation and regulation by commissions. Some attention will be given to analysis of territory served. In addition to instruction by members of the Institute Faculty, a broad range of topics of direct concern to public utilities and to users and refiners of fuels will be covered by lectures by men of special achievement in their several fields.

Ec61, 62. Business Law. Deals with the general principles of contract law, special kinds of contracts, such as contracts for the sale of real estate, contracts for the sale of personal property, contracts of employment; agency; corporation law; and law of partnerships, and negotiable instruments.

Ec63. Business Law and Organization. A graduate study of business organization from both a legal standpoint and a management standpoint. The subject of contracts and the personal relations of individuals within the organization are emphasized. The advantages and disadvantages of various types of organization are discussed.

Ec65. Statistics. Elementary instruction is given in the construction of statistical tables and charts, official sources of commercial and financial statistics of the United States, and the interpretation of such material. Some attention is given to the statistical methods of forecasting.

Ec661, Ec662. Statistical Methods. Study of the principles and methods used in more advanced statistical analysis. Some of the topics included are correlation of two variables, multiple and partial correlation, simple sampling, and the basic theory of probability with special reference to business problems. Determination of historical trends and periodic fluctuations of economic time series will receive considerable attention preparatory to the major problem of business forecasting. Students should have read an elementary text such as *Jerome's Statistical Methods, Day's Statistical Analysis, or Mill's Statistical Methods.*

Ec681, 682. Business Cycles. A study of recurrent periods of business prosperity and depression and of the theories offered to explain them. Students will examine the factors which must be considered and the statistical methods used in attempting forecasts of general business conditions and of the rules of particular enterprises.

Ec70, 71, 72. Business Management. Deals with the activities of an individual business. Emphasizes the development of scientific marketing. Among the more important topics considered are: Organization; plant location, layout and equipment; purchasing; intra-factory transportation; traffic; inspection; stores; design; time, motion and fatigue study; production control; office organization, layout and equipment; commercial research; marketing methods, sales promotion and advertising. As far as possible the practices of production and marketing are studied in parallel, thus emphasizing the development of similar principles of scientific management in both fields.

Ec74. Business Management. Deals with the business aspects of the building industry. The following topics are considered from an administrative viewpoint: Organization, estimating, purchasing, contracts, insurance, sales promotion, control of equipment, control of materials, office control, regularization of work, research, coördination of sales, finance and construction programs, organization and management of small construction enterprises.

Ec761, 762. Marketing of Manufactured Products. A study of the problems concerned in marketing the products of manufacturing industries with special reference to policies and methods. The basic factors of organization, operation and control are discussed. Readings in marketing methods are required as a foundation for a thesis on a specific practical marketing problem.

Ec80. 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 business administration of shipping activities.

The following subjects are offered as general studies. For description see Division of General Studies, page 237.

G20.	**Labor Problems.**	**G25.**	**Investment Finance.**
G22.	**Marketing Methods.**	**G26.**	**Banking and Finance.**
G23.	**Production Methods.**	**G27.**	**Economics of Corporations.**

ENGLISH AND HISTORY

The work in English is designed to arouse in the student an interest in the important problems of modern life, and through the interest thus stimulated to train him in oral and written expression. The instruction is given by lectures, and in sections which offer frequent opportunity for class discussion and for oral presentation of topics prepared by students. The written work is for the most part in the form of reports, in which emphasis is put on the clearness and accuracy of expression which are essential in the work of a professional man.

The instruction given by the Department in Literature and History is planned so that the student may acquire an understanding of the main currents of thought of the last one hundred and fifty years as they have expressed themselves in the events, the institutions, and the literature of that period. Significant works of literature which interpret phases of political, economic and social life are read and discussed concurrently with an historical study of the times. By this correlation of the work in literature and history — on which as has already been indicated the work in composition is based — it is hoped that the student may gain a broad and vital comprehension of the main forces working in life and society today.

Subjects E1 to E99 (see page 59).

E1. English (Entrance). For description see entrance requirements.

E11. English and History. Covers European History of the last hundred years and is conducted by recitations and conferences, with oral and written reports. Textbook: *Hayes, A Political and Social History of Modern Europe, Revised Edition, Vol. 2. (Macmillan.)*

E12. English and History. A continuation of E11. Textbook-*Hayes, A Political and Social History of Modern Europe, Vol. 2, Revised Edition. (Macmillan.)*

E21, 22. English and History. Includes the chief ideas of nineteenth century and contemporary thought, political, social and philosophical, handled in recitation and discussion groups, with required and collateral reading, lectures and written papers. An alternative course on "types of literature" is offered for men properly qualified.

E31. English and History. Advanced work in reading and discussion of modern intellectual problems, based on Steeves' and Ristine's "Representative Essays in Modern Thought." Lectures, recitations for discussion and written papers. Required for Course XV.

E33. Report Writing. A study of the various types of engineering and business reports. Practice in the investigation of subjects, the arrangement of material, and its presentation in good report form. A secondary part of the subject is practice in the planning and writing of the more common types of business letters.

E40. English. A study of the biographies of five or six famous men of modern times, representing different fields of activity. Collateral reading and written work.

The following subjects are offered as general studies. For description see Division of General Studies, pages 244.

G40. English (Contemporary Drama).

G41. English (Contemporary English Literature). Not offered in 1927-28.)

G42. English (Contemporary European Literature). (Not offered in 1927-28.)

G43. English (American Literature).

G45. English (Advanced Composition).

G46. Public Speaking.

G461. Argumentation and Debate. (Not offered in 1927-28.)

G47. English (Informal Public Speaking).

G48. Appreciation of Music.

G50. Fine Arts in Modern Life.

G52. Lincoln and the Period of the Civil War.

G55. French Revolution and Napoleon.

G59. Social Problems of Philosophy.

FUEL AND GAS ENGINEERING

This course is planned to afford properly prepared graduates in Engineering and allied fields of Science opportunity to obtain special theoretical and practical training in the processing and utilization of natural and manufactured fuels. Openings for men trained in this field are varied but most particularly the demand for such men comes from the petroleum, steel, gas and electric power industries. The work consists of one academic year of study at the Institute followed by six months' field work.

The content of the work at the Institute is indicated in the list of subjects given below. In the field work the theoretical side of fuel and gas engineering studied at the Institute is applied to the processes of gas manufacture and fuel utilization by plant studies and tests on full scale equipment in commercial operation. In general the thesis will be done during this period. The degree of Master of Science in Fuel and Gas Engineering will be awarded upon the satisfactory completion of the work, subject to the general rules for the Master's degree.

Subjects F1 to F99 (see page 59).

F1. Principles of Combustion. Part 1. Combustion calculations dealing with furnaces, kilns, retorts, gas producers and oil-cracking still-settings. The calculation of excess air, volume of air and flue gas, heat and material balances, etc., is thoroughly and quantitatively considered.

Part II. Study of the principles and laws governing the combustion of coals, fuel oil, natural and manufactured gas. The methods and equipment employed in industrial fuel utilization are described and studied.

F2. Development and Use of Power. Study of gas, electric and steam power and the selection of power equipment for typical conditions met in practice. The different types of steam turbines, the principles and economics of gas and oil engines, the simultaneous production of power and process steam are considered. Intended to give the student a broad vision of the entire field of power development in addition to the more important detailed methods of power application and the limitations and possibilities of the various generating methods.

F3. Furnace and Retort Design. Study of principles and calculations of furnace and retort design and construction, dealing with rates of heat transfer, flow of gases in furnaces and retorts, and construction details. The quantitative design and layout of two or three furnaces, retorts or still-settings will be carried out.

F4. Gas Engine Laboratory. Based on a series of laboratory tests on various types of gasoline and Diesel engines during which the effect of different fuels, carburetion and other variables on operating performance is studied.

F5. Natural Fuels. A study of the origin, composition, classification, production, preparation and refining of the primary natural fuels, especially bituminous and anthracite coal, petroleum and natural gas.

F6. Principles of Fuel and Gas Engineering I. A quantitative study of (1) the measurement and calculations of pressure drop of gases and liquids flowing through pipes, ducts, etc.; (2) the flow of heat in coolers, condensers, heat interchangers, furnace walls; (3) crushing, grinding and sizing of solids. The course consists of lectures, problems and conferences.

F7. Principles of Fuel and Gas Engineering II. Continuation of Fuel and Gas Engineering I, dealing with gas scrubbing and absorption, distillation and humidification. These principles will be applied to quantitative study of the unit processes of gas manufacture, petroleum refining and coal carbonization, as well as to the operation of the equipment involved. Studies in economic balance and treatment of residuals form a part of this subject.

F8. Properties of Materials. Includes a study of the chemical and physical properties of common materials of boiler and furnace construction, such as refractories, insulation, metals and alloys at high temperatures. The corrosion of metals in general and specifically condensers, boilers, stills, heat interchangers, etc., are taken up in addition to allied topics such as water softening.

F9. Manufactured Fuels. Takes up the chemistry, properties, equipment and the factors involved in the manufacture of producer gas, water gas, complete and low temperature gasification of coal, the production of oil gas, etc.

FIELD WORK AND THESIS

The field work consists in plant studies and tests of full size equipment in commercial operation. The same general methods now in use at the field stations of the School of Chemical Engineering Practice are employed. The field stations are located at Buffalo, Boston and Bayonne. At these stations the work is wholly educational and under the direct supervision of the Institute's faculty. In general, training is given in the application of acquired principles to industrial practice.

F10. Field Work and Thesis — Boston Station. The manufacture of coal gas in the various types of retorts, carburetted water gas, and large scale distribution of gas will be studied at gas plants in Massachusetts, particularly at that of the Cambridge Gas Light Company. Tests and studies have been carried out on coal gas retorts and on the possible use of waste heat boilers. Part of the time at this station will be devoted to research or investigation that will comprise the student's thesis.

F11. Field Work — Buffalo Station. At the Lackawanna plant of the Bethlehem Steel Company, the use of fuels for power generation, coking of coal, blast furnaces, open hearth and general metallurgical furnaces will be studied. Other equipment at this plant which is available for study includes three types of coke ovens, by product recovery apparatus, reheating furnaces and benzol distillation equipment. The latter part of the work at Buffalo will be carried out at the plant of the Iroquois Gas Company where the manufacture of coal gas, blue water gas and high pressure gas distribution will be studied. The plant is equipped with new Woodhall-Duckham vertical retorts, one bench of which is especially designed to permit study of coal carbonization. This plant also affords an excellent opportunity for studying the problems incident to the use of mixed natural, coke oven, coal and water gas.

F12. Field Work — Bayonne Station. The work of this station comprises studies of various types of refining equipment and methods. The Bayonne Refinery of the Tide Water Oil Company is a complete unit for the processing of crude petroleum. An excellent opportunity is afforded for the investigation of the manifold problems involved in the distillation, cracking, and purification of petroleum and its distillates. Tests of different types of stills, fractionating columns, cracking units and combustion equipment are carried out in order both to investigate the process and equipment used and to obtain data on heat transfer and similar functions necessary to the design of such equipment. This station is operated in coöperation with the School of Chemical Engineering Practice.

GENERAL STUDIES

This division includes those subjects of a general and essentially non-technical 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.

Four terms of general study subjects are required in the junior and senior years, but each student is free to elect from among the subjects listed below such as appeal to his particular personal tastes and interests. A considerable variety of subjects is offered, grouped for convenience under the headings: Social, Political, Economic and Business Subjects; Literature, English, History and Fine Arts; Science; Foreign Literature. The list may be modified or extended from year to year.

With the approval of the professor in charge of the division, other non-technical subjects of suitable character may be substituted for those listed. Such approval can only be given previous to registration in the proposed substitute course. College graduates or others who have taken elsewhere a satisfactory equivalent of liberal studies may be excused from further requirements in general studies.

Students who because of irregularities in their schedules find difficulty in utilizing the regular general study hour, are advised that any term in either European Civilization and Art 4.46, 4.47 and 4.48 or Free Hand Drawing 4.02, 4.03 and 4.04 will be credited as a general study. These courses are given under Course IV in the Rogers Building, 491 Boylston Street, Boston.

Members of the Choral Society who attend regularly throughout the academic year the rehearsals and concerts and meet the tests to the satisfaction of the director may receive credit for one general study.

SOCIAL, POLITICAL, ECONOMIC AND BUSINESS SUBJECTS

First Term

- **G23.** Production Methods.
- **G25.** Investment Finance.
- **G26.** Banking and Finance.
- **G38.** Christianity and the Social Order.
- **G59.** Social Problems of Philosophy
- **G98.** Military History and Policy of the United States.

Second Term

- **G3.** International Law and American Foreign Policy.
- **G5.** Psychology.
- **G20.** Labor Problems.
- **G22.** Marketing Methods.
- **G27.** Economics of Corporations.
- **G4.** Business and Patent Law.

SCIENCE

First Term

- **G1.** History of Science.
- **G65.** Sound and Music.
- **G71.** Principles of Biology and Heredity.
- **G72.** Technical Aspects of Bacteriology.
- **G78.** Air, Water and Food.
- **G79.** Engineering Chemistry.
- **G60.** Geology.

Second Term

- **G2.** History of Science.
- **G66.** Descriptive Astronomy.
- **G67.** Meteorology.
- **G73.** Sanitary Science and Public Health.
- **G75.** Physiology and Embryology of Reproduction.
- **G78.** Air, Water and Food.
- **G79.** Engineering Chemistry.
- **G64.** Organic Evolution.
- **G76.** History of Philosophy.

FOREIGN LANGUAGES

First Term

- **G821.** French.
- **G831.** French.
- **G941.** German.

Second Term

- **G822.** French.
- **G832.** French.
- **G942.** German.

LITERATURE, ENGLISH, HISTORY AND FINE ARTS

G41. **English (Contemporary English Literature).** (Not offered in 1927-28.)
G43. **English (American Literature).**
G46. **Public Speaking.**
G461. **Argumentation and Debate.**
G48. **Appreciation of Music.**
G52. **Lincoln and the Period of the Civil War.**
G55. **French Revolution and Napoleon.**
European Civilization and Art.
Freehand Drawing.

G40. **English (Contemporary Drama).**
G42. **English (Contemporary European Literature).** (Not offered in 1927-28.)
G45. **English (Advanced Composition).**
G47.
English (Informal Public Speaking).
G50.
G58. **Fine Arts in Modern Life.**
Choral Singing.
European Civilization and Art.
Freehand Drawing.

Subjects G1 to G99 (see page 59).

G1. History of Science. Thirty lectures or other exercises, dealing with the development and decline of Greek science; the transmission of science into western Europe; the science of the renaissance with emphasis mainly on mathematics and the sciences nearly related to it. Textbook: *Sedgwick and Tyler, A Short History of Science*, Chapters I-X.

G2. History of Science. Thirty lectures, or other exercises, dealing with the development of different fields of science. The subjects treated will vary somewhat from year to year, but include such topics as the transition from alchemy to chemistry, and the development of modern astronomical theory, of the theories of natural science and special topics from the history of engineering and industry. Textbook: *Sedgwick and Tyler, A Short History of Science*, Chapters XI-XVII.

G3. International Law and American Foreign Policy. The lectures will usually be of an historical character designed to help one to an intelligent understanding of the subject as an American citizen. They will include topics grouped as follows: Great Writers on the Law of Nations, the Birth of International Law, States and Their Recognition, the entry of America into the Family of Nations, the Monroe Doctrine, and Pan-Americanism; the Territorial Jurisdiction of a State, Ships on the High Seas and in Port, Diplomatic Protection of Citizens Abroad, and Extradition; the American Foreign Service, Treaties and the Procedure of Ratification in the United States; the Hague Conferences, the League of Nations and the Permanent Court of International Justice; Rules of Land, Sea and Air Warfare, Military Government in Occupied Territory, and the Rights and Duties of Neutral States in Time of War. There will be occasional class discussions of related problems. One report for the term will be required on a topic of current international interest based on outside reading and chosen by the student himself with the approval of the instructor. A few selected reports will be presented orally in the class either separately or as part of a symposium pre-arranged by the instructor. Textbook: *Wilson and Tucker's International Law.*

G4. Business and Patent Law. Consists of twenty lectures on business law and ten lectures on patent law.

G5. Psychology. General principles of psychology.

G6. Industrial Psychology. The applications of psychology to industrial problems of selection, placement and efficiency of personnel, with some treatment of the psychology of marketing. Given in summer session only.

G20. Labor Problems. The ground covered consists of a brief resume of modern industrial history, showing the laborer's place in the industrial world, and the general condition of labor as regards wages, hours of labor, sanitary and safety regulations, etc. The following special topics are discussed; collective bargaining; strikes and lockouts; injunctions; arbitration; coöperation; profit-sharing; workmen's compensation and social insurance; and labor legislation. Special consideration will also be given to recent developments in personnel work, industrial relations, and plans for some degree of participation of employees in the management of industry through works' councils, shop committees and other forms of joint control.

G22. Marketing Methods. Following such study of the economics of marketing as is necessary for an adequate understanding of the larger aspects of marketing, emphasis is placed on the methods by which economic goods are distributed. Includes discussion of sales organization, sales engineering and coördination of sales and production in the marketing of fabricated products. Agencies for creating demand and for supplying demand are discussed. Modern practices in organization, equipment and operating methods in the fields of sales operation, advertising, merchandising and warehousing are treated in detail.

G23. Production Methods. Emphasizes methods of organizing and directing the activities and functions of production in manufacturing. Considers the control of equipment, materials, product quality, product quantity and personnel. Equipment control is discussed in relation to building location and type, machinery and tool selection and arrangement, and the use of service equipment. Material control comprises a study of purchasing, traffic, stores, and intra-factory transportation methods. Product quality control considers the factors of design and engineering, inspection, salvage and the utilization of by-products. Product quantity control covers the work of planning, scheduling and dispatching and will survey several representative control structures now in successful operation. Personnel control deals with the methods of employment, labor maintenance and the technique of the executive.

G25. Investment Finance. Considers briefly (1) the legal rights conferred upon the owners of securities of various types; (2) the basis for credit offered by issuing corporations of various kinds: government, railroad, public utility, industrial, etc.; (3) the construction of bond tables, interest formulas, sinking fund calculation, serial bonds, amortization, and the mathematical theory of investment; (4) the stock exchanges, brokerage, speculation and the various kinds of business houses which deal in securities and investments.

G26. Banking and Finance. Considers the subject of banking in less technical form than Ec37. There is also a treatment of the investment and security market and the more elementary portions of corporation finance.

G27. Economics of Corporations. The types of business organization with special emphasis upon the corporation. Consideration is given to the internal organization of the corporation, especially on the financial side: promotion, underwriting, marketing of securities, the financial problems of a going concern, bankruptcy and receivership. Discussion of public service corporations and a brief examination of the trust movement. Textbook: *Lough, Business Finance.*

G38. Christianity and the Social Order. A discussion of the evolution of our social order in the light of modern religious and scientific thought with the object of making plain the origin and tendencies of the principal elements of western civilization. The official views of Catholicism and Protestantism are examined and their agreement with the teaching of social science emphasized. Textbooks: *Ellwood, Sociology and Modern Social Problems: The Church and Industrial Reconstruction.*

G40. English (Contemporary Drama). An untechnical discussion of notable living playwrights and their work here and abroad.

G41. English (Contemporary English Literature). Treats of a number of the most important English men of letters from 1890 to the present time. (Not offered in 1927-28.)

G42. English (Contemporary European Literature). An introductory study of some of the chief figures in European literature of the last few decades and today. (Not offered in 1927-28.)

G43. English (American Literature). From the Civil War, with especial emphasis on the period since 1900.

G441. English (Committee Work). The development of coöperative thinking and cultivation of the "group spirit" by means of committee reports on vital and timely subjects, and acceptance or constructive amendment by the class of what each report recommends. Open only to VI-A.

G442. English (Business English). A study of the principles of effective, businesslike expression; and practice, both written and oral, in the expression of those principles. Lectures, recitations, business letters, oral and written reports. Open only to VI-A.

G443. English (Modern Forms of Literature.) A brief study of the various types of contemporary novels, dramas and short stories with a view to critical appreciation of these forms of literature. Lectures, discussion and written reports and criticisms. Open only to VI-A.

G45. English (Advanced English Composition). Designed primarily for students who wish to do advanced work in composition under direction and criticism. So planned as to allow much individual freedom in the choice of materials. Those desirous of experimenting with the essay or the short story, or with technical description or exposition, may do much of their writing in any one of these fields.

G46. English (Public Speaking). The object is to set forth the principal matters of technique on which the art of speaking in public is based, and to provide training for the individual members of the class.

G461. Argumentation and Debate. Trains men to prepare intensively and to present effectively an argument. The principles of formal logic, rhetoric, and oratory together with the general principles of argumentation will be studied. The principles will be applied practically through classroom preparation of briefs and oral presentation of debates. (Not offered in 1927-28.)

G47. English (Informal Public Speaking; Committee Reports and Discussion). Training in the preparation and oral presentation of committee reports. These reports serve as a basis for class discussion.

G48. Appreciation of Music. No previous knowledge of music is needed for this subject. Many musical illustrations are performed in the class room. The lectures and textbook endeavor to give simply and clearly the knowledge needed by an intelligent listener. Written work totalling 2,500 words, and two hour examinations are required. Textbook: *Sigmund Spaeth, The Common Sense of Music.*

G50. The Fine Arts in Modern Life. Aims to develop the habit and faculty of noticing visible beauty in contemporary art, in public monuments and museum collections, and more especially in one's personal environment, such as costume, furnishing and decoration of the home, books, pictures, magazines, the theatre. The history of art is studied with a brief text in order to make the appreciation of contemporary work more discriminating. Textbooks: *Reinach, Apollo, the Story of Art and Significance of the Fine Arts.* (*Scribner's*)

G52. Lincoln and the Period of the Civil War. Life of Abraham Lincoln and his relation to the times. Textbook: *Charnwood, Life of Lincoln.*

G55. French Revolution and Napoleon. Lectures, maps, pictures, and some outside reading will be used to give the student a general idea of the most interesting features and episodes of French society just prior to the Revolution, of the Revolution itself, of the advent of Bonaparte, of the Empire and of Waterloo.

G58. Choral Singing.

G59. The Social Problems of Philosophy. Discusses in non-technical language some of the philosophical theories which underlie recent views of society and of the management of the personal life.

G60. 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. Textbook: *Shimer, Introduction to Earth History.*

G64. Organic Evolution. A study of the evolution of life throughout the past history of the earth with a discussion of the underlying laws operating today and with especial reference to the various avenues along which man is evolving.

G65. Sound and Music. A general descriptive treatment with some experimental lectures.

G66. Descriptive Astronomy. A general survey (illustrated) of the facts and theories relative to the solar system and sidereal universe. Textbook: *Moulton's Introduction to Astronomy.*

G67. Meteorology. A general descriptive account of atmospheric phenomena. Topics for consideration will include the mechanics and thermodynamics of the atmosphere, atmospheric optics, and factors of climatic control. Textbook: *Physics of the Air, W. J. Humphreys.*

G71. Principles of Biology and Heredity. Thirty lectures illustrated by demonstrations, charts and lantern slides. A cultural subject intended for students who have had little or no previous training in biology. Gives a broad view of the fundamental principles of the subject, including the properties of living matter, movement, nutrition, growth and reproduction; with a general account of form and structure of plants and animals and their classification. The questions of sex and heredity treated at length. Textbook: *Walter, Genetics, Revised Edition,* 1922.

G72. Technical Aspects of Bacteriology. Lectures on the relation of bacteria and allied microorganisms to chemical change, water and sewage treatment, and to productive processes in agriculture and industry. The role of the bacteria in soil fertility, in nitrogen fixation and other constructive processes, as well as the effect of undesirable types of microorganisms are considered. Special attention is given to the fermentation processes in different industries whereby microbes are made to work as chemical reagents. Illustrated by demonstrations and lantern slides.

G73. Sanitary Science and Public Health. Lectures (illustrated) on health and disease, parasitism, toxins and anti-toxins, resistance and immunity vaccination, epidemiology, preventive sanitation and preventive hygiene.

G75. Physiology and Embryology of 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 of the subject from the biological standpoint.

G76. History of Philosophy. A general survey of modern philosophy from the time of Descartes.

G77. Methods of Teaching General Science in Senior and Junior High Schools. A study of methods of teaching general science to high school pupils. Typical experimental lectures will be given which illustrate the best methods of presenting the subjects. Given in Summer Session only.

G78. Air, Water and Food. Takes up these essentials of life as they affect the welfare of the individual and the community. Typical subjects discussed are: factors of comfort in ventilation, tests for pure water, protection of water supplies, sewage treatment, food in relation to life and growth, an adequate dietary, food adulteration. Requires no chemistry beyond that given in the first year.

G781. Methods of Teaching Physics in Senior High Schools. A study of methods of teaching physics to senior high school pupils. Experimental lectures will be given to illustrate the best methods of presenting the subject matter. Given in Summer Session only.

G782. Methods of Teaching Chemistry in Senior High Schools. A study of methods of teaching chemistry to senior high school pupils. Experimental lectures will be given to illustrate the best methods of presenting the subject matter. Given in Summer Session only.

G783. General Science Laboratory. (For Teachers). Affords practice in setting up apparatus and performing experiments, such as would be used in a demonstration class in science. Given in Summer Session only.

G79. Engineering Chemistry. A broad, general, non-technical subject designed to furnish chemical information as applied to common things. Treats of the manufacture and testing of illuminating gases, coal tar products, perfumes, sugars, alcohols, acids, petroleum-gasoline, lubricating and fuel oils, the animal and vegetable oils, paints, varnishes, paper, ink, leather, glue, rubber, textiles and explosives. Alloys, wood and wood preservatives are also considered. Textbooks: *Rogers, Elements of Industrial Chemistry* or *Thorp, Outline of Industrial Chemistry.*

G821, G822. French. Practice in understanding spoken French, expression in French of scientific ideas, general and technical. Reading of texts on science and industry. Each term may be taken independently. (Not offered 1927–28.)

G831, G832. French. A brief survey of some period or school of French literature with the reading of some masterpieces. Such topics as the following are discussed; the literature of the Middle Ages; the Renaissance; classicism; the romantic movement; realism; naturalism; art for art's sake; impressionism and symbolism. Each term may be taken independently.

G941, G942. German. Many exercises without preparation. It is distinctively a sight reading course for practice in rapid reading. The selections are from current periodicals. Preparation is devoted to the derivation of words and vocabulary study.

G98. Military History and Policy of the United States. Military history and policy of the United States from the early colonial times to the present day given in such a manner as to avoid a too technical discussion of the strategic principles involved as are the political or other factors leading up to the events referred to except where a clear understanding of the situation requires it. Required of all students registered in any Advanced R. O. T.C. Unit. Ordinarily taken during the first term senior year but may be taken during first term junior year.

GERMAN

The study of German at the Institute has two objects: that of enabling the student to make use of the language as an instrument in scientific research, and that of giving him general training and culture. It aims to give sufficient facility with modern texts to use them without the necessity of translating, and as much familiarity with the spoken language as the individual aptitude of the student and the time available permit. From the beginning as much of the classroom work as possible is carried on in the language taught. Occasional talks therein are also given, and writing from dictation is frequently practised.

A sound knowledge of grammar is attained by the careful analysis of parts of the texts read, and by oral and written illustrative exercises. To make these of value a good pronunciation is essential, and this is striven for through constant practice in the classroom. In addition to a deeper knowledge of the language and literature, the advanced courses aim to impart familiarity with the character, customs, traditions, spirit, history and development of the peoples and countries whose language is studied.

In the designation of subjects the grades of elementary and intermediate correspond, respectively, to the definitions of the Modern Language Association of America, Report of the Committee of Twelve. All other subjects are of advanced grade.

Subjects L1 to L99 (see page 59).

L11, L12. German. (Elementary.) Intended to prepare students to fulfill the entrance requirement in German. A study of grammatical forms, syntax and vocabulary, through composition exercises and rapid reading, forms the basis of the work.

L21, L22. German. (Intermediate.) Includes a systematic review of grammar. The reading, scientific as well as literary, gradually becomes more difficult, while the syntax, idioms and synonyms of the language are carefully studied. By 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.

L23, L24. German Literature. Readings and Lectures adapted to the needs of aeronautical students.

L31, L32. German. (Advanced.) Exercises in scientific German. Selections are made from current scientific journals and from the latest scientific literature. Exercises are conducted in German as far as practicable.

L331, L332. German (Advanced). Readings in scientific advanced German.

The following subjects are offered as General Studies. For description see Division of General Studies, page 237.

G941, 942. German.

ROMANCE LANGUAGES

Several courses are offered in French and one in Spanish. Those in French are of Elementary, Intermediate and Advanced grade. In the Elementary and Intermediate courses a careful foundation is laid for reading, writing and speaking French. 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 for French sounds, 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 France. Occasional illustrated lectures are given to supplement the class exercises and stimulate interest. The advanced courses for students in Architecture are planned to give a more ready command of the language, an acquaintance with great examples of French literary art, and a familiarity with French architectural literature. The General Study courses offer the student an opportunity to carry his study of French beyond the Intermediate grade, increasing his practical command of the language, reading ability, and acquaintance with the greatest French writers.

The one-year elective course in Elementary Spanish is parallel to the course in Elementary French. It gives a training in pronunciation, essentials of grammar, and reading of varied matter. On its completion a student should be able to make intelligent contact with a Spanish-speaking country, be able to read Spanish correspondence and translate reading matter of moderate difficulty.

In all courses the foreign language is used as much as possible in the class room.

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 Cp 2; Elementary Spanish = Spanish Cp. 2; Intermediate French = French B, or French Cp. 3.

Subjects L50 to L99 (see page 59).

L51, L52. French. (Elementary.) Designed to give the necessary foundation for the study of the French language, literature, or for scientific studies; it will also enable students to fulfill the entrance requirement in elementary French. Consists of training in pronunciation, elementary grammar, acquisition of useful vocabulary and reading of easy matter. The last term will include the reading of some technical French.

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 and translation of some standard modern authors, reading of scientific French.

L63, L64. French. (Advanced.) Planned to suit the needs of Course IV. Emphasis is laid upon good pronunciation, and the ability to express in French matters dealing with travel and architecture. Some of the reading matter will deal with architectural subjects. Textbooks: such books as *Galland, French Composition; Schoell, Paris d'aujourd'hui; Hervieu, La Course du Flambeau; Loti, Pêcheur d'Islande; George Riat, Paris (Les Villes d'Art Célèbres); Foville, Pise et Lucques.*

L65. French. (Advanced.) Reading of French prose of a varied nature, part of which deals with an outline of French civilization and with the description of French cities, cathedrals, chateaux, etc. Practice in writing French, in pronunciation and conversational phrases useful for travel is given. Textbooks: *Comfort, Practical French Composition;* such reading matter as *Emile Gebhart, Florence; Besnard, Le Mont-Saint-Michel; Gautier, Voyage en Espagne; Hugo, Notre Dame de Paris; Demaison, La Cathédrale de Reims; Anatole France, Le Crime de Sylvestre Bonnard.*

L81, L82. Spanish. (Elementary.) Pronunciation, elementary grammar, easy reading matter, practice in conversational phrases useful for travel. Textbooks: such books as *Hills and Ford, First Spanish Course (Heath); Pittaro, Spanish Reader; Hills and Reinhardt, Spanish Short Stories; Romera-Navarro, Historia de Espana; Carrión and Aza, Zaragüeta.*

The following subjects are offered as General Studies. For description see Division of General Studies, page 237.

G821, G822. French.
G831, G832. French.

MATHEMATICS

Great importance is attached to the study of mathematics, both as a means of general education and as a necessary basis for further instruction in engineering and other subjects. Students in most of the regular courses study mathematics throughout the first two years, beginning with a combined course in elementary calculus and analytic geometry extending through the first year. The second year work is devoted mainly to integral calculus and elementary differential equations with systematic study of applications. From the outset, care is taken to present both underlying principles and a great variety of concrete applications, the latter connecting the mathematical instruction closely with the professional studies. The instruction is given mainly by recitations in small sections, the number of the students in a section being about twenty-five. Students having time and interest for the study of mathematics beyond the prescribed limits are given opportunity for more advanced work, and the Institute offers exceptional advantages for advanced and elective work in applied mathematics.

Undergraduates wishing to specialize in mathematics are enabled to do so by the provision for suitable electives in Course IX-C (page 102).

The department possesses an excellent library, with current journals, a mathematical laboratory with Monroe and Millionaire computing machines and a collection of models.

Subjects M1 to M99 (see page 59).

M1. Algebra (Entrance). For description see entrance requirements.

M3. Solid Geometry (Entrance). For description see entrance requirements.

M4. Trigonometry (Entrance). For description see entrance requirements.

M11. Calculus. An elementary presentation of the fundamental ideas of the calculus; differentiation and integration of the algebraic polynomial; differentiation of any algebraic function; derivatives; differentials; maxima and minima; applications to simple problems in geometry and mechanics, such as the determination of velocity, acceleration, areas, volumes, and pressure. Textbook: *Woods and Bailey, Elementary Calculus.*

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 curvature; series; partial differential. Textbook: *Woods and Bailey, Elementary Calculus.*

M21. Calculus. 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. Textbook: *Woods and Bailey, Elementary Calculus.*

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. Textbook: *Phillips, Differential Equations.*

M24. Mathematics. A brief review of M21 followed by the work of M22 given for students at Lynn intending to enter the graduate courses in electrical or mechanical engineering conducted by the Institute in co-operation with the General Electric Company. Open only to students at the General Electric Company.

M26. Least Squares and Probability. A brief discussion of the general principles and the more common scientific and engineering applications of the method of least squares. Textbook: *Bartlett, Method of Least Squares.*

M31. Differential Equations of Electricity. 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.

M36, M37. Advanced Calculus. 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 variation, elliptic integrals.

M41. Calculus, Applications of. Especially adapted to the needs of students in chemical engineering.

M43, M44. Theoretical Aeronautics. Open to third and fourth-year students. The main topics covered are (*a*) The mechanics of the airplane, including vibrations, moment of momentum, moving axes, etc. (*b*) The mechanics of irrotational fluid motion and its application to lift and drag. (*c*) The stability of the airplane.

M451, M452. Fourier's Series and Integral Equations. The theory of Fourier's series, Bessel's functions and their application to the solution of such problems in physics as can be expressed by certain partial differential equations.

M46, M47. Advanced Wing Theory. Selected advanced topics in continuation of M44. Textbooks: *Joukowski, L'Aerodynamique; Prandtl, Applications of Modern Hydrodynamics to Aeronautics; published by the National Advisory Committee for Aeronautics.*

M51, M52, M53. Engineering Science. Mechanics, hydrodynamics, and electricity, designed to illustrate the correlation between these subjects and their general application to engineering problems.

M54. Mathematical Laboratory. Practical instruction in numerical, graphical and mechanical calculation and analysis as required in the engineering or applied mathematical sciences, numerical solution of equations; graphical methods; nomography and the construction of graphical charts; curve fitting to empirical data; approximate methods of integration, differentiation and interpolation; the use and principles of construction of instruments employed in calculation, and many kindred topics. Textbook: *Lipka, Graphical and Mechanical Computation.*

M561, M562. Theory of Functions. A study of the elementary functions for complex values of the variable. Development and application of the fundamental theorems of the analytic function theory. A portion of the first term will be devoted to selected topics from the theory of functions of a real variable.

M57. Theory of the Gyroscope. A mathematical discussion of the gyroscope, together with its application to torpedoes and stabilizers.

M571. Theory of the Gyroscope. Given to students taking Army Ordnance Course.

M60. Vector Analysis. Algebraic combinations of vectors, differentiation and integration of vector functions, Green's and Stokes' theorems, potential functions, applications to geometry and physics.

M62. Modern Algebra. Determinants, matrices, systems of linear equations, linear transformations, finite groups.

M631, M632. Differential Geometry. A study of *n* dimensional geometry with the use of the Ricci absolute calculus, theory of tensors, applications to Euclidean and Riemannian manifolds, and manifolds of higher connection.

M651. Analytical Mechanics. Lagrangian and Hamiltonian systems are discussed, and their relations to a minimum principle brought out. The elements of elasticity theory and of hydrodynamics are treated.

M652. Analytical Mechanics. Continuation of the topics treated in M651. Introduction to relativistic mechanics.

M70. History of Science. Same as G1 with 30 extra hours preparation.

M72. Differential Equations. (For students from the United States Army.) A review of calculus, including differentiation, differential properties of curves, rates, maxima and minima, integration, multiple integration, geometrical, mechanical and physical problems; differential equations of the first order, special types of second order equations, linear equations with constant coefficients and simultaneous linear equations. The application of the calculus and differential equations is made to various problems of mechanics, physics, and engineering. Textbooks: *Wilson, Advanced Calculus; Phillips, Differential Equations.*

M731, M732. Rigid Dynamics. The fundamental principles of the mechanics of rigid bodies.

M75. Exterior Ballistics. The calculation of the trajectories of projectiles under standard conditions, and of the differential corrections for variations from standard conditions is discussed here. The method of Siacci-Ingalls and that of numerical integration are both treated. Applications to the construction of Range Tables are given. Textbook: *Introduction to Ballistics, A. A. Bennett,* prepared in the Technical Staff of the Ordnance Department.

M77. Vector Analysis. A treatment of the vector functions and operations required in theoretical work on electricity. Preparation for 8.242.

M78. Analytical Geometry. Conic sections, transformation of coördinates, general equation of the second degree, coördinates in space, quadrics, curves in space.

M80. Methods of Teaching Junior High School Mathematics. Will include the observation of a demonstration class, showing actual teaching of a typical group of junior high school pupils.

M81. Methods of Teaching Senior High School Mathematics. A study of methods in teaching algebra, plane geometry, solid geometry, trigonometry, with special reference to the recommendation of the National Committee on mathematical requirements, and to the recently revised requirements of the College Entrance Examination Board.

M82. Classroom Problems of the Junior and Senior High Schools. Aims to discuss problems of particular value to the teacher, including classroom methods and technique, methods of study, rating of pupils, and the like.

M90. Mathematical Reading. 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.

The following subjects are offered as General Studies. For description see Division of General Studies, page 237.

G1. History of Science.
G2. History of Science.
G76. History of Philosophy.

MILITARY SCIENCE AND TACTICS

Courses in Military Science are divided into: Basic Course, compulsory, and Advanced Course, optional.

The Basic Course consists of the subjects given during the first and second years. Male students who enter the Institute as first-year students are required to complete satisfactorily both years of the Basic Course. Those who enter as second-year students are required to complete satisfactorily the second year of the Basic Course. Aliens, students found physically unfit for military service, and students with military training equivalent to that prescribed by the two-year Basic Course are exempt from Military Science.

Students desiring relief from any part of the military requirements should consult the Professor of Military Science and Tactics immediately upon registration.

Each student taking the first year of the Basic Course is issued a uniform. He must provide himself with a pair of high tan shoes to wear with it.

The great demand for technically trained officers in the more scientific branches of the army was most evident during the recent war. The majority of the courses at the Institute, and the excellent facilities available in connection therewith, afford the student an admirable preparation for the scientific duties of an officer of a technical arm of the service. Accordingly the military training prescribed at the Institute is designed to impart the specialized knowledge most essential to supplement the general technical education of the student so as to render his services of the maximum value to the country in time of war as an officer of Coast Artillery, Engineers, Signal Corps, Ordnance, Air Service or Chemical Warfare Service.

Having satisfactorily completed the two-year compulsory course in military training, the student who is registered in the Institute as a third year student may elect to pursue the Advanced Course of the Reserve Officers' Training Corps.

To do this he must enroll for this course in one of the six units of the Reserve Officers' Training Corps Units: Coast Artillery, Engineer, Signal Corps, Ordnance, Air Service or Chemical Warfare Service established at this institution, depending upon his choice and the Institute course he is pursuing.

With the approval of the professor in charge of his Institute Course he signs a contract which binds him to attend one six-weeks' R. O. T. C. summer camp, and to pursue the Advanced Course during two academic years. The Advanced Course, once entered upon, becomes, in accordance with the terms of the establishment of the R. O. T. C. at the Institute, a prerequisite for graduation.

In recognition of his service, the Federal Government allows him commutation of subsistence (amounting at present to 30 cents per day) during his third and fourth years, including the vacation period which intervenes between them; transportation to and from the summer camp, and, during the period while he is on duty thereat, feeds and clothes him, provides him with all books, equipment, supplies, quarters and medical attendance. Upon graduation from the Institute he is eligible to receive a Reserve commission for a period of five years in the United States Army, but continues in civil life, subject to call as an officer in time of war, or for not more than fifteen days' service in any year in time of peace. Under present conditions students who elect to pursue the Advanced Course receive not only their complete support for one six-weeks' period, but in addition are paid over $210.00 in cash. This is, in effect, a military scholarship, open to all students who are citizens of the United States, physically sound, who have made a satisfactory record in their compulsory military training and display such physical, mental and moral qualifications as, in the judgment of the Professor of Military Science and Tactics, render them suitable candidates for a commission.

The right is reserved to discharge from the Advanced Course any student who is guilty of misconduct, or whose work in any department of the Institute falls below standard, or who is found in any way unfit or unsuitable for the commission for which he is a candidate.

Subjects MS1 to MS99 (see page 59).

MS11. Military Science. (Required in all courses.) Consists of seven weeks of infantry drill, school of the soldier, squad and platoon; five weeks of lectures on elementary subjects of military training; and three weeks of instruction, both theoretical and practical, in infantry weapons and rifle marksmanship.

MS12. Military Science. (Required in all courses.) Consists of fifteen weeks of infantry drill and rifle gallery practice.

MS21. Military Science. (Required in all courses.) Consists of a six weeks' course in topography and map reading; five weeks of lectures on field fortification; and two weeks of lectures on signal communications; followed by two weeks devoted to one lecture on the particular duties of each of the units of the R. O. T. C. represented here. Opportunity is given the student to choose the unit in which he desires to continue his training during the following year. Those who do not report their choice of a unit before the beginning of the following term will be arbitrarily assigned to a unit.

MS221. Military Science. Coast Artillery Unit. Consists of fifteen weeks devoted to gunners' instruction.

MS222. Military Science. Engineer Unit. Fifteen weeks devoted to instruction in the elements of engineer training.

MS223. Military Science. Signal Unit. A fifteen weeks' course in electrical communications.

MS224. Military Science. Ordnance Unit. Lectures on interior and exterior ballistics.

MS225. Military Science. Air Corps Unit. Six hours "History of Aviation," five hours employment of air force, six hours air tactics, five hours aerial navigation, eight hours Air Corps small arms, and fifteen hours aerial communications.

MS226. Military Science. Chemical Warfare Unit. Instruction both theoretical and practical for fifteen weeks in the chemical warfare service.

MS311. Military Science. Coast Artillery Unit, Advanced. (R. O. T. C.) Five weeks devoted to instruction on fire control instruments; and ten weeks to the computations of firing data for heavy mobile artillery.

MS312. Military Science. Coast Artillery Unit, Advanced. (R O.T.C.) Seven weeks' study of the dispersion and probability of fire; and eight weeks of observation and adjustment of fire.

MS321. Military Science. Engineer Unit, Advanced. (R. O. T. C.) Consists of lectures for four weeks on organization and duties of engineers; three weeks on administration, supply and equipment; and eight weeks on musketry and combat principles.

MS322. Military Science. Engineer Unit, Advanced. (R. O. T. C.) Consists of lectures for eight weeks on general construction in war; and seven weeks on field and permanent fortifications.

MS331. Military Science. Signal Unit, Advanced. (R. O. T. C.) Fifteen weeks devoted to signal communication and tactics.

MS3311. Military Science. Signal Unit, Advanced. (R. O. T. C.) Shorter than MS331.

MS332. Military Science. Signal Unit, Advanced (R. O. T. C.) Consists of instruction for eleven weeks in codes and ciphers and radio, and four weeks of practical signal work in the field.

MS3321. Military Science. Signal Unit, Advanced. (R. O. T. C.) Shorter than MS332.

MS341. Military Science. Ordnance Unit, Advanced. (R. O. T. C.) Consists of lectures; three weeks on organization, mission and function of the Ordnance Department; two weeks on the history of the development of ordnance; and ten weeks on light artillery material.

MS342. Military Science. Ordnance Unit, Advanced. (R. O. T. C.) Fifteen lectures on heavy artillery material.

MS35. Military Science. Air Corps Unit. Fifteen hours of Aerial Photography, fifteen of Aircraft Engines and fifteen of Observation Aviation.

MS351. Military Science. Air Service Unit, Advanced. (R. O. T. C.) Register for Airplane Design 16.015.

MS352. Military Science. Air Service Unit, Advanced. (R. O. T. C.) Register for MS35.

MS361. Military Science. Chemical Warfare Unit, Advanced, (R. O. T. C.) Covered by Institute subjects. (See R. O. T. C. schedules.)

MS362. Military Science. Chemical Warfare Unit, Advanced. (R. O. T. C.) Lectures for fifteen weeks on organization and duties of chemical warfare service. Personnel and materiel.

MS411. Military Science. Coast Artillery Unit, Advanced. (R.O.T.C.) Lectures on coast artillery materiel, three weeks; organization and administration of the coast artillery corps, three weeks; camp sanitation and military hygiene, two weeks; gunners' instruction for anti-aircraft artillery, five weeks; and six periods throughout the term for examinations.

MS412. Military Science. Coast Artillery Unit, Advanced. (R. O. T. C.) Lectures for fifteen weeks on the tactical employment of artillery, the various types of artillery, military law, and motor transporation.

MS421. Military Science. Engineer Unit, Advanced. (R. O. T. C.) Covered in Institute courses.

MS422. Military Science. Engineer Unit, Advanced. (R. O. T. C.) Covered in Institute courses.

MS431. Military Science. Signal Unit, Advanced. (R. O. T. C.) Take Wire Communication 6·281. (See R. O. T. C. schedules.)

MS432. Military Science. Signal Unit, Advanced. (R. O. T. C.) Take Radio Communication 6·282. (See R. O. T. C. schedules.)

MS441. Military Science. Ordnance Unit, Advanced. (R. O. T. C.) Covered by Institute subjects. (See R. O. T. C. schedules.)

MS442. Military Science. Ordnance Unit, Advanced. (R. O. T. C.) Covered by Institute subjects. (See R. O. T. C. schedules.)

MS451. Military Science. Air Corps Unit, Advanced. (R. O. T. C.) Covered by Institute courses.

MS452. Military Science. Air Corps Unit, Advanced. (R. O. T. C.) Covered by Institute courses.

MS461. Military Science. Chemical Warfare Unit, Advanced. (R. O. T. C.) Covered by Institute subjects. (See R. O. T. C. schedules.)

MS462. Military Science. Chemical Warfare Unit, Advanced. (R. O. T. C.) Covered by Institute subjects. (See R. O. T. C. schedules.)

DEPARTMENT OF HYGIENE

The gymnasium of the Institute is located on the third floor of the Walker Memorial Building, fronting on the Esplanade, east of the educational buildings. This gymnasium 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 are the gift of 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. With the acquisition of this building the Walker Gymnasium is left free for the regular gymnastics for which it was designated.

The Athletic Field gives an opportunity for track-team contests and inter-class games. This field is provided with a quarter-mile running track, straight-away 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 physical examinations during the first month — one at Walker Memorial by the Physical Director, from which anthropometric charts are plotted, and one at the Medical Department by a physician. 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 to the left is the subject number. The numbers under the title are the numbers of the preparatory subjects. Those in italics indicate subjects to be taken simultaneously. To the right of the subjects are noted the Professional Courses which prescribe the subject and the year and term in which the subject is taught. Under the heading "Term and Hours of Exercise and Preparation" the first number shows the hours assigned to Lecture or Recitation in the term of fifteen weeks, the second the time assigned to preparation. Underneath the first number are the hours for laboratory, drawing or field exercises. To the extreme right is given the name of the teacher in charge of the subject.

CIVIL ENGINEERING — 1·00–1·99

No.	*Subject and Preparation*	*Taken by*	*Year*	*Term and Hours of Exercise and Preparation* *1st Term*	*2d Term*	*Instructor in Charge*
1·00	Surveying and Plotting .... M4, D22 (Not open to first year students.)	I, XI, XV$_1$	2	30–45	.. ..	Robbins
1·01	Surveying and Plotting .... M4, D22 (Not open to first year students.)	I, XI, XV$_1$	2	.. ..	2– 0 28	Robbins
1·02	Surveying and Plotting	III$_2$, VI	3	Summer	20– 5 50	Hosmer
	M4, D22	VI-A (Op. 2,3)	2	Summer	20– 5 50	
1·03	Surveying................ M4, D22 (Not open to first year students.)	II, XVI	2	10– 0 20	.. ..	Howard
		IX-B, XV$_2$	2	.. ..	10– 0 20	
		IV-A	3	.. ..	10– 0 20	
1·04	Surveying................ M4, D22 (Open only to students entering the third year.)	(Elective)		Camp Technology	25–30 300	Howard
1·05	Plane Surveying.......... 1·00, 1·01; 1·12 (Open only to students entering the third year.)	I, XI, XV$_1$	3	Camp Technology	10–10 80	Howard
1·06	Geodetic and Topographic Surveying *1·05*	I, XI, XV$_1$	3	Camp Technology	5– 5 90	Hosmer
1·07	Geodetic Surveying .... 1·13, 1·06	(Elective)	3	Camp Technology	0– 0 150	Hosmer
1·09	Surveying .... M4, D22 (Not open to first year students.)	XVII	3	Summer	0–50 150	Hosmer
1·10	Surveying................ M4, D12, D22 (Open to students entering the third year.)	III$_{1,3}$ XII	3 4	Summer Mining Camp 80–15 265		Eberhard
1·12	Astronomy and Spherical Trigonometry.......... M4, *1·00*	I	2	45–60	.. ..	Hosmer
1·13	Geodesy................. M22 and 1·12	I	3	30–30	.. ..	Hosmer
1·14	Advanced Geodesy........ 1·13	I	G(A)	.. ..	30–60	Hosmer
1·15	Navigation.............. M4	VII$_2$	3	.. ..	15–45	Hosmer

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
1·18	Map Reading and Topographical Drawing D22	I, XI	2	6 – 0 24	.. ..	Howard
1·20	Railway Fieldwork........ 1·01, *1·05*	I, XI, XV₁	3	Camp Technology 15– 5 60		Babcock
1·21	Railway and Highway Engineering................ M21, 1·01, 1·20	I₁, ₂, XV₁	3	30–60	.. ..	C. B. Breed
1·211	Railway and Highway Engineering................ M21, 1·01, 1·20	I₂, XI	3	20–40	.. ..	C. B. Breed
1·22	Railway and Highway Engineering................ 1·21 or 1·211	I, XI, XV₁	3	.. ..	30–30	C. B. Breed
1·23	Railway Drafting.......... 1·20, *1·21*, or *1·211*	I₁, ₂, XI	3	0– 0 60	.. ..	Babcock
1·24	Railway Drafting.......... 1·23, *1·22*	I₁, ₂, XI	3	.. ..	0– 0 45	Babcock
1·25	Engineering Construction and Estimates........... 1·20, 1·22, 2·20	I₂, XI, XV₁, Mil. Eng.	4	30–45	.. ..	C. B. Breed
1·26	Railway Engineering ...... *1·25*	I₂a	4	30–30	.. ..	C. B. Breed
1·27	Railway Engineering ...... 1·26	I₂a	4	.. ..	30–60	C. B. Breed
1·28	Railway Design........... 1·24, *1·27*	I₂a	4	.. ..	0– 0 75	C. B. Breed
1·301	Advanced Railway Engineering................ 1·27, 1·28	I	G(A)	30–60	.. ..	C. B. Breed
1·302	Advanced Railway Engineering 1·301	I	G(A)	.. ..	30–60	C. B. Breed
1·311	Advanced Railway Design . 1.28, *1·301*	I	G(A)	0– 0 45	.. ..	C. B. Breed
1·312	Advanced Railway Design.. 1·311, *1·302*	I	G(A)	.. ..	0– 0 45	C. B. Breed
1·35	Roads and Pavements..... 1·22, *1·211* for XI	I₁, ₂ XI	4 3	20–25 20–25	.. ..	C. B. Breed
1·36	Testing Highway Materials 1·35, 2·37	I₂b	4	.. ..	0–15 15	C. B. Breed
1·37	Highway Transportation... 1·25, *1·36*, 5·37	I₂b	4	.. ..	30–60	C. B. Breed
1·38	Highway Design.......... 1·24, *1·37*	I₂b	4	.. ..	0– 0 45	Babcock
1·39	Graphic Statics........... 8·02 (Not open to first year students.)	I XVII	2 3	.. .. Summer	15–15 30 15–15 30	Mitsch
1·40	Structures................ 2·20, 2·211	I, IV-A, IX-B, XI, XV₁, XVII Mil. Eng.	3 4	.. .. Summer	45–75 45–75	Fife
1·401	Structures................ 2·20, 2·211	(Elective)	3	.. ..	45–75	Newell
1·41	Structures................ 1·40, 1·43	I, IV-A, XI, XV₁, XVII Mil. Eng.	4	60–120	.. ..	Spofford
1·42	Structures................ 1·41	I₁, ₂, Mil Eng.	4	.. ..	60–120	Spofford
1·421	Structures................ 1·41	I₃, XI, XV₁	4	.. ..	30–60	Spofford
1·422	Structures................ 1·41	IV-A, XVII	4	.. ..	30–60	Spofford
1·43	Materials................. 2·20	I, IV-A, XI, XV₁	3	.. ..	15–30	Sutherland
1·44	Stationary Structures...... 2·20	III₁,₃	4	.. ..	30–45	Fife
1·45	Theory of Structures...... 2·20 or equivalent	II(O.D.)XIII-A	G	45–90	.. ..	Fife
1·46	Structural Design......... 1·45	XIII-A	G	.. ..	0 - 0 30	Fife

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
1·461	Structural Design .... 1·45	II (O.D.)	G	.. ..	0–0 45	Fife
1·48	Foundations .... 1·40 or 1·44	XV$_1$ I	4 3	15–15 15–15	.. ..	Terzaghi
1·481	Foundations and Soil Mechanics .... *1·41*	XVII	4	45–75	.. ..	Terzaghi
1·491	Soil Mechanics .... 2·20	I	G(A)	45–90	.. ..	Terzaghi
1·492	Soil Mechanics .... 1·491	I	G(A)	.. ..	45–90	Terzaghi
1·501	Bridge Design .... 1·40	I$_{1,2}$	4	0–0 105	.. ..	Mirabelli
1·502	Bridge Design .... 1·501, *1·42*	I$_{1,2}$	4	.. ..	0–0 75	Mirabelli
1·511	Bridge Design .... 1·40	I$_2$	4	0–0 60	.. ..	Mirabelli
1·512	Bridge Design .... 1·511, *1·421*	I$_3$	4	.. ..	0–0 90	Mirabelli
1·52	Structural Design .... 1·41	XI	4	.. ..	0–0 90	Mirabelli
1·53	Structural Design .... *1·41*	XV$_1$	4	0–0 60	.. ..	Mirabelli
1·55	Structural Design Advanced 1·562	I	G(A)	.. ..	0–0 120	Sutherland
1·561	Advanced Structures ...... 1·42 or 1·421 or 1·422, 1·502 or 1·512 or 4·922	I	G(A)	45–135	.. ..	Spofford
1·562	Advanced Structures ...... 1·561	I	G(A)	.. ..	45–135	Spofford
1·57	Secondary Stresses .... *1·42 or 1·421 or 1·422*	I	G(A)	.. ..	30–60	Fife
1·581	Rein·rced Concrete Design 1·42 or 1·421	I Mil. Eng.	G(A) 4	0–30 90 0–30 90	.. ..	Sutherland
1·582	Reinforced Concrete Design 1·581	I	G(A)	.. ..	30–60	Sutherland
1·60	Hydrographic Surveying ... M12, *1·05, 1·06*	I, XI, XV$_1$	3	Camp Technology 15–5 55		Liddell
1·62	Hydraulics .... 2·15 or equivalent	I, IX-B, XI, XVII	3	.. ..	45–75	G. E. Russell
1·63	Hydraulics .... 2·15 or equivalent	III, IV-A XIII$_1$	4	30–45	.. ..	G. E. Russell
1·64	Hydraulics .... 2·15 or equivalent	II, VI, XV$_2$ VI-A (A) VI-A(B), XV$_1$	4 5 4	45–90 Summer	.. .. 45–90 45–90	G. E. Russell
1·66	Advanced Hydraulics ...... 1·62 or equivalent (Open to undergraduates only on petition.)	I	G(A)	20–60	.. ..	G. E. Russell
1·70	Water Power Engineering .. 1·62	I$_3$	4	45–90	.. ..	Barrows
1·71	Water Power Engineering .. 1·70, 1·41	I$_2$	4	.. ..	30–45 60	Barrows
1·731	Advanced Water Power Engineering .... 1·42, 1·71, *1·851*	I	G(A)	45–90	.. ..	Barrows
1·732	Advanced Water Power Engineering .... 1·731, *1·852*	I	G(A)	.. ..	45–90	Barrows
1·75	Hydraulic and Sanitary Engineering .... 1·62	I$_1$	4	60–75	.. ..	R. G. Tyler
1·76	Hydraulic and Sanitary Engineering .... 1·62	I$_1$	4	.. ..	60–75	R. G. Tyler
1·77	Sanitary Engineering ...... 1·62	XI	4	60–75	.. ..	R. G. Tyler
1·78	Sanitary Engineering ...... 1·62	XI	4	.. ..	45–60	R. G. Tyler

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
1·79	Hydraulic and Sanitary Design 1·75	I_1	4	.. ..	0– 0 30	Reynolds
1·80	Sanitary Design 1·75 or 1·77	XI	4	.. ..	0– 0 90	Reynolds
1·811	Advanced Sanitary Engineering 1·75 or 1·77	XI	G(A)	30–60	.. ..	R. G. Tyler
1·812	Advanced Sanitary Engineering 1·811	XI	G(A)	.. ..	30–60	R. G. Tyler
1·851	Advanced Water Power Design 1·731	I	G(A)	0– 0 90	.. ..	Barrows
1·852	Advanced Water Power Design 1·851, *1·732*	I	G(A)	.. ..	0– 0 90	Barrows
1·881	Advanced Sanitary Design *1·811*	XI	G(A)	0– 0 90	.. ..	R. G. Tyler
1·882	Advanced Sanitary Design *1·812*	XI	G(A)	.. ..	0– 0 90	R. G. Tyler

MECHANICAL ENGINEERING — 2·00–2·99

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
2·00	Mechanism D11, D21, M11	II, VI, VI-A XIII, XV_2, XVI	2	45–90	.. ..	Merrill
2·01	Mechanism D11, D21, M11	I, III, VII_2, X VIII, XIV, XV_1 IX-B	2 2	.. .. Summer 30–60	30–60 30–60	Merrill
2·011	Mechanism D11, D21, M11	XI	2	30–45	.. ..	Merrill
2·02	Mechanism D11, D21, M11	XV_1	2	30–30	.. ..	Merrill
2·03	Mechanisms	II (A.O)	4	30–30 60	.. ..	Swett
2·04	Mechanical Engineering Equipment 2·00	II	2	.. ..	15– 0	Taft
2·05	Mechanism of Machines 2·00	II	3	30–30 30	.. ..	Swett
2·06	Mechanism of Machines 2·00	II (O.D.)(T.D.)	G	30–30	.. ..	Swett
2·07	Automatic Machinery *2·06*, 2·21	II (T.D.)	G	45–45	.. ..	Swett
2·08	Automatic Machinery 2·07	II (T.D.)	G	.. ..	15–60 45	Swett
2·09	Design of Automatic Machinery 2·05, 2·21, 2·850	II	G(A)	.. ..	0– 0 180	Swett
2·10	Mechanical Engineering Drawing D12, D22, *2·00*	II, XVI	2	0– 0 90	.. ..	James
2·101	Mechanical Engineering Drawing D12, D22, *2·00*	$XIII_1$	2	0– 0 60	.. ..	
2·11	Mechanical Engineering Drawing D12, D22, *2·00*	XV_2	3	Summer	0– 0 75	James
2·12	Mechanical Engineering and Machine Drawing D12, D22, *2·00*	VI	2	15– 0 105	.. ..	James
2·121	Mechanical Engineering and Machine Drawing D12, D22, *2·00*	VI-A, IX-B, $XIII_1$	2	15– 0 75	.. ..	James
2·13	Machine Drawing D12, D21	II, XVI	2	.. ..	15– 0 75	James

No.	*Subject and Preparation*	*Taken by*	*Year*	*Term and Hours of Exercise and Preparation* 1st *Term*	2d *Term*	*Instructor in Charge*
2·131	Machine Drawing.........	XV_3	3	0– 0	.. ..	James
	D12, D21			75		
2·14	Machine Drawing.........	III_3	3	Summer	0– 0	James
	D12				60	
2·15	Applied Mechanics (Statics and Kinetics)...........	I, II, IX-B,	2	.. ..	45–90	Johnston
	M21, 8·02	X, XI, XVI, XVII				
		IV-A	2	45–90	.. ..	
		III	3	45–90	.. ..	
2·16	Applied Mechanics (Statics)	VI, XIII, XV	2	.. ..	30–60	Johnston
	M12, 8·02	XIV	3	30–60	.. ..	
		VI-A	2	30–60	.. ..	
2·17	Applied Mechanics (Statics-Strength of Materials)...	IV	2	45–75	.. ..	Johnston
	M12					
2·18	Applied Mechanics (Strength of Materials, Graphic Statics)................	IV	2	.. ..	45–75	Johnston
	2·17					
2·20	Applied Mechanics (Strength of Materials............	I, II, IV-A, VI	3	45–90	.. ..	Johnston
		VI-A (B)				
	2·15 or 2·16	VI-C, IX-B, X,				
		XI, XIII, XV, XVI, XVII				
		IV-A	2	.. ..	45–90	
		III, XIV	3	.. ..	45–90	
		VI-A (A)	3	Summer	45–90	
		Mil. Eng.	4	Summer	45–90	
2·21	Applied Mechanics........	II, XVI	3	.. ..	45–75	Fuller
	2·20	Mil. Eng.	4	Summer	45–75	
2·211	Applied Mechanics........	IV-A	3	.. ..	45–90	Fuller
	2·20					
2·22	Applied Mechanics........	VI, VI-A (A)	3	.. ..	45–75	Fuller
	2·20	VI-A (A) (1, 2)	4	45–75	.. ..	
		VI-A (B) (1, 2)	4	Summer	45–75	
2·221	Applied Mechanics........	$XIII_{1,2}$, XV_2	3	.. ..	45–90	Fuller
	2·20					
2·251	Dynamics of Machines.....	II, XVI	4	30–60	.. ..	Riley
	2·21	II(O.D.) (T.D.)	G	30–60	.. ..	
2·252	Dynamics of Machines, Advanced................	II	G	30–80	.. ..	Riley
	2·251 or equivalent	(G. E. Co.)				
2·254	Dynamics of Engines......	II (A. E.)	G	30–60	.. ..	Riley
	2·251	II	G(A)	30–60	.. ..	
2·255	Dynamics of Engines.......	XVI	G(A)	30–30	.. ..	Riley
	2·254 or equivalent					
2·26	Mechanics of Engineering..	II	4	.. ..	45–90	Fuller
	2·25					
2·271	Theory of Elasticity.......	II (A.O.)	4	60–120	.. ..	Fuller
	M72					
2·272	Theory of Elasticity.......	II (A.O.)	4	.. ..	30–60	Fuller
	2·271					
2·281	Advanced Mechanics and Theory of Elasticity.....	II	G(A)	45–120	.. ..	Fuller
	2·26	II (O.D.)	G	45–120	.. ..	
2·282	Advanced Mechanics and Theory of Elasticity.....	II	G(A)	.. ..	45–120	Fuller
	2·281	II (O.D.)	G	.. ..	45–120	
2·283	Mechanics Advanced......	II	G	15–45	.. ..	Fuller
				(G. E. Co.)		
2·284	Theory of Elasticity.......	II	G	.. ..	45–120	Fuller
				(G. E. Co.)		
2·29	Interior Ballistics.........	II (O.D.)	G	.. ..	30–45	Johnston
	M22, 2·15					
2·30	Materials of Engineering...	II, $XIII_1$, XVI	3	.. ..	30–30	H. W. Hayward
	2·20 or *2·20*	Mil. Eng.	4	.. ..	30–30	
2·301	Materials of Engineering...	II (T.D.)	G	30–30	.. ..	H. W. Hayward
2·305	Materials and Testing......	Elective	G	.. ..	0 –45	H. W. Hayward
	2·21, 2·36, 2·843				105	
2·31	Materials of Engineering...	XV_2	3	15–30	.. ..	H. W. Hayward
	2·20 or *2·20*	$XIII_2$	4	15–30	.. ..	
2·331	Physical Metallurgy.......	II(O.D.) (T.D.)	G	30–30	.. ..	Williams

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation: 1st Term	2d Term	Instructor in Charge
2·332	Physical Metallurgy 2·331	II(O.D.) (T.D.)	G	.. ..	15–30 105	Williams
2·333	Physical Metallurgy *16·83*	(Elective)	G	15–45 30	.. ..	Williams
2·341	Physical Metallurgy 2·30	II	G(A)	15–30 135	.. ..	Williams
2·342	Physical Metallurgy 2·341	II	G(A)	.. ..	15–30 135	Williams
2·35	Testing Materials Laboratory 2·20 and 2·30	II, XVI	4	0–30 60	.. ..	H. W. Hayward
2·36	Testing Materials Laboratory 2·20 and 2·30 or 2·31	$XIII_1$	4	0–15 30	.. ..	H. W. Hayward
		XV_2	3	.. ..	0–15 30	
2·361	Testing Materials Laboratory 2·20	IV-A, Mil.Eng.	4	0–30 30	.. ..	H. W. Hayward
2·362	Testing Materials Laboratory, Concrete 2·20	IV-A, Mil.Eng.	4	30–15	.. ..	H. W. Hayward
2·37	Testing Materials Laboratory 2·20	I (1st 10 w.)	3	.. ..	0–10 20	H. W. Hayward
		III (l. 5 w.)	3	.. ..	0–10 20	
		X, XI, $XIII_2$ (1st 10 w.)	4	.. ..	0–10 20	
		XVII	4	0–10 20	.. ..	
		XV_1, XV_3 (1st 10 w.)	3	.. ..	0–10 20	
2·371	Testing Materials Laboratory 2·20	VI-A(A) (1,2) (l. 5 w.)	3	.. ..	0–25 20	H. W. Hayward
2·381	Testing and Examination of Materials, Advanced 2·21, 2·35, 2·856	II	G(A)	0–30 60	.. ..	H. W. Hayward
2·382	Testing and Examination of Material, Advanced 2·381	II	G(A)	.. ..	0–30 60	H. W. Hayward
2·390	Reinforced Concrete Design and Laboratory	XVII	4	0– 0 105	.. ..	Peabody
2·391	Reinforced Concrete Design 2·211	IV-A	4	0– 0 105	.. ..	Peabody
2·392	Reinforced Concrete Design 2·391	IV-A	4	.. ..	0– 0 90	Peabody
2·393	Reinforced Concrete Design, Advanced 2·392	(Elective)	G	0– 0 100	.. ..	Peabody
2·394	Concrete Research 2·362	(Elective)	G	0– 0 100	.. ..	Peabody
2·395	Concrete Buildings, Design and Specifications 2·21 or 2·211	Mil. Eng.	4	.. ..	60–30	Peabody
2·40	Heat Engineering M22, 8·04	II, IX-B, XIII, XV_2, XVI	3	45–90	.. ..	Berry
		II(T.D.)	G	45–90	.. ..	
2·41	Heat Engineering *2·40*	II, XV_2	3	30–30	.. ..	Miller
2·42	Heat Engineering 2·40	II, IX-B, XIII, XVI	3	.. ..	45–75	Berry
		II (T.D.)	G	.. ..	45–75	
2·421	Heat Engineering 2·40	XV_2	3	.. ..	45–75	W. H. Jones
2·43	Heat Engineering 2·42	II	4	30–60	.. ..	Berry
2·44	Heat Engineering M22, 8·04	III_2, X, $XV_{1,3}$	3	45–75	.. ..	Taft
		$III_{1,3}$	4	45–75	.. ..	
2·441	Heat Engineering M22, 8·04	VI, VI-A(B) (1,2)	3	45–90	.. ..	Taft
		VI-A(A)	3	Summer	45–90	

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
2·45	Heat Engineering......... 2·44	III_2, X, $\text{XV}_{1,3}$	3	.. ..	45–75	Taft
		$\text{III}_{1,3}$	4	.. ..	45–75	
2·451	Heat Engineering......... 2·441	VI, VI-A(A)	3	.. ..	45–90	Taft
		VI-A(B)(1, 2)	4	Summer	45–90	
		VI-A(A)(1, 2)	4	45–90	.. ..	
2·46	Heat Engineering......... M22, 8·04	I, XI	4	60–105	.. ..	Miller
		Mil. Eng.	4	Summer	60–105	
		Chem. War.	G	60–105	.. ..	
2·461	Heat Engineering.........	II (A.O.)	4	45–90	.. ..	Miller
2·47	Heat Engineering......... 2·46	I, XI	4	.. ..	30–45	Miller
		Mil. Eng.	4	Summer	30–45	
		Chem. War.	G	.. ..	30–45	
2·471	Heat Engineering......... 2·461	II (A.O.)	4	.. ..	45–60	Miller
2·48	Internal Combustion Engines	XIII-A	4	.. ..	15–30	Riley
2·49	Refrigeration............. 2·43	II_4	4	.. ..	45–75	Berry
2·501	Advanced Heat Engineering 2·43	II	G(A)	45–135	.. ..	Berry
2·502	Advanced Heat Engineering 2·501	II	G(A)	.. ..	45–135	Berry
2·503	Advanced Heat Engineering	II	G	45–120 (G. E. Co.)	.. ..	Berry
2·51	Torpedoes................ 2·40	II (T.D.)	G	.. ..	30–60	Berry
2·58	Power Plant Design....... 2·41 and 2·42	II	4	.. ..	0– 0 60	Miller
2·59	Mechanical Equipment of Buildings, Heating and Ventilation............. M22, 8·04	IV-A, XVII	4	.. ..	60–45	Holt
2·601	Engineering Laboratory.... 2·40	II	4	0–60 60	.. ..	Eames
		II (T.D.)	G	0–60 60	.. ..	
2·602	Engineering Laboratory.... 2·601	$\text{II}_{\text{Gen.},2}$	4	.. ..	0–60 60	Eames
2·603	Engineering Laboratory.... 2601	$\text{II}_{1,3,4}$, Ord.	4	.. ..	0–30 30	Eames
2·611	Engineering Laboratory....	$\text{III}_{1,3}$	4	.. ..	0–15 30	Eames
	2·40 or 2·44	III_2, XIII	3	.. ..	0–15 30	
2·612	Engineering Laboratory.... 2·611	XIII	4	0–30 30	.. ..	Eames
2·613	Engineering Laboratory.... 2·612	XIII_1	4	.. ..	0–30 30	Eames
2·614	Engineering Laboratory.... 2·40	XV_2	4	0–45 60		Eames
2·615	Engineering Laboratory.... 2·601 or 2·614	XV_3	4	.. ..	0–30 30	
2·62	Engineering Laboratory....	IX-B, X	4	0–30 60	.. ..	Eames
	2·40 or 2·44	XV_3	4	.. ..	0–30 60	
2·621	Engineering Laboratory.... 2·44 or 2·441	VI	4	.. ..	0–30 45	Eames
		VI-A (A)	5	Summer	0–30 45	
2·63	Engineering and Hydraulic Laboratory............. 2·44 or 2·46	$\text{I}_{1,2}$, XI, XV_1	4	.. ..	0–30 30	Eames
2·631	Engineering and Hydraulic Laboratory............. 2·44 or 2·46	I_3, Mil. Eng.	4	.. ..	0–45 45	Eames
2·64	Refrigeration Laboratory... 2·43 and 2·601	II_4	4	.. ..	0–30 30	Eames
2·65	Power Laboratory......... 2·461	II (A.O.)	4	.. ..	0–30 30	Eames
		Chem. War.	G	.. ..	0–30 30	
2·651	Gas Engine Laboratory....	Elective	Summer		0–0 195	Fales

No.	*Subject and Preparation*	*Taken by*	*Year*	*Term and Hours of Exercise and Preparation* 1st Term	2d Term	*Instructor in Charge*
2·66	Automobile Laboratory.... 2·601, *2·79*	II$_1$	4	.. ..	0-30 30	Fales
2·661	Maintenance and Operation of Automotive Equipment 2·79	II II (A.E.)	G(A) G	30-20 30-20	.. ..	Fales
2·671	Engine Testing........... 2·66	II(A.E.)	G	0-30 60	.. ..	Fales
2·672	Motor Vehicle Testing..... 2·801 and 2·671	II II (A.E.)	G(A) G	.. ..	10-45 65 10-45 65	Fales
2·681	Aero. Engine Laboratory...	Elective	G	0-60 60	.. ..	Fales
2·691	Aero. Engine Laboratory... 2·601	II(T.D.)	G	.. ..	0- 0 30	Fales
2·70	Machine Design.......... 2·13, 2·20, 2·41	II	3	.. ..	20- 0 40	Swett
2·71	Machine Design.......... 2·70, 2·21	II$_{Gen. 3, 4}$ Ord. II(O.D.)	4 G	0- 0 90 0- 0 90	.. ..	Haven
2·711	Machine Design.......... 2·70, 2·21	II$_{1, 2}$	4	0- 0 60	.. ..	Haven
2·712	Machine Design.......... 2·711	II$_1$	4	.. ..	0- 0 30	Haven
2·721	Machine Design.......... 2·20	XV$_1$	4	30- 0 30	.. ..	Haven
2·722	Machine Design.......... 2·721	XV$_2$	4	.. ..	30- 0 30	Haven
2·731	Machine Design..........	XVI	4	30-60	..	Haven
2·732	Machine Design.......... 2·731	XVI	4	.. ..	30-60	Haven
2·741	Machine Design, Advanced. 2·71 or 2·712	II	G(A)	45-30 75	.. ..	Haven
2·742	Machine Design, Advanced. 2·741	II	G(A)	.. ..	45-30 75	Haven
2·743	Machine Design, Advanced.	II	G	.. ..	45- 0 75 (G. E. Co.)	
2·75	Machine Design, Advanced. 2·71	II(O.D.)	G	.. ..	45- 0 105	Haven
2·761	Machine Design..........	II(T.D.)	G	30-30 60	.. ..	Haven
2·762	Machine Design.......... 2·761	II(T.D.)	G	.. ..	30-30 60	Haven
2·77	Engine Design........... 2·251, 2·71	II$_2$	4	.. ..	30-45 60	Riley
2·781	Industrial Plants.......... 2·71	II	4	.. ..	45-45	Haven
2·782	Industrial Plants.......... *2·781*	II$_{Gen.}$	4	.. ..	60- 0	Haven
2·79	Gasoline Automobile...... 2·42	II$_1$	4	.. ..	45-45	Park
2·801	Automotive Engineering ... 2·25, 2·79	II II (A.E.)	G(A) G	45-90 45-90	.. ..	Park
2·802	Automotive Engineering ... 2·801	II II (A.E.)	G(A) G	.. ..	45-90 45-90	Park
2·811	Automotive Design........ *2·801*	II(A.E.)	G	0- 0 120	.. ..	Park
2·812	Automotive Design........ *2·802*	II(A.E.)	G	.. ..	0- 0 150	Park
2·84	Heat Treatment.......... 2·30	II$_{1, 2}$	4	0- 0 30	.. ..	H. W. Hayward
2·841	Heat Treatment..........	II(O.D.)(T.D.)	G	15- 0 30	.. ..	H. W. Hayward
2·842	Heat Treatment.......... 2·84	II(A.E.)	G	15- 0 30	.. ..	H. W. Hayward
2·843	Heat Treatment..........	II(Elective)		.. .. (G. E. Co.)	15- 0 30	H. W. Hayward
2·850	Automatic Machinery..... 2·05, 2·21	II$_{Gen.}$ (Elective)	4	.. ..	30-30	Swett

No.	*Subject and Preparation*	*Taken by*	*Year*	*Term and Hours of Exercise and Preparation* 1st Term	2d Term	*Instructor in Charge*
2·851	Fire Protection Engineering 2·05	II_2 $II_{Gen.}$(Elective)	4	....	30-30	Haven
2·853	Locomotive Engineering.... 2·251	$II_{Gen.}$(Elective)	4	....	30-30	Fuller
2·854	Mechanical Equipment of Buildings.............. 2·42	$II_{Gen.}$ (Elective)	4	....	30-30	Holt
2·855	Steam Turbine Engineering 2·42	$II_{Gen.}$ (Elective)	4	....	30-30	Taft
2·856	Heat Treatment.......... 2·85	$II_{Gen.}$ (Elective)	4	....	15- 0 45	H. W. Hayward
		II Ord.	4	....	15- 0 45	
2·857	Heat Treatment.......... 2·30	Mil. Eng.	4	....	0- 0 30	H. W. Hayward
2·858	Inspection Methods....... 2·951	II (Elective)	4	....	30-30	Buckingham
2·86	Heat Treatment and Metallography............... 2·842	II	G(A)	....	15-20 45	Williams
		II (A.E.)	G	....	15-20 45	
2·861	Heat Treatment .... 2·333, 2·37	(Elective)	G	....	15-30 45	H. W. Hayward
2·87	Textile Engineering....... 2·05	II_2	4	....	30--30 60	Haven
2·88	Ordnance Engineering ..... 2·21 or 2·221	II Ord.	4	....	45-45 30	Fuller
2·891	Mechanics...............	II(A.O.)	4	Summer	190-45	Fuller
2·892	Ordnance Problems .... 2·271	II(A.O.)	4	....	120- 0	Fuller
2·90	Forging................. D12	II, XVI	2	....	0- 0 45	Lambirth
2·901	Forging................. D12	III, $XIII_1$	2	0- 0 30	....	Lambirth
		$XIII_2$	3	0- 0 30	....	
2·902	Forging................. D12	$XIII_1$	2	....	0- 0 30	Lambirth
2·91	Foundry................. D12	II, XVI	2	0- 0 60	....	O'Neill
		III_3	2	....	0- 0 60	
2·911	Foundry................. D12	IV-A	2	....	0- 0 30	O'Neill
2·912	Foundry................. D12	XV_2		Summer	0- 0 30	O'Neill
		VI, $XIII_1$	2	....	0- 0 30	
		$XIII_2$	4	....	0- 0 30	
2·92	Pattern Making.......... 2·91	II, XVI	2	....	0- 0 30	O'Neill
2·921	Carpentry...............	XVII	3	....	30- 0	O'Neill
2·941	Machine Tool Laboratory.. D12	VI	2	15-0 45	....	Littlefield
2·942	Machine Tool Laboratory.. 2·941	VI	2	....	5- 0 25	English
2·951	Machine Tool Laboratory.. D12	II, $XIII_1$, XVI	3	30- 0 60	....	R. H. Smith
2·952	Machine Tool Laboratory.. 2·951	II, $XIII_1$, XVI	3	....	15- 0 45	R. H. Smith
2·96	Machine Tool Laboratory.. D12	VIII, IX-B	2	....	15- 0 45	R. H. Smith
		XIV	2	15- 0 45	....	
2·961	Machine Tool Laboratory.. D12	XV_2	2	....	10- 0 20 (first 10 weeks)	R. H. Smith
		$XIII_2$,	4	....	15- 0 15	
2·971	Machine Tool Laboratory.. D12	XV_2	3	Summer	10- 0 35	R. H. Smith

No.	Subject and Preparation	Taken by	Term and Year	Exercise and Hours of Preparation 1st Term	2d Term	Instructor in Charge
2·972	Machine Tool Laboratory... 2·971	XV_2	3	.. ..	15–0 30	R. H. Smith
2·98	Production Methods....... 2·952	II	4	.. ..	15–15	R. H. Smith
2·981	Manufacturing Processes... 2·952	II II (A.E.)	G(A) G	45–15 45–15	.. ..	R. H. Smith
2·99	Metrology and Dimensional Engineering Standardization 2·951	(Elective)	G	45–90	.. ..	Buckingham

MINING ENGINEERING AND METALLURGY — 3·00–3·99

Including Petroleum Production

No.	Subject and Preparation	Taken by	Term and Year	Exercise and Hours of Preparation 1st Term	2d Term	Instructor in Charge
3·01	Mining Methods.......... 1·10, 8·04, 12·01	$III_{1,3}$	3	75–45	.. ..	Hutchinson
3·02	Mining Methods......... 3·01	$III_{1,3}$	3	.. ..	60–45	Hutchinson
3·03	Economics of Mining...... 3·02, 3·08, 3·21	$III_{1,3}$	4	60–45	.. ..	Hutchinson
3·04	Mining, Principles of...... 3·03	$III_{1,3}$	4	.. ..	45–60	Hutchinson
3·05	Mining, Elements of.......	XII III_3	3 4	30–30 30–30	.. ..	Hutchinson
3·061	Mining Engineering, Advanced................ 3·04	III_1	G(A)	✦	.. ..	Hutchinson
3·062	Mining Engineering, Advanced................ 3·04	III_1	G(A)	.. ..	✦	Hutchinson
3·08	Mining Practice..........	$III_{1,3}$	3	Summer	0–0 45	Hutchinson
	1·10	XII (Optional)		Summer Mining Camp		
3·09	Mining Law............. 3·04	III_1	G(A)	30–120	.. ..	Hutchinson
3·101	Mine Valuation........... 3·04, 3·08	III_1	G(A)	45–120	.. ..	Hutchinson
3·102	Mine Valuation........... 3·101	III_1	G(A)	.. ..	45–120	Hutchinson
3·12	Economics of Mining, Advanced................ 3·04	III_1	G(A)	.. ..	✦	Hutchinson
3·21	Ore Dressing............ *3.22*, 12·01	III_1	3	.. ..	45–30	Locke
3·22	Ore Dressing Laboratory... *3.21*, 3·31, 5·13	III_1	3	.. ..	15–30 60	Locke
3·23	Ore Dressing .... 12·01	$III_{2,3}$, XII	3	.. ..	20–30 25	Locke
3·241	Ore Dressing, Advanced... 3·21, 3·22; or 3·23	III_1	G(A)	✦	.. ..	Locke
3.242	Ore Dressing, Advanced... 3·21, 3·22, or 3·23	III_1	G(A)	.. ..	✦	Locke
3·251	Theory and Practice of Flotation................ 3·21, 3·22; or 3·23	III	G(A)	30–60	.. ..	Locke
3·252	Theory and Practice of Flotation................ 3·21, 3·22; or 3·23	III	G(A)	.. ..	30–60	Locke
3·26	Ore Dressing, Economics... 3·21, 3·22; or 3·23	III	G(A)	Either term	30–60	Locke
3·271	Ore Dressing, Design...... 3·21, 3·22; or 3·23	III	G(A)	30–60	.. ..	Locke
3·272	Ore Dressing, Design ...... 3·21, 3·22; or 3·23	III	G(A)	.. ..	30–60	Locke

✦ Time specially arranged.

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
3·31	Fire Assaying 12·01, 5·12	III$_{1,2}$ XII (Elective)	3	30–30 60	.. ..	Bugbee
3·32	Fire Assaying and Metallurgical Laboratory 5·12	XIV (Elective)	4	30–30 30	.. ..	Bugbee
3·331	Fire Assaying, Advanced 5·12, 3·31	III	G(A)	90– 0 105	.. ..	Bugbee
3·332	Fire Assaying, Advanced 3·31, 5·12	III	G(A)	.. ..	90– 0 105	Bugbee
3·41	Metallurgy: Copper, Lead, etc. 5·13, 12·01, 3·60	III$_2$	4	80–45 70	.. ..	C. R. Hayward
3·411	Metallurgy: Copper, Lead, etc. 5·13, 12·01, 3·60	III$_2$	4	60–45 30	.. ..	C. R. Hayward
3·412	Metallurgy: Copper, Lead Zinc, etc. 5·13, 12·01	III$_1$	4	50–45 25	.. ..	C. R. Hayward
3·42	Metallurgy: Gold and Silver 3·31, 3·23	III$_{1,2}$	4	.. ..	30–30 45	Bugbee
3·43	Metallurgy: Iron and Steel. 5·02, 3·60	III$_2$	4	105–45	.. ..	Waterhouse
3·431	Metallurgy: Iron and Steel. 5·02, 3·60	III$_2$	4	45–45	.. ..	Waterhouse
3·432	Metallurgy: Iron and Steel. 5·02	III$_1$	4	30–15	.. ..	Waterhouse
3·44	Metallurgy: General, Zinc and Minor Metals 3·411, 3·431	III$_2$	4	.. ..	60–45	C. R. Hayward
3·45	Metallurgy, Heat Treatment of Steel 3·431, 3·61, 8·12	III$_2$	4	.. ..	30–15	Waterhouse
3·46	Metallurgy of Common Metals 5·02	V (Elective) XII	4 4	.. ..	45–45 45–45	C. R. Hayward
3·501	Metallurgy: Iron and Steel, Advanced 3·43	III$_2$	G(A)	✦	.. ..	Waterhouse
3·502	Metallurgy, Iron and Steel, Advanced 3·43	III$_2$	G(A)	.. ..	✦	Waterhouse
3·511	Metallurgical Plant Design. 3·41, 3·42, 3·43	III$_2$	G(A)	195– 0	.. ..	Waterhouse
3·512	Metallurgical Plant Design. 3·41, 3·42, 3·43	III$_2$	G(A)	.. ..	195– 0	Waterhouse
3·521	General Metallurgy, Ad-Advanced 3·44	III$_2$	G(A)	45–90	.. ..	C. R. Hayward
3·522	General Metallurgy, Advanced 3·44	III$_2$	G(A)	.. ..	45–90	C. R. Hayward
3·531	Non-Ferrous Metallurgy, Advanced 3·41, 3·42, 3·44	III$_2$	G(A)	✦	.. ..	C. R. Hayward
3·532	Non-Ferrous Metallurgy, Advanced 3·41, 3·42, 3·44	III$_2$	G(A)		✦	C. R. Hayward
3·541	Gold and Silver Metallurgy, Advanced 3·42	III$_2$	G(A)	✦	.. ..	Bugbee
3·542	Gold and Silver Metallurgy, Advanced 3·42	III$_2$	G(A)	.. ..	✦	Bugbee
3·56	Metallurgical Plants 3·41, 3·42, 3·43	III$_2$(Elective)	4	.. ..	45–45	Waterhouse
3·60	Metallurgical Plant Visits	III$_2$	4	Summer	30–30	C. R. Hayward
3·61	Metallography 5·13, 8·12	III$_2$	3	.. ..	30–15 45	Waterhouse
3·611	Metallography 5·13	XIV V	4 4	.. .. 30–15 30	30–15 30	Williams

✦ Time specially arranged.

No.	Subject and Preparation	Taken by	Term and Year	Exercise and 1st Term	Hours of Preparation 2d Term	Instructor in Charge
3·612	Metallography 5·13	VIII	4	.. ..	30–15 15	Williams
3·651	Physical Metallurgy Advanced 3·61	III$_2$	G(A)	✦	.. ..	Waterhouse
3·652	Physical Metallurgy Advanced 3·651	III$_2$	G(A)	.. ..	✦	Waterhouse
3·66	Applications of Metallography 3·61, 3·611 or 3·612	III$_2$	G(A)	Either term	0– 0 75	Homerberg
3·81	Elements of Petroleum Engineering 1·10, 8·04, 12·30	III$_3$	3	90–45	.. ..	Mann
3·82	Elements of Petroleum Engineering 3·81	III$_3$	3	.. ..	60–45	Mann
3·85	Petroleum Production and Utilization 3·82	III$_3$	4	75–30	.. ..	Mann
3·86	Petroleum Production and Utilization 3·85	III$_3$	4	.. ..	75–30	Mann
3·89	Oil Field Visits ·10	III$_3$	3	Summer	50– 0	Mann
3·901	Oil and Gas Land Valuation 3·86, 3·89	III$_3$	G(A)	45–120	.. ..	Mann
3·902	Oil and Gas Land Valuation 3·901	III$_3$	G(A)	.. ..	45–120	Mann
3·911	Advanced Petroleum Engineering 3·86	III$_3$	G(A)	✦	.. ..	Mann
3·912	Advanced Petroleum Engineering 3·86	III$_3$	G(A)	.. ..	✦	Mann
3·92	Oil and Gas Law 3·86	III$_3$	G(A)	30–30	.. ..	Mann
3·93	Oil Well Waters 3·86	III$_3$	G(A)	.. ..	30–30	Mann

ARCHITECTURE — 4·00–4·99

No.	Subject and Preparation	Taken by	Term and Year	Exercise and 1st Term	Hours of Preparation 2d Term	Instructor in Charge
4·021	Freehand Drawing	IV	2	0– 0 60	.. ..	W. F. Brown
4·022	Freehand Drawing	IV	2	.. ..	0– 0 60	W. F. Brown
4·031	Freehand Drawing	IV	3	0– 0 60	.. ..	W. F. Brown
4·032	Freehand Drawing	IV	3	.. ..	0– 0 60	W. F. Brown
4·041	Freehand Drawing	IV	4	0– 0 90	.. ..	W. F. Brown
4·042	Freehand Drawing	IV	4	.. ..	0– 0 90	W. F. Brown
4·051	Freehand Drawing and Decorative Design 4·042	IV	G(A)	0– 0 90	.. ..	W. F. Brown
4·052	Freehand Drawing and Decorative Design 4·051	IV	G(A)	.. ..	0– 0 90	W. F. Brown
4·06	Graphics	IV	1	90– 0	.. ..	Beckwith
4·061	Graphics	XVII	1	.. ..	55– 0	Beckwith
4·071	Modelling	IV	3	0– 0 45	.. ..	Larsen

✦ Time specially arranged.

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
4·072	Modelling	IV	3	.. ..	0– 0 45	Larsen
4·081	Color: Theory and Exercises	IV	3	15–45	.. ..	Robinson
4·082	Color: Theory and Exercises	IV	3	.. ..	15–45	Robinson
4·091	Color: Design and Application	IV	4	15–60	.. ..	Hewlett
4·092	Color: Design and Application	IV	4	.. ..	15–60	Hewlett
4·10	Architectural Drawing	XVII	1	.. ..	45– 0	Beckwith
4·11	Shades and Shadows	IV	1	0– 0 45	.. ..	Gardner
4·12	Perspective 4·06 or *D811*	IV	1	45– 0	.. ..	Beckwith
4·13	Perspective	IV-A	2	15–45	.. ..	Lawrence
4·20	Office Practice	IV	2	.. ..	75– 0	Jenney
4·21	Office Practice 4·711, 4·013	IV	3	Summer 100 hours		Jenney
4·22	Office Practice 4·212	IV-A	3	90– 0	.. ..	Jenney
4·23	Office Practice	(Elective)	Either term		90– 0	Jenney
4·241	Professional Relations	IV, IV-A, XVII	4	15–15	.. ..	Jenney
4·242	Professional Relations	IV, IV-A	4	.. ..	15–15	Jenney
4·25	Estimating 4·20, or 4·22, 4·812 or 4·912	IV-A	4	15–30	.. ..	Jenrick
4·311	Theory of Architecture	IV	1	15– 0	.. ..	Beckwith
4·312	Theory of Architecture	IV	1	.. ..	15– 0	Beckwith
4·321	Theory of Architecture	IV	2	15–15	.. ..	F. J. Robinson
4·322	Theory of Architecture	IV	2	.. ..	15–15	F. J. Robinson
4·331	Theory of Architecture	IV	3	15–15	.. ..	Gardner
4·332	Theory of Architecture	IV	3	.. ..	15–15	Gardner
4·411	Architectural History	IV	1	30–60	.. ..	Putnam
		IV-A	2	30–60	.. ..	
4·412	Architectural History	IV	1	.. ..	30–60	Putnam
		IV-A	2	.. ..	30–60	
4·413	Architectural Drawing	XVII	2	30–60	.. ..	C. H. Walker
4·421	Architectural History	IV	2	15–30	.. ..	Putnam
		IV-A	3	15–30	.. ..	
4·422	Architectural History	IV	2	.. ..	15–30	Putnam
		IV-A	3	.. ..	15–30	
4·461	European Civilization and Art E11	IV, IV-A	3	45–60	.. ..	Sumner
4·462	European Civilization and Art 4·461	IV, IV-A	3	.. ..	45–60	Sumner
4·471	European Civilization and Art	IV	4	45–60	.. ..	Sumner
4·472	European Civilization and Art	IV	4	.. ..	45–60	Sumner
4·481	European Civilization and Art 4·472	IV	G(A)	30–60	.. ..	Sumner
4·482	European Civilization and Art 4·481	IV	G(A)	.. ..	30–60	Sumner
4·49	History of Renaissance Art	IV	4	.. ..	15–15	Walker
4·52	Philosophy of Architecture	IV	4	.. ..	15– 0	Walker
4·61	Town Planning	IV	4	30–45	.. ..	T. Adams
4·712	Design I	IV	1	.. ..	0– 0 180	Beckwith
4·721	Design II 4·712	IV	2	0– 0 180	.. ..	F. J. Robinson
4·722	Design II 4·721	IV	2	.. ..	0– 0 225	F. J. Robinson
4·731	Design III 4·722	IV	3	0– 0 210	.. ..	Gardner
4·732	Design III 4·731	IV	3	.. ..	0– 0 225	Gardner
4·741	Design IV 4·732	IV	4	0– 0 345	.. ..	Cash

No.	Subject and Preparation	Taken by	Term and Year	Exercise and 1st Term	Hours of Preparation 2d Term	Instructor in Charge
4·742	Design IV 4·741	IV	4	.. ..	0– 0 375	Cash
4·751	Design V 4·742	IV	G(A)	0– 0 540	.. ..	Carlu
4·752	Design V 4·751	IV	G(A)	.. ..	0– 0 540	Carlu
4·80	Building Construction	IV IV-A	3 2	15–15 15–15	.. ..	P. W. Norton
4·811	Constructive Design 2·17, 2·18	IV	3	90– 0	.. ..	P. W. Norton
4·812	Constructive Design 4·811	IV	3	.. ..	105– 0	P. W. Norton
4·90	Structural Drawing D22	IV-A	2	.. ..	15– 0 45	P. W. Norton
4·911	Structural Design 4·90, *2·20*	IV-A	3	105– 0	.. ..	W. H. Lawrence
4·912	Structural Design 4·911	IV-A	3	.. ..	150–0	W. H. Lawrence
4·921	Structural Design 4·912, 1·40	IV-A	4	120– 0	.. ..	W. H. Lawrence
4·922	Structural Design 4·921	IV-A	4	.. ..	195– 0	W. H. Lawrence

CHEMISTRY — 5·00–5·99

No.	Subject and Preparation	Taken by	Term and Year	Exercise and 1st Term	Hours of Preparation 2d Term	Instructor in Charge
5·00	Chemistry	Entrance		Summer	50–70 50	Blanchard
5·01	Chemistry 5·00	All courses except IV	1	60–75 60	.. ..	H. M. Smith
5·02	Chemistry 5·01	All courses except IV	1	.. ..	60–75 60	Mueller
5·04S	Chemistry	II (A.O.)		Summer	90– 0	Schumb
5·06	Inorganic Chemistry 5·13	V Chem. War. X (Optional)	4 G 4	.. .. 45–45	45–45 45–45	Schumb
5·08	Preparation of Inorganic Compounds 5·12	(Elective)	G	.. ..	15–15 60	Hall
5·09	Theories and Applications of Catalysis 5·50, 5·502	V	G(A)	.. ..	30–30	Underwood
5·10	Qualitative Analysis 5·02	V, X V, X Elective	2 2	Summer 45–60 165	45–60 165	Williams
5·101	Qualitative Analysis 5·02	XIV, XV_3 XIV, XV_3 (Elective)	2 2	Summer 45–30 135	45–30 135	Williams
5·11	Qualitative Analysis 5·02	III, IX-A, XI, XII VII, VIII, IX-A	2 2	30–30 75 Summer	.. .. 30–30 75	Williams
5·12	Quantitative Analysis 5·10, 5·101 or 5·11	V, XIV, XV_3 III, IX-A, XI, XII VII	2 2 2	30–30 75 .. .. Summer	.. .. 30–30 75 30–30 75	Williams
5·121	Quantitative Analysis 5·10	X	2	45–45 90	.. ..	Williams
5·13	Quantitative Analysis 5·12	$III_{1,2}$, XII V, XV_3	3 2	30–30 75	.. .. 30–30 75	Williams
5·131	Quantitative Analysis 5·121	X	2	.. ..	15–15 75	Williams
5·132	Quantitative Analysis 5·12	XIV	2	.. ..	15–15 45	Williams

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
5·14	Industrial Applications of Quantitative Analysis ... 5·13	V	3	45–45	....	Williams
5·16	Analytical Chemistry......	X-A	4	....	15-15 45	Hamilton
5·17	Methods of Electrochemical Analysis.............. 5·12	V	G(A)	....	15–30 45	Hall
5·18	Advanced Qualitative Analysis................... 5·10 or 5·101	V	G(A)	15–15 120	....	Hall
5·191	Chemical Literature....... L11, 12, L51, 52	V	3	30–45	....	Hall
5·192	Chemical Library......... Technique 5·191, 5·52, 5·652	V	4	15–15	....	Huntress
5·20	Water Supplies........... 5·12	VII	3	15–15 30	....	Woodman
5·21	Industrial Water Analysis.. 5·12	XI	3	....	5– 0 25	Woodman
5·22	Water Supplies and Wastes Disposal............... 5·12	XI	4	0–15 30	....	Woodman
5·25	Chemistry of Foods....... 5·12, 5·50 or 5·51	VII	3	15–15 60	....	Woodman
5·251	Chemistry of Foods....... 5·12, 5·50 or 5·51	V (Elective)	4	Either term	15–15 30	Woodman
5·26	Food Analysis............ 5·12, 5·50 or 5·51	V (Elective)	4	Either term	5– 0 70	Woodman
5·27	Chemistry of Plant and Animal Life............... 5·50 or 5·51	(Elective)	4	....	45–75	Mueller
5·29	Optical Methods.......... 5·12, 8·02	V (Elective)	4	Either term	0–15 30	Woodman
5·30	Proximate Analysis........ 5·121, 5·50 or 5·51, L22	V, X, XIV (Elective)		15–30 75	....	Gill
5·31	Gas Analysis.............	III$_2$	2	....	10– 5 15	Gill
	5·121	V	3	10– 5 15	....	
5·32	Gas Analysis............. 5·31	(Elective)	4	Either term	10– 0 20	Gill
5·33	Study of War Gases.......	V C.W.S.	3	....	15–15	Gill
5·34	Engineering Chemistry .... 5·02	II (Elective) IX (Elective) XV$_2$ (Elective)	4	Either term	60– 0	Gill
5·35	Applied Chemistry........ 5·02	XIII	4	....	20–25	Gill
5·37	Chemistry of Road Materials 5·02	I$_2$	4	15– 0 45	....	Gill
5·38	Lubricating and Fuel Oil Testing...............	II, V, IX-B, XV$_2$ (Elective)	4	Either term	10–15 35	Gill
		III$_3$	3	10–15 35	....	
5·40	Special Methods.......... 5·12, 8·02	V	3	0–15 30	....	Gil
5·50	Organic Chemistry........ 5·01, 5·02	VIII IX-A, XI, XIV	2 3	30–30 30–30	....	Huntress
5·501	Organic Chemistry 5·01, 5·02	VII XV$_2$	2 3	45–30 45–30	....	Huntress
5.51	Organic Chemistry I...... 5·12, 8·04............	V, X II (A.O.)	3 4	60–45 60–45	....	Mulliken
5·511	Organic Chemistry I....... 5·13, 8·03	X C.W.S., V C.W.S.	3	60–45	....	Mulliken
5·52	Organic Chemistry I....... 5·51..................	V, X II (A.O.)	3 4	....	60–30 60–30	Mulliken
5·521	Organic Chemistry I....... 5·511	V C.W.S., X C.W.S.	3	....	60–30	Mulliken
5·531	Organic Chemistry II...... 5·52	V Chem. War.	G(A) G	30–30	 30–30	Norris

No.	Subject and Preparation	Taken by	Year	Term and Exercise and Preparation 1st Term	Hours of Preparation 2d Term	Instructor in Charge
5·532	Organic Chemistry II...... 5·52	V	G(A)	.. ..	30–30	Norris
5·54	Organic Chemistry III..... 5·52	V	G(A)	45–90	.. ..	Mulliken
5·55	Organic Qualitative Analysis 5·52, 5·61	V	G(A)	Either term	0– 0 150	Mulliken
5·56	Industrial Organic Chemistry.................. 5·50, 5·502	V	G(A)	.. ..	30–30	Underwood
5·57	Powder and Explosives..... 5·52	V (Elective), V, C.W.S., II (A.O.) X Ord.				Davis
		X C.W.S.	4	.. ..	30–30	
		V	G(A)	.. ..	30–30	
5·571	Chemistry of Medicinal Products and Allied Topics... 5·52	(Elective)		Summer	10–10	Underwood
5·581	Synthetic Methods in Organic Chemistry........ 5·52	V	G(A)	45–45	.. ..	Davis
5·582	Chemistry of Dyes........ 5·52	V	G(A)	.. ..	30–30	Mulliken
5·583	Catalytic and Electrochemical Methods in Organic Chemistry............ 5·52, 5·62 or 5·622T	(Elective)		Summer 100 hours		Underwood
5·601	Journal Meeting in Organic Chemistry............ 5·52	V	G(A)	15–15	.. ..	Norris
5·602	Journal Meeting in Organic Chemistry............ 5·52	V	G(A)	.. ..	15–15	Norris
5·61	Organic Chemical Laboratory.................. 5·12, 5·51, or 5·511	V	3	0– 0 135	.. ..	Mulliken
		II (A.O.)	4	0– 0 135	.. ..	
5·611	Organic Chemical Laboratory.................. 5·12, 5·511	V C.W.S.	3	0– 0 135	.. ..	Mulliken
5·612	Organic Chemical Laboratory.................. 5·12, 5·51, or 5·511	X	3	0– 0 105	.. ..	Mulliken
5·613	Organic Chemical Laboratory.................. 5·12, 5·511	X C.W.S.	3	0– 0 90	.. ..	Mulliken
5·614	Organic Chemical Laboratory.................. 5·501	XV_1	3	0– 0 45	.. ..	Huntress
5·615	Organic Chemical Laboratory.................. 5·50	IX-A, XIV	3	.. ..	0– 0 75	Huntress
		VII	2	.. ..	0–15 75	
5·62	Organic Chemical Laboratory.................. 5·61	V	3	.. ..	0– 0 195	Mulliken
5·621	Organic Chemical Laboratory.................. 5·611	V C.W.S.	3	.. ..	0– 0 135	Mulliken
		Chem. War.	G	.. ..	0– 0 135	
5·622	Organic Chemical Laboratory.................. 5·612	X	3	.. ..	0– 0 45	Mulliken
5·623	Organic Chemical Laboratory.................. 5·613....	X C.W.S.	3	.. ..	0– 0 60	Mulliken
5·624	Organic Chemical Laboratory.................. 5·614	XV_1	3	.. ..	0– 0 60	Huntress

No.	Subject and Preparation	Taken by	Term and Year	Hours of Exercise and Preparation 1st Term	Hours of Exercise and Preparation 2d Term	Instructor in Charge
5·631	Organic Laboratory Practice, Advanced .... 5·61, 5·62	V	G(A)	0–15 60	.. ..	Morton
5·632	Organic Laboratory Practice, Advanced .... 5·61, 5·62	V	G(A)	.. ..	0–15 60	Morton
5·64	Recent Advances in Organic Chemistry .... (Open to Graduate Students only)	V	G(A)	.. ..	15–15	Davis
5·651	Chemical Principles .... M21, 8·03, 5·13	V, X	3	60–90 15	.. ..	Sherrill
5·652	Chemical Principles .... 5·651	V, X	3	.. ..	60–90 15	Sherrill
5·66	Chemical Principles .... 5·652	V	4	30–60 15	.. ..	Sherrill
5·671	Chemical Principles .... M21, 8·03, 5·13	V, X (Elective)		60–90	.. ..	Sherrill
5·672	Chemical Principles .... M21, 8·03, 5·13	V, X (Elective)		.. ..	60–90	Sherrill
5·68	Thermochemistry and Chemical Equilibrium .... M21, 8·04, 5·13	III$_2$, XII	4	30–60	.. ..	Mueller
5·681	Thermochemistry and Chemical Equilibrium .... M21, 8·04, 5·13 or 5·131	XV$_2$	3	45–75	.. ..	Mueller
5·69	Surface and Colloid Chemistry .... 5·512 and 5·66	V	4	.. ..	30–15	Scatchard
5·701	The Logic of Scientific Inquiry (open to graduate students only)	V	G(A)	30–30	.. ..	Davis
5·702	The Logic of Scientific Inquiry (open to graduate students only)	V	G(A)	.. ..	30–30	Davis
5·71	Physical Chemistry Seminar 5·651 and 5·652	V, X	G(A)	.. ..	30–30	Millard
5·721	Thermodynamics and Chemistry .... 5·651 and 5·652	V	G(A)	30–60	.. ..	Gillespie
5·722	Thermodynamics and Chemistry .... 5·721	V	G(A)	.. ..	15–30	Gillespie
5·723	Thermodynamics and Chemistry .... 5·722	V	G(A)	.. ..	30–60	Beattie
5·73	Free Energy .... 5·66 or 5·672	V	G(A)	30–60	.. ..	Sherrill
5·741	Kinetic Theory of Gases, Liquids and Solids M31	V	G(A)	30–60	.. ..	Keyes
5·742	Kinetic Theory of Gases, Liquids and Solids M31	V	G(A)	.. ..	30–60	Keyes
5·75	Atomic Structure	(Elective)		.. ..	10–20	Blanchard
5·761	Sub-Atomic Chemistry ..... 5·50 or 5·51; 5·652 or 8·802	V	G(A)	15–30	.. ..	Blanchard
5·762	Sub-Atomic Chemistry ..... 5·761	V	G(A)	.. ..	15–30	Blanchard
5·771	Conference on Physical Chemistry M31	V	G(A)	15–15	.. ..	Scatchard
5·772	Conference on Physical Chemistry M31	V	G(A)	.. ..	15–15	Scatchard
5·78	Thermodynamics	V II (T.D.)	G(A) G	.. ..	30–30 30–30	Keyes
5·79	Radiation Chemistry ...... M21, 8·03	V	4	.. ..	30–45	Sherrill
5·81	Organic and Explosives Laboratory .... 5·048, 5·51, 5·61	II (A.O.)	4	.. ..	0– 0 105	Mulliken, Davis

No.	Subject and Preparation	Taken by	Term and Exercise Year	Hours of Preparation 1st Term	Hours of Preparation 2d Term	Instructor in Charge
5·82	Physical Chemistry....... 5·01, 5·02, 8·03, 8·04	II Mil. Eng., XVI Chem. War.	3 4 G	30–30 30–30 30–30	.. ..	Millard
5·83	Elements of Chemical Theory	VII₁	2	.. ..	30–60	Gillespie
5·84	Quantum Theory Applications.................. 5·66	V	G (A)	30–60	.. ..	Beattie
5·85	Theory of Solutions....... 5·721	V	G (A)	.. ..	30–60	Scatchard
5·91	Organic Physical Chemistry 5·52, 5·66		G (A)	.. ..	15–15	Morton
5·93	History of Chemistry...... 5·50 or 5·51	V	4	.. ..	30–30	Davis
5·951	Research Problem and Thesis.................	V	4	0–30 225	.. ..	Keyes
5.952	Research Problem and Thesis	V	4	.. ..	0– 0 315	Keyes
5·96	Thesis Reports...........	V	4	.. ..	15–15	Keyes
5·98	Research................. 5·52, 5·66	V	G (A)	Time arranged		Norris
5·991	Research Conferences in Physical and Organic Chemistry............. 5·52, 5·66	V	G (A)	15–15	.. ..	Scatchard
5·992	Research Conferences in Physical and Organic Chemistry............. 5·52, 5·66	V	G (A)	.. ..	15–15	Norris

ELECTRICAL ENGINEERING — 6·00–6·99

No.	Subject and Preparation	Taken by	Term and Exercise Year	Hours of Preparation 1st Term	Hours of Preparation 2d Term	Instructor in Charge
6·00	Principles of Electrical Engineering................ *M22*, 8·03	VI, VI-A	2	.. ..	75–90	Barker
6·01	Principles of Electrical Engineering................ 6·00, M22	VI, VI-C	3	45–60	.. ..	Barker
6·01T	Principles of Electrical Engineering...............	VI-A(A) VI-A(B)	3 3	Summer Summer	45–60 30–75	Barker
6·02	Principles of Electrical Engineering................ 6·00, 6·01	VI, VI-C VI-A(B)	3 3	 75–90	75–90	R. R. Lawrence
6·021	Electrical Engineering, Principles.................. 6·01	VI-A(A)	3	30–60	.. ..	R. R. Lawrence
6·023	Electrical Engineering, Principles.................. 6·021	VI-A(A)	3	.. ..	75–90	R. R. Lawrence
6·03	Principles of Electrical Engineering................ 6·01, 6·02	VI, VI-C	4	90–120	.. ..	R. R. Lawrence
6·031	Electrical Engineering, Principles 6·02.............	VI-A(B)	3	.. ..	30–75	R.R.Lawrence
6·04	Principles of Electrical Engineering................ 6·03, 6·116	VI	4	.. ..	75–105	Woodruff
6·043	Principles of Electrical Engineering................	VI (Elective)		Summer G. E. Co.	36–72	Woodruff

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
6·06	Principles of Electrical Engineering *M22*, 8·03	XIV	2	.. ..	45–75	Barker
6·07	Principles of Electrical Engineering 6·06, M31	XIV	3	60–90	.. ..	Barker
6·08	Principles of Electrical Engineering 6·07	XIV	3	.. ..	60–90	Lyon
6·09	Principles of Electrical Engineering 6·08	XIV	4	60–90	.. ..	Lyon
6·105	Principles of Electrical Engineering 6·104	VI-A (A)	4	Summer	20–40	R. R. Lawrence
6·106	Principles of Electrical Engineering 6·02 or 6·105	VI-A (A)	4	90–105	.. ..	R. R. Lawrence
6·107	Principles of Electrical Engineering 6·106	VI-A (A)	4	.. ..	30–60	Woodruff
6·115	Principles of Electrical Engineering 6·114	VI-A (B)	4	Summer	50–60	R. R. Lawrence
6·116	Principles of Electrical Engineering 6·115	VI-A (B)	4	30–60	.. ..	Woodruff
6·117	Principles of Electrical Engineering 6·116	VI-A (B)	4	.. ..	75–90	Woodruff
6·121	Electrical Engineering, Principles 6·104	VI-A (A)₃	4	90–105	.. ..	R. R. Lawrence
6·122	Principles of Electrical Engineering	VI-A(B)₃	4	Summer	30–60	R. R. Lawrence
6·123	Electrical Engineering, Principles 6·122	VI-A (B)₃	4	.. ..	45–75	R. R. Lawrence
6·20	Power Transmission Equipment 6·03 or equivalent	VI (Elective)	4	.. ..	45–90	Woodruff
6·21	Industrial Applications of Electric Power 6·03	VI (Elective)	4	.. ..	45–90	Dawes
6·221	Central Stations	VI (Elective)	4	45–90	.. ..	Balsbaugh
6·222	Central Station Design	VI (Elective)	4	.. ..	45–90	Balsbaugh
6·23	Electrical Equipment of Buildings 8·04	XVII (Elective)	4 3, 4	.. ..	15–30 15–30	Hudson
6·24	Electric Railways	VI (Elective)	4	45–90	.. ..	Entwistle
6·251	Electric Machinery Design 6·02	VI (Elective)	4	45–90	.. ..	Dwight
6·252	Electric Machinery Design 6·03	VI (Elective)	4	.. ..	45–90	Dwight
6·27	Illumination 8·02, 6·03	VI (Elective)	4	45–90	.. ..	Drisko
6·281	Principles of Wire Communication 6·02, *6·03*	VI (Elective)	4	45–90	.. ..	C. E. Tucker
6·282	Principles of Radio Communication 6·02	VI (Elective)	4	.. ..	45–90	Clapp
6·29	Storage Batteries	VI (Elective)	4	One term only	15–15	R. R. Lawrence
6·301	Principles of Electrical Communication 6·00	VI-C	3	45–90	.. ..	C. E. Tucker
6·302	Principles of Electrical Communication 6·301, *6·02*	VI-C	3	.. ..	45–90	Bowles

No.	*Subject and Preparation*	*Taken by*	*Year*	*Term and Hours of Exercise and Preparation* 1st *Term*	2d *Term*	*Instructor in Charge*
6·311	Principles of Electrical Communication............. 6·02	VI-A (A)$_3$, VI-C	4	45–60	.. ..	Bowles
6·312	Principles of Electrical Communication............. 6·301, 6·02, 6·03	VI-C	4	.. ..	45–60	C. E. Tucker
6·32	Electrical Communications, Principles............. 6·311 or 6·354	VI-A (B)$_3$	4	.. ..	45–60	Bowles
6·330	Communications Electrical Laboratory............. *6·311*	VI-A (A)$_3$	4	0–45 30	.. ..	Clapp
6·331	Communication Electrical Laboratory............. *6·311* or 6·354	VI-C	4	0–60 45	.. ..	Clapp
		VI-A (B)$_3$	4	.. ..	0–60 45	
6·332	Communication Electrical Laboratory............. 6·331 or 6·330	VI-C	4	.. ..	0–60 45	Clapp
6·342	Principles of Electrical Communication............. 6·341	VI-A (A)$_3$	4	Summer	20–40	Bowles
6·343	Electrical Communications, Principles............. 6·342	VI-A (A)$_3$	4	.. ..	30–60	Bowles
6·353	Principles of Electrical Communication............. 6·352	VI-A (B)$_3$	4	Summer	30–60	Bowles
6·354	Electrical Communications, Principles............. 6·02	VI-A (B)$_3$	4	30–60	.. ..	Bowles
6·355	Electrical Communications, Principles............. 6·354	VI-A (B)$_3$	4	.. ..	75–105	Bowles
6·40	Elements of Electrical Engineering............... 8·04	I, XI, XV$_1$, XVII	3	60–90	.. ..	Hudson
		II, IX-B, XV$_2$	3	.. ..	60–90	
		III, X, XIII, XV$_3$, XVI, Mil. Eng.	4	60–90	.. ..	
		V (Elective)	4	Either term	60–90	
6·41	Elements of Electrical Engineering............... 8·04	X-B	4	48–72	.. ..	Hudson
6·42	Elements of Electrical Engineering...............	II (A.O.)	4	75–75	.. ..	Hudson
6·43	Generation and Distribution of Electric Energy	XV$_1$	4	.. ..	60–90	Balsbaugh
6·44	Electric Transmission and Distribution of Energy ..	I$_3$	4	30–60	.. ..	Balsbaugh
6·451	Alternating Currents and Alternating-Current Machinery...................	XIII-A	4	30–60	.. ..	R. R. Lawrence
6·452	Alternating Currents and Alternating-Current Machinery...................	XIII-A	4	.. ..	30–60	
6·46	Industrial Applications of Electric Power.......... 6·40	II (O.D.)	G	.. ..	45–30	Dawes
		Mil. Eng.	4	.. ..	45–30	
6·47	Central Stations...	I$_3$	4	.. ..	30–60	Balsbaugh
6·501	Electrical Engineering Seminar................... 6·03, 6·04, Ec32 or equivalents	VI	G(A)	120	.. ..	Bush
6·502	Electrical Engineering Seminar................... 6·03, 6·04, Ec32 or equivalents	VI	G(A)	.. ..	120	Bush
6·511	Electric Circuits.......... 6·03, 6·04, Ec32 or equivalents	VI	G(A)	150	.. ..	Dahl

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
6'512	Electric Circuits .... 6'03, 6'04, Ec32 or equivalents	VI	G(A)	.. ..	150	Dahl
6'521	Alternating-Current Machinery .... 6'03, 6'04, Ec32 or equivalents	VI	G(A)	150	.. ..	Lyon
6'522	Alternating-Current Machinery .... 6'03, 6'04, Ec32 or equivalents	VI	G(A)	.. ..	150	Lyon
6'531	Organization and Administration of Public Service Companies .... 6'03, 6'04, Ec32 or equivalents	VI	G(A)	150	.. ..	Jackson
6'532	Organization and Administration of Public Service Companies .... 6'03, 6'04, Ec32 or equivalents	VI	G(A)	.. ..	150	Jackson
6'541	Power Stations and Distribution Systems .... 6'03, 6'04, Ec32 or equivalents	VI	G(A)	135	.. ..	Balsbaugh
6'542	Power Stations and Distribution Systems .... 6'03, 6'04, Ec32 or equivalents	VI	G(A)	.. ..	135	Balsbaugh
6'551	Railroad Electric Traction . 6'03, 6'04, Ec32 or equivalents	VI	G(A)	135	.. ..	Entwistle
6'552	Railroad Electric Traction . 6'03, 6'04, Ec32 or equivalents	VI	G(A)	.. ..	135	Entwistle
6'561	Principles of Electrical Communication .... 6'03, 6'04, Ec32 or equivalents	VI	G(A)	45–60 45	.. ..	Bowles
6'562	Principles of Electrical Communication .... 6'03, 6'04, Ec32 or equivalents	VI	G(A)	.. ..	45–60 45	Bowles
6'57	Illumination .... 6'27	VI	G(A)	One term only 135		Drisko
6'58	Operational Calculus ...... 6'03, 6'04, Ec32 or equivalents	VI	G(A)	150	.. ..	Bush
6'591	Principles of Electrical Engineering .... 6'04 or 6'106 and 6'107	VI-A(A)	G	Summer	50–60	Dahl
6'592	Electrical Engineering, Principles .... 6'591	VI-A(A)	G	40–75	.. ..	Dahl
6'593	Principles of Electrical Engineering .... 6'04, 6'511 or 6'591, 6'592	VI-A(A)	G	20–60	.. ..	Dahl
6'601	Principles of Electrical Engineering .... 6'04 or 6'116, 6'117	VI-A(B)	G	Summer	30–60	Dahl
6'602	Principles of Electrical Engineering .... 6'601	VI-A(B)	G	20–60	.. ..	Dahl
6'603	Principles of Electrical Engineering .... 6'511 or 6'601, 6'602	VI-A(B)	G	20–70	.. ..	Dahl
6'661	Principles of Electric Machinery Development .... 6'03, 6'04, Ec32 or equivalents	VI	G(A)	150	.. ..	Dwight

No.	Subject and Preparation	Taken by	Year	Term and Exercise and Hours of Preparation 1st Term	2d Term	Instructor in Charge
6·662	Principles of Electric Machinery Development.... 6·03, 6·04, Ec32 or equivalents	VI	G(A)	.. ..	150	Dwight
6·70	Electrical Engineering Laboratory... .... *6·00*, *6·01*	VI, VI-C	3	40–65 60	.. ..	Laws C. E. Tucker
6·71	Electrical Engineering Laboratory .... 6·70, *6·02*	VI, VI-C	3	.. ..	30–75 45	Laws C. E. Tucker
6·72	Electrical Engineering Laboratory .... 6·71, *6·03*	VI, VI-C	4	35–90 55	.. ..	Laws C. E. Tucker
6·73	Electrical Testing......... 6·03, 6·04, Ec32 or equivalents	VI	G(A)	✦		Laws
6·74	Electrical Engineering Laboratory................ 6·72 or equivalent	VI	G(A)	✦		C.E.Tucker
6·75	Electrical Engineering Laboratory................ *6·00*	VI-A	2	.. ..	15–25 20	Laws
6·76	Electrical Engineering Laboratory................ 6·75, *6·01*	VI-A(A)	3	Summer	30–45 30	C. E. Tucker
		VIA-(B)	3	30–45 30	.. ..	
6·77	Electrical Engineering Laboratory................ 6·76, 6·105; or 6·114	VI-A(B)1,2	4	Summer	10–30 20	Laws
		VI-A(A)1,2	4	10–30 20	.. ..	
6·77T	Electrical Engineering Laboratory................ *6·76*, 6·023	VI-A(A)	3	.. ..	20–35 20	Laws
6·771	Electrical Engineering Laboratory................ 6·76, *6·121*	VI-A(A)3	4	15–75 45	.. ..	Laws
6·772	Electrical Engineering Laboratory................ 6·76, *6·122*	VI-A(B)3	4	Summer	15–60 50	Laws
6·78	Electrical Engineering Laboratory................ 6·77; 6·106 or 6·116	VI-A(A)	5	Summer	25–45 35	C. E. Tucker
		VI-A(B)1,2	4	.. ..	25–45 35	
6·782	Electrical Engineering Laboratory................ 6·772, *6·123*	VI-A(B)3	4	.. ..	30–70 50	C. E. Tucker
6·80	Electrical Engineering Laboratory................	VI (Elective)	4	✦		Laws C. E. Tucker
6·81	Electrical Engineering Laboratory................ 6·06, *6·07*	XIV	3	15–35 25	.. ..	Laws C. E. Tucker
6·82	Electrical Engineering Laboratory................ 6·81, *6·08*	XIV	3	.. ..	15–35 25	Laws C. E. Tucker
6·83	Electrical Engineering Laboratory................ 6·82, *6·09*	XIV	4	15–35 25	.. ..	C. E. Tucker
6·85	Electrical Engineering Laboratory................ 6·40	III, X, XV3, XVI, Mil. Eng.	4	.. ..	0–45 30	C. E. Tucker
		IX-B	4	0–45 30	.. ..	
6·86	Electrical Engineering Laboratory................ 6·40	XI	3	.. ..	0–30 15	C. E. Tucker
6·871	Electrical Engineering Laboratory................ *6·451*	XIII-A	4	.. ..	10–20 20	C. E. Tucker

✦Time specially arranged.

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
6·872	Electrical Engineering Laboratory 6·452	XIII-A	4	.. ..	10–25 20	C. E. Tucker
6·88	Electrical Engineering Laboratory 6·42	II(A.O.)	4	.. ..	20–90 40	Laws C. E. Tucker
6·89	Electrical Engineering Laboratory 6·40	I, XV_1, XVII	3	.. ..	0–30 30	C. E. Tucker
		II(O.D.)	G	0–30 30	.. ..	
		II, XV_2	4	0–30 30	.. ..	
		$XIII_1$	4	.. ..	0–30 30	
6·901	Manufacturing Practice....	VI-A(A) (1)	3	1st term 48 hrs. per week		Timbie
		VI-A(B) (1)	3	Summer 48 hrs. per week		
6·902	Manufacturing Practice....	VI-A(B) (1)	3	2d term 48 hrs. per week		Timbie
6·903	Manufacturing Practice....	VI-A(A) (1)	4	Summer 48 hrs. per week		Timbie
		VI-A(B) (1)	4	1st term 48 hrs. per week		
6·904	Manufacturing Practice....	VI-A(A) (1)	4	2d term 48 hrs. per week		Timbie
		VI-A(B) (1)	G	Summer 48 hrs. per week		
6·905	Manufacturing Practice....	VI-A (1)	G	1st term 48 hrs. per week		Timbie
6·911	Public Utility Practice.....	VI-A(A) (2)	3	1st term 48 hrs. per week		Timbie
		VI-A(B) (2)	3	Summer 48 hrs. per week		
6·912	Public Utility Practice.....	VI-A(B) (2)	3	2d term 48 hrs. per week		Timbie
6·913	Public Utility Practice.....	VI-A(A) (2)	4	Summer 48 hrs. per week		Timbie
		VI-A(B) (2)	4	1st term 48 hrs. per week		
6·914	Public Utility Practice.....	VI-A(A) (2)	4	2d term 48 hrs. per week		Timbie
		VI-A(B) (2)	G	Summer 48 hrs. per week		
6·915	Public Utility Practice.....	VI-A (2)	G	1st term 48 hrs. per week		Timbie
6·921	Public Utility Practice.....	VI-A(A) (2)	3	1st term 48 hrs. per week		Timbie
		VI-A(B) (2)	3	Summer 48 hrs. per week		
6·922	Public Utility Practice.....	VI-A(B) (2)	3	2d term 48 hrs. per week		Timbie
6·923	Public Utility Practice.....	VI-A(A) (2)	4	Summer 48 hrs. per week		Timbie
		VI-A(B) (2)	4	1st term 48 hrs. per week		
6·924	Public Utility Practice.....	VI-A(A) (2)	4	2d term 48 hrs. per week		Timbie
		VI-A(B) (2)	G	Summer 48 hrs. per week		
6·925	Public Utility Practice.....	VI-A (2)	G	1st term 48 hrs. per week		Timbie
6·931	Public Utility Practice.....	VI-A(A) (2)	3	1st term 48 hrs. per week		Timbie
		VI-A(B) (2)	3	Summer 48 hrs. per week		
6·932	Public Utility Practice.....	VI-A(B) (2)	3	2d term 48 hrs. per week		Timbie
6·933	Public Utility Practice.....	VI-A(A) (2)	4	Summer 48 hrs. per week		Timbie
		VI-A(B) (2)	4	1st term 48 hrs. per week		
6·934	Public Utility Practice.....	VI-A(A) (2)	4	2d term 48 hrs. per week		Timbie
		VI-A(B) (2)	G	Summer 48 hrs. per week		
6·935	Public Utility Practice.....	VI-A (2)	G	1st term 48 hrs. per week		Timbie
6·941	Communications Practice ..	VI-A(A) (3)	3	1st term 48 hrs. per week		Timbie
		VI-A(B) (3)	3	Summer 48 hrs. per week		Timbie
6·942	Communications Practice .. 6·941	VI-A(B) (3)	3	2d term 48 hrs. per week		Timbie
6·943	Communications Practice .. 6·942	VI-A(A) (3)	4	Summer 48 hrs. per week		Timbie
		VI-A(B) (3)	4	1st term 48 hrs. per week		
6·944	Communications Practice .. 6·943	VI-A(A)	4	2d term 48 hrs. per week		Timbie
		VI-A(B)	G	Summer 48 hrs. per week		
6·945	Communications Practice .. 6·944	VI-A	G	1st term 48 hrs. per week		Timbie

BIOLOGY AND PUBLIC HEALTH — 7·00–7·99

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
7·01	General Biology..........	VII	2	15–45 60	.. ..	Riley
7·011	Methods of Teaching General Biology................	Elective		Summer	65–25	

No.	Subject and Preparation	Taken by	Year	Term and Exercise and Hours of Preparation 1st Term	2d Term	Instructor in Charge
7·03	Theoretical Biology....... 7·103, 7·301	VII	4	30–45	.. ..	Turner
7·06	Botany.................. 7·01	VII	2	.. ..	15–30 45	Turner
7·07	Mycology.............. 7·06	VII$_{2b}$	3	15–30 30	.. ..	Proctor
7·08	Parasitology............. 7·01, 7·11	VII$_{1}$	4	.. ..	30–60	Bigelow
7·09	Parasitology (Adv.)....... 7·08	VII	G(A)	.. ..	15–45	Bigelow
7·10	Zoology................. 7·01	VII	2	.. ..	15–30 45	Riley
7·11	Anatomy and Histology....	VII$_{1}$	3	30–75 90	.. ..	Bigelow
7·12	Anatomy and Histology....	VII	3	.. ..	30–60 90	Bigelow
7·13	Cytology................. • 7·03, 712	VII	G(A)	.. ..	✦	Bigelow
7·14	History of Biology........ 7·01	VII	G(A)	30–90	.. ..	Bigelow
7·18	Technical Aspects of Entomology............... 7·08	VII	G(A)	✦	.. ..	Blake
7·20	Physiology............... 5·50 or 5·501; 7·11	VII$_{1}$	3	.. ..	30–75 90	Bunker
7·22	Personal Hygiene and Nutrition.................	VII	3	30–45	.. ..	Bunker
7·23	Applied Nutrition.........	VII (Elective)	4	.. ..	15–30	Turner
7·25	Physiological Basis of Nutrition............... 7·20	VII	G(A)	15–45	.. ..	Bunker
7·28	Biology and Bacteriology...	V, IX-A	2	15–15 30	.. ..	Riley
		XI	3	15–15 30	.. ..	
7·29	Biology and Bacteriology...	XI	3	.. ..	15–30 60	Riley
7·291	Biology and Bacteriology...	V, IX-A	2	.. ..	15–15 30	Riley
7·301	Bacteriology.............. 7·01	VII	3	30–60 60	.. ..	Horwood
7·302	Bacteriology............. 7·301	VII	3	.. ..	15–45 60	Horwood
7·31	Bacteriology..............	Mil. Eng.	4	30–30	.. ..	S. C. Prescott
7·321	Bacteriology, Advanced.... 7·301, 7·302, 7·80	VII	G(A)	30–75	.. ..	S. C. Prescott Bunker
7·322	Bacteriology, Advanced.... 7·321	VII	G(A)	.. ..	30–75	S. C. Prescott Bunker
7·34	Microscopy of Waters...... 7·01 or 7·28	VII XI	3 4	15–15 15–15	.. ..	Bunker
7·35	Planktonology........... 7·34	VII	G(A)	✦	.. ..	Blake
7·361	Industrial Microbiology.... 7·301	VII	4	15–30 60	.. ..	S. C. Prescott
7·362	Industrial Microbiology.... 7·361	VII$_{3}$	4	.. ..	15–30 45	S. C. Prescott
7·371	Industrial Microbiology.... 7·361 or 7·712	VII	G(A)	15–60 60	.. ..	S. C. Prescott
7·372	Industrial Microbiology....	VII	G (A)	.. ..	✦	S. C. Prescott
7·39	Zymology............... 7·301	VII	G(A)	15–60	.. ..	S. C. Prescott
7·421	Food Fishes.............. 7·10	VII$_{2a}$	3	30–75 90	.. ..	Bigelow
7·422	Food Fishes.............. 7·421	VII$_{2a}$	3	.. ..	30–60 75	Bigelow
7·43	Fish Culture............. 7·10	VII$_{2a}$	3	.. ..	30–30	Bigelow
7·441	Technology of Fishery Products................... 7·301, 7·302	VII$_{2a}$	4	30–30	.. ..	S. C. Prescott

✦ Time specially arra nged.

No.	*Subject and Preparation*	*Taken by*	*Year*	*Term and Hours of Exercise and Preparation* 1st Term	2d Term	*Instructor in Charge*
7·442	Technology of Fishery Products 7·441	VII$_{3}$	4	.. ..	15–60 60	S. C. Prescott
7·50	Infection and Immunity 7·301	VII$_{1}$	4	45–75	.. ..	Slack
7·52	Industrial Hygiene 7·50	VII$_{3b}$	3	.. ..	15–60 45	Turner
		VII$_{1}$	4	.. ..	15–60 45	
7·53	Plant Sanitation 7·301	VII$_{3}$	4	.. ..	15–15	Prescott
7·541	Public Health Administration 7·302	VII$_{1}$	4	30–30	.. ..	Turner
7·542	Public Health Administration 7·302	VII$_{1}$	4	.. ..	30–45	Turner
7·551	Public Health Laboratory Methods 7·301	VII$_{1}$	4	15–15 30	.. ..	Slack
7·552	Public Health Laboratory Methods 7·301	VII$_{1}$	4	.. ..	30–30 60	Slack
7·553	Public Health Laboratory Methods	Elective		Summer	60–30	Slack
7·56	Public Health Surveys 7·57	VII$_{1}$	4	.. ..	15–30	Horwood
7·57	Municipal Sanitation 7·301	VII Mil. Eng.	3 4	.. ..	60–50 60–50	Horwood
7·58	Vital Statistics	VII$_{1}$	4	30–45	.. ..	Horwood
7·59	Health Records and Statistical Procedure	Elective		Summer	30–30	Riley
7·60S	Hygiene of the School Child	(Elective)		Summer	45–60	Proctor
7·601	Health Education 7·01	VII	G (A)	30–60	.. ..	Turner
7·602	Health Education 7·601	VII	G(A)	.. ..	✦	Turner
7·603	Health Education Methods	Elective		Summer	30–60 15	Turner
7·61	Health Education Administration	VII	G(A)	15–30	.. ..	Turner
7·62	Health Surveys and Statistics 7·56	VII	G(A)	45–90	.. ..	Horwood
7·63	Public Health Field Work 7·542	VII	G(A)	.. ..	30–60	Turner
7·64	Public Health Problems 7·542	VII	G(A)	.. ..	30–60	Turner
7·65	Health Hazards in Special Industries 7·52	VII	G(A)	.. ..	15–75	S. C. Prescott Turner
7·66	Epidemiology 7·302, 7·50	VII	G(A)	30–90	.. ..	Horwood
7·67	Communicable Disease Control 7·542	VII$_{1}$	G(A)	.. ..	.. ..	Slack Place
7·68	Pathology 7·12, 7·551, 7·552	VII$_{1}$	G(A)	Either term	15–60 30	Slack
7·701	Technology of Food Supplies *7·301*	VII$_{2b}$	3	30–45 45	.. ..	S. C. Prescott
7·702	Technology of Food Supplies *7·301, 7·302*	VII$_{2b}$	3	.. ..	30–75 60	S. C. Prescott
7·711	Technology of Food Products 7·701, 7·702	VII$_{2b}$	4	30–30	.. ..	S. C. Prescott
7·712	Technology of Food Products 7·701, 7·702	VII$_{2b}$	4	.. ..	15–60 60	S. C. Prescott
7·80	Biochemistry 5·50, 7·301	VII$_{1}$ (Elective)	4	45–75 75	.. ..	Bunker

✦Time specially arranged.

No.	Subject and Preparation	Taken by	Year	Term and Exercise and 1st Term	Hours of Preparation 2d Term	Instructor in Charge
7·821	Biochemistry, Selected Topics 7·80	V, VII	G(A)	15–45	.. ..	Bunker
7·822	Biochemistry, Selected Topics 7·80	VII	G(A)	.. ..	15–45	Bunker
7·83	Serology 7·551, 7·552	VII	G(A)	.. ..	45–45	Anderson
7·91	Biological Colloquium	VII	4	15–15	.. ..	S. C. Prescott and Staff
7·92	Biological Colloquium	VII	4	.. ..	15–15	S. C. Prescott
7·93	Biological Seminar 7·11 or 7·301	VII	G(A)	✦	✦	Bigelow

PHYSICS — 8·00–8·99

No.	Subject and Preparation	Taken by	Year	Term and Exercise and 1st Term	Hours of Preparation 2d Term	Instructor in Charge
8·00	Physics (Entrance)			Summer	35–70	
8·01	Physics (Mechanics) 8·00, M4	All courses except IV	1	45–75 15	.. ..	Drisko
8·012	Physics (College Class) M11		1	30–50 10	.. ..	Drisko
8·02	Physics (Mechanics and Optics) 8·01	All courses except IV	1	.. ..	45–75 15	Drisko
8·03	Physics (Electricity) 8·01, M12	All courses except IV	2	45–75 15	.. ..	Page
8·034	Physics (College Class) M12		2	30–50 10	.. ..	Page
8·04	Physics (Electricity and Heat) 8·03	All courses except IV	2	.. ..	45–75 15	Page
8·05	Sound, Speech and Audition 8·04, M12	VI-C, VIII	4	.. ..	45–90 45	Barss
8·06	Acoustics, Illumination and Color	IV-A	3	15–30	.. ..	Barss
8·07	Precision of Measurements M22	XIII-A	G	10–10		Goodwin
8·10	Heat Measurements 8·04	VIII	3	15–30 45	.. ..	Wilkes
		V (Elective)	4	15–30 45	.. ..	
8·11	Heat Measurements 8·04	IX-A, XIV	3	0–15 30	.. ..	Wilkes
8·12	Heat Measurements 8·04	III_2	3	15–15 30	.. ..	Wilkes
8·13	Heat Measurements 8·04	Elective	G	.. ..	15–15 60	Wilkes
8·14	Heat Measurements II 8·10, 8·11, or 8·12	VIII	G(A)	✦	.. ..	Wilkes
8·15	Photography 8·02	VIII	2	30–15	.. ..	Hardy
8·151	Photographic Laboratory *8·15*	VIII	2	0–15 45	.. ..	Hardy
		XIV (Air Service)		.. ..	0–15 45	
8·16	Photography, Seminar 8·151	VIII	G(A)	.. ..	45–30	Hardy
8·161	Aerial Photography	Elective	4	15– 5	.. ..	Hardy
8·17	Geometrical Optics 8·02	VIII	3	.. ..	30–45	Hardy
8·171	Geometrical Optics (Ordnance) 8·17			✦	✦	Hardy

✦Time specially arranged.

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation: 1st Term	2d Term	Instructor in Charge
8·18	Physical Optics 8·04	VIII	4	30–40 30	.. ..	Hardy
8·191	Microscope Theory and Photomicrography 8·04	Elective	G	.. ..	15–15 30	Hardy
8·192	Optics, Advanced 8·17 and 8·18	VIII	G(A)	.. ..	90– 0	Hardy
8·201	Electricity 8·04, M22	VIII	3	30–[illegible] 45	.. ..	Page
8·202	Electricity 8·201	VIII	3	.. ..	30–90 45	Page
8·21	Elements of Electron Theory and Electron Apparatus 8·04	VI-A(B) (1, 2)	4	.. ..	30–60 30	Knobel
		VI-A(A) (1, 2)	4	30–60 30	.. ..	
8·211	Electron Theory 8·03, 8·04	(Elective)		Summer	30–30	Knobel
8·212	Gaseous Conduction 8·03, 8·04	VIII	G(A)	.. ..	45–105	Knobel
8·221	Advanced Physics I 8·04, M22	VIII, IX-C	3	45–75	.. ..	Frank
8·222	Advanced Physics I 8·221	VIII, IX-C	3	.. ..	45–75	Frank
8·231	Advanced Physics II 8·222	VIII, IX-C	4	45–105	.. ..	Sears
8·232	Advanced Physics II 8·231	VIII, IX-C	4	.. ..	45–105	Allis
8·241	Electromagnetic Theory M77	VI-C	4	30–30	.. ..	Vallarta
		VI-A(B) (3)	4	.. ..	30–30	
8·242	Electromagnetic Wave Propagation 8·241	VI-C	4	.. ..	30–45	Vallarta
8·25	Practical Spectroscopy 8·17, 8·18	VIII	G(A)	15–30 30	.. ..	de Laszlo
8·26	Dielectric and Magnetic Molecular Properties 8·232, 8·301 (Not offered in 1927–28)	VIII	G(A)	30–60	.. ..	Müller
8·29	Lattice Theory of Rigid Bodies 8·232	VIII	G(A)	30–60	.. ..	Müller
8·301	Atomistic Theories M37, 8·222, 8·232	VIII	G(A)	30–105	.. ..	Frank
8·302	Atomistic Theories	VIII	G(A)	.. ..	30–105	Müller
8·31	Celestial and Atomic Mechanics M37, M651, or 8·302 or equivalent	VIII	G(A)	.. ..	30–90	Vallarta
8·33	X-Rays and Radiology 8·03, 8·04, M22 Elective for other courses	VIII, XIV	4	15–15 30	.. ..	J. T. Norton
8·36	Radiation Measurements Laboratory 8·04	(Elective)	4	Either term	0–15 45	Stockbarger
8·37	General Theory of Radiation 8·301	VIII	G(A)	.. ..	30–60	Frank
8·38	Theory of Relativity M37, M632, 8·232	VIII	G(A)	30–60	.. ..	Vallarta
8·431	Applied Elasticity 2·20, 2·21, or equivalent	VIII	G(A)	30–60	.. ..	Frost
8·432	Photoelasticity 8·431	VIII	G(A)	.. ..	15–60 30	Frost
8·44	Applications of X-Ray and Photoelasticity 8·03, 8·04, 2·20, 2·21	$II_{Gen.}$ (Elective)	4	.. ..	30– 0 30	J. T. Norton
		II(T.D.)	G	.. ..	30– 0 30	Frost
8·451	Physics Colloquium	VIII	4	15–15	.. ..	Barss
8·452	Physics Colloquium	VIII	4	.. ..	15–15	Barss
8·46	Industrial Radiology 8·03, 8·04	Elective	4	.. ..	15–15 30	J. T. Norton

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
8·801	Electrochemistry, Principles of 8·04, M22	VIII, XIV	3	60–90	.. ..	Goodwin
8·802	Electrochemistry, Principles of 8·801	VIII, XIV	3	.. ..	45–90	Goodwin
8·82	Electrochemistry 8·02 or equivalent	XIV	4	30–60	.. ..	Goodwin
8·83	Electrochemistry, Advanced 8·82 or equivalent	VIII	G(A)	.. ..	15–30	Knobel
8·84	Photochemistry 5·50, 8·802 or equivalent	VIII	G(A)	30–60	.. ..	Stockbarger
8·851	Applied Electrochemistry 8·82	XIV	4	15–30	.. ..	Thompson
8·852	Applied Electrochemistry 8·851	XIV	4	.. ..	25–80	Thompson
8·86	Electrochemical Laboratory *8·82*	XIV	4	0– 0 70	.. ..	Goodwin
8·871	Applied Electrochemical Laboratory *8·851*	XIV	4	0– 0 35	.. ..	Thompson
8·872	Applied Electrochemical Laboratory 8·871	XIV	4	.. ..	0– 0 35	
8·89	Electric Furnaces 8·04, 5·02	Elective	4	15–30 30	.. ..	Thompson
8·90	Electrochemistry, Elements of 8·04 and 5·02	III_1	4	.. ..	30–30 30	Thompson
8·93	Colloquium 8·82	XIV	4	.. ..	15–15	Goodwin
8·94	Precision of Measurements M22, 8·04	VIII, XIV	4	10–20	.. ..	Goodwin
8·98	Glass Blowing	XIV (Elective)	4	Either term	0– 0 15	Thompson

CHEMICAL ENGINEERING — 10·00–10·99

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
10·11	Problems of the Chemical Engineer 5·02	X	2	15– 0	.. ..	Lewis
10·12	Plant Engineering 5·131	Chem. War.	G	Summer	216–108	Robinson
10·13	Plant Engineering 10·12	Chem. War.	G	120–250	.. ..	Robinson
10·14	Applied Chemistry 10·13	Chem. War.	G	.. ..	45–120	McAdams
10·15	Thesis Reports	X	4	.. ..	15– 0	Lewis
10·191	Chemical Engineering Literature L12 and L52	X (Elective)	2	30–30	.. ..	Lewis
10·192	Chemical Engineering Literature 10·191	X (Elective)	2	.. ..	30–30	Lewis
10·20	Industrial Chemistry *5·52, 5·652*	X	3	.. ..	75–75	Lewis
10·201	Industrial Chemistry *5·52 or 8·802 or 5·652*	V, XV_1 XIV	3 4	.. ..	60–60 60–60	Lewis
10·202	Industrial Chemistry *5·52 and 5·652*	V C.W.S.	3	.. ..	75–75	Lewis
10·203	Industrial Chemistry *5·52, 5·652*	X C.W.S.	3	.. ..	75–75	Lewis
10·206	Industrial Chemistry 5·131	Chem.War.	G	.. ..	90–150	Lewis
10·21	Industrial Chemistry	X	4	30–30	.. ..	Lewis
10·211	Industrial Chemistry 10·201	V	4	45–45	.. ..	Lewis

No.	*Subject and Preparation*	*Taken by*	*Year*	*Term and Hours of Exercise and Preparation 1st Term*	*2d Term*	*Instructor in Charge*
10·212	Industrial Chemistry..... 10·201	XV$_2$.	4	45–30	.. ..	Lewis
10·213	Industrial Chemistry..... 10·202	V C.W.S.	4	45–45	.. ..	Lewis
10·214	Industrial Chemistry..... 10·20	X C.W.S.	4	45–45	.. ..	Lewis
10·22	Industrial Chemistry.....	X-B	4	24–24	.. ..	
10·224	Industrial Chemistry.....	X-B (Ord.)	4	24–24	.. ..	
10·25	Industrial Stoichiometry..	X	G(A)	30–45	.. ..	C. S. Robinson
10·26	Industrial Chemical Laboratory............... 10·21	X, V (Elective)	4	30–30 75	.. ..	C. S. Robinson
10·27	Industrial Chemical Laboratory............... *10·212*	XV$_2$	4	.. ..	30–15 60	C. S. Robinson
10·31	Chemical Engineering.... 2·45, *10·21*	X	4	75–75	.. ..	C. S. Robinson
10·311	Chemical Engineering.... 2·45, *10·21*	X Ord. XC.W.S.	4	75–90	.. ..	C. S. Robinson
10·32	Chemical Engineering.... 10·31	X	4	.. ..	60–60	C. S. Robinson
10·321	Chemical Engineering.... 10·311	X Ord. X C.W.S.	4	.. ..	45–60	C. S. Robinson
10·33	Chemical Engineering.... 2·45, *10·21*	X-B	4	72–168	.. ..	McAdams
10·331	Chemical Engineering.... 2·45, *10·21*	X-B Ord.C.W.S	4	72–168	.. ..	McAdams
10·34	Chemical Engineering.... 10·33	X-B	4	.. ..	30–60	Haslam
10·341	Chemical Engineering.... 10·331	X-B Ord.	4	.. ..	30–60	Haslam
10·35	Chemical Engineering....	XV$_3$	3	.. ..	45–60	
10·36	Chemical Engineering.... 10·201 and 2·45	XV$_2$	4	45–75	.. ..	C. S. Robinson
10·37	Chemical Engineering Laboratory............... 10·32	X	G(A)	.. ..	0–30 45	Lewis
10·41	Distillation.... .... 10·32	X, X-A	G(A)	.. ..	30–60	McAdams
10·42	Drying.................. 10·32	X, X-A	G(A)	.. ..	30–60	McAdams
10·43	Evaporation............ 10·32	X, X-A	G(A)	.. ..	30–60	McAdams
10·44	Combustion............. 10·80	X-A	G(A)	20–60	.. ..	Ward
10·45	Mechanical Separation.... 10·32	X, X-A	G(A)	30–60	.. ..	Weber
10·46	Extraction I............ 10·31	X, X-A	G(A)	.. ..	30–60	McAdams
10·47	Extraction II .... 10·46	X, X-A	G(A)	.. ..	30–60	McAdams
10·50	Heat Transmission....... 10·31	X, X-A	G(A)	.. ..	30–60	McAdams
10·51	Furnace and Retort Design	X, X-A	G(A)	.. ..	30–60	Ward
10·53	Chemical Engineering Design..................	X-A	G(A)	40–50	.. ..	McAdams
10·54	Economic Balance....... *10·31*	X, X-A	G(A)	45–90	.. ..	McAdams
10·61	Corrosion............... 10·21 or *10·32*	X	G(A)	.. ..	30–30	R. P. Russell
10·62	Applied Chemical Thermodynamics............ 5·652	X	G(A)	.. ..	45–90	Lewis
10·69	Tanning and Allied Subjects................. 10·21		G(A)	.. ..	15–30	Frolich
10.691	Leather and Rubber....	X	G(A)	.. ..	15–30	Frolich
10·70	Sulphuric Acid.......... 10·21	X	G(A)	30–30	.. ..	Phelan
10·71	Glass, Ceramics and Refractories............. 10·21	X, X-A	G(A)	.. ..	30–45	Lewis

No.	Subject and Preparation	Taken by	Term and Year	Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
10·72	Iron and Steel.......... 10·21	X, X-A	G(A)	30–60	.. ..	Waterhouse
10·73	Starch and Cellulose..... 10·21	X, X-A	G(A)	30–30	.. ..	Frolich
10·74	Petroleum............. 10·21	X, X-A	G(A)	.. ..	30–45	Frolich
10·76	Nitrogen Fixation....... 5·52	X, X-A	G(A)	30–45	.. ..	Underwood
10·77	Rubber................ 10·21	X, X-A	G(A)	.. ..	30–45	Lewis
10·78	Wood Distillation........ 10·21	X, X-A	G(A)	.. ..	30–45	C. S. Robinson
10·79	Paints, Oils and Varnishes. 10·21	X, X-A	G(A)	.. ..	30–30	Gill
10·81	School of Chemical Engineering Practice (Bangor Station)..............	X-A	G(A)	Field Work	160 hours	Haslam
10·82	School of Chemical Engineering Practice (Boston Station)..............	X-A	G(A)	Field Work	160 hours	Haslam
10·83	School of Chemical Engineering Practice (Buffalo Station)..............	X-A	G(A)	Field Work	160 hours	Haslam
10·84	School of Chemical Engineering Practice (Bangor Station)..............	X-B X-A	4 G(A)	Field Work	160 hours	Haslam
10·85	School of Chemical Engineering Practice (Boston Station)..............	X-B X-A	4 G(A)	Field Work	160 hours	Haslam
10·86	School of Chemical Engineering Practice (Buffalo Station)..............	X-B X-A	4 G(A)	Field Work	160 hours	Haslam
10·87	School of Chemical Engineering Practice (Bayonne Station).....	X-A	G(A)	Field Work	160 hours	Ward
10·90	Experimental Research...	X	G(A)	Time to be arranged		Lewis
10·911	Research Conferences.....	X	G(A)	15–15	.. ..	Lewis
10·912	Research Conferences.....	X	G(A)	.. ..	15–15	Lewis
10·921	Applied Science of X-rays. 5·652	X	G(A)	30–60	.. ..	Clark
10·922	Applied Science of X-rays. 10·921	X	G(A)	.. ..	30–60	Clark
10·93	Automotive Fuel Problems 10·21	X, F. and G. Eng.	G(A)	30–45	.. ..	McAdams
10·931	Automotive Fuels........	II(A.E.)	G	45–75	.. ..	McAdams
10·94	Organization and Methods of Industrial Research..	X	G(A)	15–30	.. ..	R. P. Russell
10·941	Technical Organization...	Chem. War.	G(A)	30–30	.. ..	R. P. Russell
10·95	Applied Colloid Chemistry 5·652	X	G(A)	.. ..	45–90	Frolich
10·951	Applied Colloid Chemistry Laboratory........... *10·95*	X	G(A)	.. ..	0–60 45	Frolich
10·952	Experimental Problems in Applied Colloid Chemistry.................	X	G(A)	0–150 60	.. ..	Frolich
10·991	Seminar in Chemical Engineering..............	X	G(A)	10– 0	.. ..	R. P. Russell
10·992	Seminar in Chemical Engineering..............	X	G(A)	.. ..	10– 0	R. P. Russell

GEOLOGY — 12·00–12·99

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
12·01	Mineralogy 5·02	III, XII	2	15–30 105	.. ..	Newhouse
12·02	Mineralogy 12·01	XII	2	.. ..	15–15 60	Newhouse
12·03	Mineralogy 5·02	V (Elective)	2	.. ..	15–15 30	Newhouse
		X (Elective)	4	.. ..	15–15 30	
		IX-A	3	.. ..	15–15 30	
12·04	Mineralogy (Advanced) 12·02, 12·151	XII	G(A)	15–30 105	.. ..	Gillson
12·05	Mineralogy (Advanced) 12·02, 12·151	XII	G(A)	75–15	.. ..	Gillson
12·151	Petrography 8·02, 12·02	XII	3	15–30 75	.. ..	Gillson
12·152	Petrography 12·151	XII	3	.. ..	15–30 75	Gillson
12·161	Petrography (Advanced) 12·152	XII	G(A)	15–30 105	.. ..	Gillson
12·162	Petrography (Advanced) 12·161	XII	G(A)	.. ..	15–30 105	Gillson
12·20	Optical Examination of Chemical Precipitates 8·02	V(Elective)	2	.. ..	15–15 30	Buerger
12·211	Optical Crystallography 8·02	Elective	4	15–15 45	.. ..	Buerger
12·212	Optical Crystallography 12·211	XII	G(A)	.. ..	✦	Gillson
12·22	Optical Ceramics 12·211	Elective	4	.. ..	0–15 45	Buerger
12·30	Geology 12·01, *12·03* for IX-A	$III_{1,3}$ XII	2	.. ..	45–45	Gunning
		IX-A	3	.. ..	45–45	
12·31	Geology 12·30	$III_{1,3}$ XII	3	45–45 30	.. ..	Shimer
		IX-A	4	45–45 30	.. ..	
12·321	Geology	I XI XVII	3 4 3	30–15 30–15 30–15	.. ..	Gunning
12·322	Geology 12·321	I	3	.. ..	45–45	Gunning Terzaghi
12·33	Field Geology	$III_{1,3}$	4	0–15 45	.. ..	Gunning
	1·03, 12·01, 12·31	XII	4	0–30 45	.. ..	
12·331	Geology	V (Elective)	2	30–30	.. ..	Shimer
12·34	Geological Surveying 12·152, 12·33	XII	4	.. ..	0–45 120	Gunning
12·351	Geological Surveying (Advanced) 12·34	XII	G(A)	0–60 60	.. ..	Gillson
12·352	Geological Surveying (Advanced) 12·351	XII	G(A)	.. ..	0–60 60	Gillson
12·36	Geology, Field 12·30	XII III_1 (Elective)	4	Summer	0– 0 50	Lindgren
12·37	Field Geology 12·322	I	4	0–15 15	.. ..	Gunning
12·38	Physiography 12·31	XII	4	.. ..	30–15 15	Shimer
12·40	Geology, Economic 12·01, 12·31	$III_{1,3}$ XII	3	.. ..	75–45	Newhouse
12·41	Economic Geology Laboratory 12·40	XII	4	0–30 90	.. ..	Newhouse
12·42	Geology, Applied Economic 12·40	XII	4	.. ..	30–15	Lindgren

✦Time specially arranged.

No.	Subject and Preparation	Taken by	Year	Term and Exercise and Hours of Preparation 1st Term	2d Term	Instructor in Charge
12·431	Geology Economic Laboratory (Advanced) 12·41	XII	G(A)	0–15 60	. . . .	Lindgren
12·432	Geology Economic Laboratory (Advanced) 12·431	XII	G(A)	. . . .	0–15 60	Lindgren
12·433	Economic Geology Seminar (Advanced) 12·40	XII	G(A)	30–30	. . . .	Lindgren
12·434	Economic Geology Seminar (Advanced) 12·433	XII	G(A)	. . . .	30–30	Lindgren
12·44	Economic Geology of Fuels G60	(Elective)	4	. . . .	30–30	Special Lecturer
12·46	Economic Geology of Non-Metallic Deposits 12·40	XII	4	30–45 30	. . . .	Gillson
12·47	Economic Geology of Non-Metallic Deposits (Advanced) 12·46	XII	G(A)	. . . .	15–15 45	Gillson
12·48	Engineering Geology and Hydrology 12·31	XII	4	. . . .	45–30	Gunning
12·49	Geology of Materials	IV-A	3	15–30	. . . .	Gunning
12·50	Historical Geology 12·31	XII	4	15–30 30	. . . .	Shimer
12·511	Paleontology 12·31	XII	3	15–30 30	. . . .	Shimer
12·512	Paleontology 12·511	XII	3	. . . .	0–15 15	Shimer
12·521	Paleontology (Advanced) 12·512	XII	G(A)	15–45 45	. . . .	Shimer
12·522	Paleontology (Advanced) 12·521	XII	G(A)	. . . .	15–45 45	Shimer
12·53	Index Fossils 12·512	XII	G(A)	. . . .	30–15 60	Shimer
12·54	Micropaleontology 12·511, 12·512	XII	G(A)	45–30	. . . .	Shimer
12·55	Organic Evolution (Advanced) G64	XII	G(A)	. . . .	30–45	Shimer
12·591	Stratigraphy (Advanced) 12·50	XII	G(A)	60–45	. . . .	Shimer
12·592	Stratigraphy (Advanced) 12·591	XII	G(A)	. . . .	60–45	Shimer
12·621	Geological Seminar 12·31	XII	4	30–60	. . . .	Shimer
12·622	Geological Seminar 12·621	XII	4	. . . .	30–60	Gillson
12·631	Geological Seminar (Advanced) 12·622	XII	G(A)	30–75	. . . .	Shimer
12·632	Geological Seminar (Advanced) 12·631	XII	G(A)	. . . .	30–75	Lindgren
12·64	Geology of North America 12·31, 12·50, 12·512	XII	G(A)	30–60	. . . .	Shimer
12·65	Geology of Europe 12·31, 12·50, 12·512	XII	G(A)	. . . .	30–60	Shimer
12·80	Geology of Coal and Petroleum 12·31	III$_3$, XII	4	60–45	. . . .	Special Lecturer
12·82	Chemistry Applied to Ore Deposition 12·40	XII (Elective)	4	. . . .	30–60	Boydell

NAVAL ARCHITECTURE AND MARINE ENGINEERING — 13·00–13·99

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
13·00	Yacht Design and Model Making	Elective		Summer	20– 0 55	Owen
13·01	Naval Architecture M12, 8·01	XIII$_1$ XIII-A	3 4	30–30 30–30	.. ..	Jack
13·011	Naval Architecture	XIII$_2$	3	30–30	.. ..	Chapman
13·02	Naval Architecture 13·01	XIII$_1$ XIII-A	3 4	.. ..	30–30 30–30	Jack
13·021	Naval Architecture 13·011	XIII$_2$	3	.. ..	30–30	Chapman
13·03	Naval Architecture 13·02	XIII$_1$ XIII-A	4 G	45–45 45–45	.. ..	Jack
13·11	Theory of Warship Design	XIII-A	4	60–90	.. ..	Hovgaard
13·12	Theory of Warship Design	XIII-A	4	.. ..	60–60	Hovgaard
13·13	Theory of Warship Design	XIII-A	G	75–120	.. ..	Hovgaard
13·14	Theory of Warship Design	XIII-A	G	.. ..	75–90	Hovgaard
13·21	Warship Design	XIII-A	4	0– 0 120	.. ..	Hovgaard
13·22	Warship Design	XIII-A	4	.. ..	0– 0 120	Hovgaard
13·23	Warship Design	XIII-A	G	0– 0 150	.. ..	Hovgaard
13·24	Warship Design	XIII-A	G	.. ..	0– 0 150	Hovgaard
13·31	Ship Construction	XIII$_1$	2	30–30	.. ..	Owen
13·32	Ship Construction 13·31	XIII$_1$	2	.. ..	30–30	Jack
13·321	Ship Construction	XIII$_2$	2	.. ..	30–30	Jack
13·33	Ship Construction 13·32	XIII$_1$	3	45–60	.. ..	Jack
13·331	Ship Construction 13·321	XIII$_2$	3	30–30	.. ..	Jack
13·37	Merchant Shipbuilding	XIII-A	4	.. ..	30–30	Jack
13·38	Shipyard Organization 13·02, 13·32	XIII$_1$	4	.. ..	30–15	Jack
13·39	Shipyard Practice	XIII-A	4	.. ..	30–30	Jack
13·41	Ship Drawing	XIII$_1$	2	.. ..	0– 0 105	Owen
13·411	Ship Drawing	XIII$_2$	2	.. ..	0– 0 75	Owen
13·42	Ship Design	XIII$_1$	3	0– 0 60	.. ..	Owen
13·43	Ship Design 13·42	XIII$_1$	3	.. ..	0– 0 45	Owen
13·45	Ship Design 13·43	XIII$_1$	4	0– 0 105	.. ..	Owen
13·46	Ship Design 13·45	XIII$_1$	4	.. ..	0– 0 45	Owen
13·47	Ship Design 13·021, 13·51	XIII$_2$	4	15– 0 75	.. ..	Owen
13·48	Model Making	XIII-A	4	.. ..	0– 0 30	Owen
13·51	Marine Engineering 2·40	XIII	3	.. ..	30–30	Burtner
13·52	Marine Engineering 2·221, 2·40	XIII	4	20–10	.. ..	Burtner
13·53	Marine Engineering 13·51	XIII$_1$	4	.. ..	30–30	Burtner
13·58	Marine Engineering	XIII-A	4	30–30	.. ..	Keith
13·61	Marine Engine Design 13·51	XIII$_1$	4	0– 0 45	.. ..	Burtner
13·62	Marine Engine Design 13·61	XIII$_1$	4	.. ..	0– 0 90	Burtner
13·63	Marine Engine Design	XIII-A	4	0– 0 45	.. ..	Keith
13·64	Marine Engine Design	XIII-A	4	.. ..	0–30 60	Keith
13·66	Marine Engine Design 2·42, 13·51	XIII$_2$	4	.. ..	0– 0 45	Burtner

No.	Subject and Preparation	Taken by	Year	Term and Exercise and Hours of Preparation 1st Term	2d Term	Instructor in Charge
13·70	Steam Turbines.......... 2·42, 13·51	XIII	4	30–45	.. ..	Burtner
13·71	Steam Turbines..........	XIII-A	4	.. ..	30–60	Keith
13·72	Marine Diesel Engines and Auxiliaries.............	XIII	4	.. ..	30–45	Chapman
13·81	Ship Operation........... 13·021, 13·51	XIII$_3$	4	30–30	.. ..	Chapman
13·82	Ship Operation........... 13·81	XIII$_3$	4	.. ..	45–60	Chapman
13·83	Terminal Facilities.......	XIII$_2$	3	30–15	.. ..	Chapman

AERONAUTICS — 16.00–16.99

No.	Subject and Preparation	Taken by	Year	Term and Exercise and Hours of Preparation 1st Term	2d Term	Instructor in Charge
16·01	Airplane Design......... M22 and 2·21 or 1·401	XVI	4	75–90	.. ..	Chatfield
16·015	Airplane Design......... M22 and 1·401 or 2·21	Air Corps Unit	3	45–45	.. ..	W. G. Brown
16·04	Advanced Airplane Design. 16·01, *16·14*	XVI	G(A)	.. ..	30–60	Chatfield
16·06	Advanced Airplane Structures.................. 16·01, *16·14*	XVI	G(A)	.. ..	30–60	Newell
16·11	Airplane Design Practice.. *16·01*	XVI	4	0– 0 30	.. ..	Chatfield
16·115	Aeronautics .... 16·785	Air Corps Unit	4	.. ..	30–30 30	Chatfield
16·12	Airplane Design Practice.. 16·11	XVI	4	.. ..	0– 0 60	Chatfield
16·13	Airplane Design Practice... *16·01*	Elective	G	0– 0 90	.. ..	Chatfield
16·14	Airplane Design Practice... 16·13	Elective	G	.. ..	0– 0 120	Chatfield
16·21	Airship Theory........... M22	XVI	G(A)	30–45	.. ..	Warner
16·22	Non-Rigid Airship Design (Not given 1927–28) 16·21	XVI	G(A)	.. ..	30–30	Warner
16·24	Non-Rigid Airship Design Practice (Not given 1927–28) *16·22*	XVI	G(A)	.. ..	60– 0	Warner
16·26	Rigid Airship Design...... 16·21 (Not given 1927–28)	XVI	G(A)	.. ..	45–60	Warner
16·28	Rigid Airship Design Practice. (Not given 1927–28) *16·26*	XVI	G(A)	.. ..	0– 0 120	Warner
16·30	Aerial Propellers.......... 16·01	XVI	G(A)	.. ..	30–30	W. G. Brown
16·32	Aerial Propeller Design Practice............... *16·30*	Elective	G	.. ..	0– 0 45	W. G. Brown
16·35	Aircraft Instruments...... 16·65	Elective	G	15–30	.. ..	W. G. Brown
16·41	History of Aeronautics..... 16·74 (Not given 1927–28)	Elective	G	15–15	.. ..	Warner
16·42	Aerial Transport.......... Ec21 or Ec31	Elective	G	.. ..	15–30	W. G. Brown
16·48	Aircraft Armament.......	II(O.D.)	G	.. ..	45–75	W. G. Brown
16·51	Rigging and Maintenance of Aircraft................	XVI	3	0–15 45	.. ..	Short
16·54	Airplane Construction .... 16·01, 16·51	XVI	4	.. ..	30–15	Short
16·62	Aeronautical Laboratory... M22, 8·04	XVI	4	.. ..	30–30 30	W. G. Brown

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
16·65	Aeronautical Research Methods M22, 8·04	Elective	G	30–45	.. ..	W G. Brown
16·67	Aeronautical Laboratory *16·65*	Elective	G	0–60 15	.. ..	W. G. Brown
16·68	Conduct of Aeronautical Research 16·65, 16·67	XVI	G(A)	.. ..	15–45	W. G. Brown
16·69	Aeronautical Seminar	XVI	G(A)	.. ..	15–15	Chatfield
16·72	Propellers and Airships 16·01	XVI	4	.. ..	30–30	Chatfield
16·76	Aeronautics M22, 2·22	II (Elective) XIII-A	4 G	 30–60	30–30	Chatfield
16·78	Aeronautics 16·76	XIII-A	G	.. ..	45–75	W. G. Brown
16·785	Aeronautics 16·015	Air Corps Unit	4	45–45	.. ..	W. G. Brown
16·82	Aero Engines 2·30, 2·42, 2·251	XVI	4	.. ..	30–30	Taylor
16·83	Airplane Engine Design 16·82	XVI	G(A)	75–90	.. ..	Taylor
16·84	Airplane Engine Design 16·83	XVI	G(A)	.. ..	30–45	Taylor
16·85	Airplane Engine Design Practice *16·83*, 2·731	XVI	G(A)	0– 0 60	.. ..	Taylor
16·86	Airplane Engine Design Practice *16·84*, 16·85, 2·732	XVI	G(A)	.. ..	0– 0 120	Taylor
16·90	Aero Engine Laboratory 2·42	XVI	4	.. ..	0– 0 45	Fales

BUILDING CONSTRUCTION 17·00 — 17·99

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
17·21	Building Construction 4·10	XVII	2	45– 0 180	.. ..	R. F. Tucker
17·22	Building Construction 17·21	XVII	2	.. ..	45– 0 135	R. F. Tucker
17·31	Building Construction 17·22	XVII	3	45– 0 165	.. ..	R. F. Tucker
17·32	Building Construction and Materials 17·31	XVII	3	.. ..	30–30 165	R. F. Tucker
17·41	Building Construction 17·32	XVII	4	15– 0 105	.. ..	R. F. Tucker
17·42	Building Construction 17·41	XVII	4	.. ..	15– 0 135	R. F. Tucker
17·50	Job Management	XVII	4	.. ..	15–15	R. F. Tucker

DIVISION OF DRAWING

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
D11	Mechanical Drawing	All courses except IV	1	3– 0 42	.. ..	S. A. Breed
D12	Working Drawings D11	All courses except IV and XVII	1	.. ..	3– 0 42	Goodrich
D21	Descriptive Geometry M2, M3	All courses except IV	1	15–10 30	.. ..	Kenison
D22	Descriptive Geometry D21	All courses except IV and XVII	1	.. ..	15–10 30	Kenison

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
D23	Descriptive Geometry (College Class) M2, M3		1	45–65	.. ..	Goodrich
D31	Descriptive Geometry D22	I	2	30–45 30	.. ..	Bradley
D311	Descriptive Geometry (College Class) D23		1	.. ..	30–75	Bradley

ECONOMICS

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
Ec21	Political Economy E12	VII, XIII$_2$, XV XVII	2 3	45–75 45–75	.. ..	Doten
Ec31	Political Economy E22	I, II, III, IV, IV-A V, VI, VI-C, VIII, IX-A, IX-B, IX-C, X, XI, XII, XIII$_1$, XIV, XVI	3	45–45	.. ..	Dewey D. S. Tucker
		VI-A	2	.. ..	45–45	
		VI-A (A)	4	45–45	.. ..	
Ec32	Political Economy	I, II, III, IV, IV-A V, VI VI-C, VI-A(A) VIII, IX-A, IX-B, IX-C, X, XI, XII, XIII$_1$, XIV, XVI	3	.. ..	45–45	Dewey D. S. Tucker
		VI-A(B)	3	45–45	.. ..	
		VI-A(B)	4	Summer	45–45	
		VI-A(A)	5	Summer	45–45	
Ec35	Political Economy E12	XIII-A	4	45–75	.. ..	Armstrong
Ec37	Banking Ec21, Ec65	XV XIII$_2$	2 3	.. ..	45–60 45–60	Dewey
Ec46	Industrial Relations Ec70	XV, XIII$_2$ XVII	4 3	.. ..	45–60 45–60	Doten
Ec471	Personnel Management Ec21 or Ec31 and Ec46	XV	G(A)	30–90	.. ..	Doten
Ec472	Personnel Management Ec471	XV	G(A)	.. ..	30–90	Doten
Ec50	Accounting E12	I$_2$ III$_2$, XVII VII, XV XIII$_1$ XIII$_2$	3 3 2 4 2	45–45	.. .. 45–45 45–45 45–45 45–45	Shugrue
Ec51	Cost Accounting Ec50, Ec70	XIII$_2$, XV	4	60–75	.. ..	Shugrue
Ec53	Building Finance Ec21	XVII	4	45–90	.. ..	D. S. Tucker
Ec541	Manufacturers' Accounts Ec50 and Ec51, or equivalent	XV	G(A)	30–90	.. ..	
Ec542	Manufacturers' Accounts Ec541	XV	G(A)	.. ..	30–90	
Ec55	Tax Returns and Accounts Ec50 and Ec51 or equivalent	XV	G(A)	30–90	.. ..	
Ec56	Corporate Organization Ec21, Ec50	XIII$_2$, XV	3	45–90	.. ..	Armstrong
Ec57	Corporate Finance and Investments Ec56	XIII$_2$, XV	3	.. ..	45–90	Armstrong
Ec581	Financial Administration of Industry Ec50, Ec56 and Ec57 or equivalent	XV	G(A)	30–90	.. ..	Shugrue

No.	Subject and Preparation	Taken by	Term and Exercise Year	Hours of Preparation 1st Term	Hours of Preparation 2d Term	Instructor in Charge
Ec582	Financial Administration of Industry.............. Ec581	XV	G(A)	.. ..	30–90	Shugrue
Ec591	Public Utility Management and Finance........... A course in general economics	F. and G. Eng.	G(A)	30–60	.. ..	Armstrong
Ec592	Public Utility Management and Finance........... Ec591	F. and G. Eng.	G(A)	.. ..	30–60	Armstrong
Ec61	Business Law Ec37, Ec57	VII$_2$, XIII-A, XIII$_2$, XV	4	30–60	.. ..	Hausserman
Ec62	Business Law............ Ec61	VII$_2$, XIII$_2$, XV	4	.. ..	30–60	Hausserman
Ec63	Business Law and Organization............... Ec21	VI-A	5	.. ..	45–75	Hausserman
Ec65	Statistics................ E12	VII$_2$, XIII$_2$ XV	3 2	45–15 45–15	.. ..	Dewey
Ec661	Statistical Methods....... Ec65, M21	XV	G(A)	30–90	.. ..	MacKinnon
Ec662	Statistical Methods....... Ec661	XV	G(A)	.. ..	30–90	MacKinnon
Ec681	Business Cycles.......... A course in the principles of economics	XV	G(A)	30–90	.. ..	D. S. Tucker
Ec682	Business Cycles.......... Ec681	XV	G(A)	.. ..	30–90	D. S. Tucker
Ec70	Business Management..... Ec56	VII$_2$, XV	3	.. ..	45–45	Schell Freeland
Ec71	Business Management..... Ec70	VII$_2$, XV	4	60–90	.. ..	Schell Freeland
Ec72	Business Management..... Ec71	VII$_2$, XV	4	.. ..	60–90	Schell Freeland
Ec74	Business Management....	XVII	4	.. ..	45–90	Schell
Ec761	Marketing of Manufactured Products.............. Ec70, 71 and 72 or equivalent	XV	G(A)	30–90	.. ..	Freeland
Ec762	Marketing of Manufactured Products.............. Ec761	XV	G(A)	.. ..	30–90	Freeland
Ec80	Shipping Administration...	XIII$_2$	3	.. ..	30–45	

ENGLISH AND HISTORY

No.	Subject and Preparation	Taken by	Term and Exercise Year	Hours of Preparation 1st Term	Hours of Preparation 2d Term	Instructor in Charge
E1	English (Entrance)			Summer	35–70	
E11	English and History	All courses	1	45–75	.. ..	A. T. Robinson
E12	English and History........	All courses	1	.. ..	45–75	A. T. Robinson
E21	English and History........	All courses....	2	45–75	.. ..	Rogers
E22	English and History........	All courses	2	.. ..	45–75	Rogers
E31	English	XV	3	30–60	.. ..	W. Prescott
E33	Report Writing............	IV-A, XIII$_2$ XV$_2$ I$_3$, XV$_1$, XV$_2$, XVI	3 3	30–30	 30–30	W. Prescott
E40	English..................	VI, VI-C, VI-A(B) (1, 2) VI-A(A)	4 5	 45–75	45–75	Pearson

FUEL AND GAS ENGINEERING — F1–10

No.	Subject and Preparation	Taken by	Year	Term and Exercise and Hours of Preparation 1st Term	2d Term	Instructor in Charge
F1	Principles of Combustion...	F. and G. Eng.	G(A)	30–60	.. ..	Haslam
F2	Development and Use of Power..................	F. and G. Eng.	G(A)	30–60	.. ..	Riley
F3	Furnace and Retort Design..	F. and G. Eng.	G(A)	.. ..	30–30 75	Ward
F4	Gas Engine Laboratory......	Elective	G	0– 0 45	.. ..	Fales
F5	Natural Fuels	F. and G. Eng.	G(A)	30–60	.. ..	Haslam
F6	Principles of Fuel and Gas Engineering I...........	Elective	G	75–75	.. ..	C. S. Robinson
F7	Principles of Fuel and Gas Engineering II...........	F. and G. Eng.	G(A)	.. ..	75–75	Ward
F8	Properties of Materials.....	F. and G. Eng.	G(A)	.. ..	30–30	Ward
F9	Manufactured Fuels	F. and G. Eng.	G(A)	.. ..	30–60	Haslam
F10	Field Work and Thesis. (Boston Station)........	F. and G. Eng.	G(A)	240	.. ..	Ward
F11	Field Work (Buffalo Station)	F. and G. Eng.	G(A)	240	.. ..	Ward
F12	Field Work (Bayonne Station)	F. and G. Eng.	G(A)	240	.. ..	Ward

GENERAL STUDIES — G1-G99

No.	Subject and Preparation	Taken by	Year	Term and Exercise and Hours of Preparation 1st Term	2d Term	Instructor in Charge
G1	History of Science......... M13		**3, 4**	30–30	.. .	H. W. Tyler
G2	History of Science......... M13		**3, 4**	.. ..	30–30	H. W. Tyler
G3	International Law and American Foreign Policy.		**3, 4**	.. ..	30–30	Tryon
G4	Business and Patent Law...		**3, 4**	.. ..	30–30	Hausserman
G5	Psychology...............		**3, 4**	.. ..	30–30	Holmes / Whittemore
G6	Industrial Psychology......	Elective		Summer	30–30	
G20	Labor Problems........... Ec31		**3, 4**	.. ..	30–30	Doten
G22	Marketing Methods.......		**3, 4**	.. ..	30–30	Freeland
G23	Production Methods.......		**3, 4**	30–30	.. ..	Schell
G25	Investment Finance.......		**3, 4**	30–30	.. ..	D. S. Tucker
G26	Banking and Finance......		**3, 4**	30–30	.. ..	Shugrue
G27	Economics of Corporations..	VII₁	**3**	.. ..	30–30	Armstrong
			3, 4	.. ..	30–30	
G38	Christianity and the Social Order..................		**3, 4**	30–30	.. ..	Sutherland
G40	English (Contemporary Drama)...............		**3, 4**	.. ..	30–30	Rogers
G41	English (Contemporary English Literature) (Not offered in 1927–28)........		**3, 4**	30–30	.. ..	Rogers
G42	English (Contemporary European Literature) (Not offered in 1927–28)......		**3, 4**	.. ..	30–30	Rogers
G43	English (American Literature)..................		**3, 4**	30–30	.. ..	Roger
G441	English (Committee Work).	VI-A(A)	**3**	30–60	.. ..	D. M. Fulle
		VI-A(B) (3)	**4**	30–60	.. ..	
G442	English (Business English)..	VI-A(A)	**4**	Summer	20–40	A. T. Robinso
		VI-A(B)	**3**	Summer	20–40	
G443	English (Modern Forms of Literature)............	VI-A(A)	**4**	.. ..	30–60	W. Prescot
		VI-A(B)	**3**	.. ..	30–60	
G45	English Composition Advanced..................		**3, 4**	.. ..	30–30	Copithorn
G46	English (Public Speaking)..		**3, 4**	30–30	.. ..	

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
G461	Argumentation and Debate (Not offered in 1927–28)		3, 4	30–30	....	
G47	English (Informal Public Speaking)		3, 4	....	30–30	W. Prescott
G48	Appreciation of Music		3, 4	30–30	...	Roberts
G50	The Fine Arts in Modern Life		3, 4	....	30–30	H. L. Seaver
G52	Lincoln and the Period of the Civil War		3, 4	30–30	....	Pearson
G55	French Revolution and Napoleon		3, 4	30–30	....	Crosby
G58	Choral Singing		3, 4	Taken in two terms Register both terms		Townsend
G59	Social Problems of Philosophy		3, 4	30–30	....	A. T. Robinson
G60	Geology	(Not open to students in I, III1, XI, XII)	3, 4	30–30	....	Shimer
G64	Organic Evolution		3, 4	....	30–30	Shimer
		IX-A	3	....	30–30	
		XII	3	....	30–30	
G65	Sound and Music	(Not open to students in VIII)	3, 4	30–30	....	Barss
G66	Descriptive Astronomy	IX-A (Req.)	4	....	30–30	Goodwin
		(Not open to students in I, IX-A)	3, 4	....	30–30	
G67	Meteorology		3, 4	....	30–30	Conant
G71	Principles of Biology and Heredity	(Not open to students in XI)	3, 4	30–30	....	Bigelow
G72	Industrial Aspects of Bacteriology	(Not open to students in VII and XI)	3, 4	30–30	....	S. C. Prescott Proctor
G73	Sanitary Science and Public Health	(Not open to students in I, XI)	3, 4	....	30–30	Turner
G75	Physiology and Embryology of Reproduction		3, 4	....	30–30	Bunker
G76	History of Philosophy M12		3, 4	....	30–30	Wiener
G77	Methods of Teaching General Science in Senior and Junior High Schools	(Elective)		Summer	30–60	
G78	Air, Water and Food		3, 4	Either term	30–30	Woodman
G781	Methods of Teaching Physics in Senior High Schools	(Elective)		Summer	30–60	
G782	Methods of Teaching Chemistry in Senior High Schools	(Elective)		Summer	30–60	
G783	General Science Laboratory (for Teachers)	(Elective)		Summer	0–40 40	Lunt
G79	Engineering Chemistry 5·02	Any but V, X, XIV who have *not* had 10·23 and 5·52	3, 4	30–30	....	Gill
G821	French (Not offered 1927–28) L62		3, 4	30–30	....	Langley
G822	French (Not offered 1927–28) L62		3, 4	....	30–30	Langley
G831	French L62		3, 4	30–30	....	Langley
G832	French L62		3, 4	....	30–30	Langley
G941	German L21, L22		3, 4	30–30	....	Vogel

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
G942	German.................. G941		3, 4	.. ..	30–30	Vogel
G98	Military History and Policy of the United States.....	All R.O.T.C. advanced course students	3, 4	30–30	.. ..	Cloke

GERMAN

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
L11	German (Elementary)......	Elective		45–75	.. ..	Vogel
L12	German (Elementary)...... L11	Elective		.. ..	45–75	Vogel
L21	German (Intermediate)..... L11, L12 or entrance requirement	Elective		45–75	.. ..	Vogel
L22	German (Intermediate)..... L21	Elective		.. ..	45–75	Vogel
L23	German (Intermediate) L11	Elective		45–75	.. ..	Vogel
L24	German (Intermediate) L23	Elective		.. ..	45–75	Vogel
L31	German (Advanced)....... L21, L22	Elective		45–75	.. ..	Vogel
L32	German (Advanced)....... L31	Elective		.. ..	45–75	Vogel
L331	German (Advanced).......	Elective		30–60	.. ..	Vogel
L332	German (Advanced)	Elective		.. ..	30–60	Vogel

(Students making up entrance requirements in L11, 12 or L21, 22 will take 45–90 hours per term.)

ROMANCE LANGUAGES

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
L51	French (Elementary)......	Elective		45–75	.. ..	Langley
L52	French (Elementary)...... L51	Elective		.. ..	45–75	Langley
L61	French (Intermediate)..... L52	Elective		45–75	.. ..	Langley
L62	French (Intermediate)..... L61	Elective		.. ..	45–75	Langley
L63	French (Advanced)........ L62	IV	1	45–90	.. ..	Langley
L64	French (Advanced)........ L63	IV	1	.. ..	45–90	Langley
L65	French, Advanced......... L64	IV	2	45–75	.. ..	Langley
L81	Spanish (Elementary)......	Elective		45–75	.. ..	Langley
L82	Spanish (Elementary)...... L81	Elective		.. ..	45–75	Langley

(Students making up entrance requirements in L51, 52 or L61, 62 will take 45–90 hours per term.)

MATHEMATICS

				Term and Hours of Exercise and Preparation		
No.	*Subject and Preparation*	*Taken by*	*Year*	*1st Term*	*2d Term*	*Instructor in Charge*
M1	Algebra (Entrance)			Summer	35-70	Rice
M3	Solid Geometry (Entrance)			Summer	35-70	Vehse
M4	Trigonometry (Entrance)			Summer	35-70	Zeldin
M11	Calculus M1, M3, M4	All courses	1	45-90	.. ..	Bailey
M12	Calculus M11	All courses	1	.. ..	45-90	George
M21	Calculus M12	All courses except IV	2	45-90	.. ..	Bartlett
M22	Differential Equations M21	I, II, III, IV-A, V, VI, VI-A, VIII, IX-A, IX-B, IX-C, XI, XII, XIII, XIV, XV$_1$, XV$_2$, XVI, XVII	2	.. ..	45-90	H. B. Phillips
M24	Mathematics M21	II, VI (Elective) (at G. E. Co.)		.. ..	45-45	Phillips
M26	Least Squares and Probability M22	IX-C	4	30-30	.. ..	Bartlett
M31	Mathematics M22	VI, VI-C, VI-A(B) VI-A(A)	3 3	30-60	 30-60	Moore
M36	Advanced Calculus M22	VIII, IX-C V (Elective)	3 4	45-90 45-90	.. ..	Woods
M37	Advanced Calculus M36	VIII, IX-C V (Elective)	3 4	.. ..	45-90 45-90	Woods
M41	Calculus, Applications of M21	X, X Ord. X C.W.S. X-B, X-B (R.O.T.C.)	4 4	45-90 36-72	.. ..	Hitchcock
M43	Theoretical Aeronautics M21	IX-C (Elective) XVI	4 3	45-90 45-90	.. ..	C. L. E. Moore
M44	Theoretical Aeronautics M43	IX-C (Elective) XVI	4 3	.. ..	45-90 45-90	C. L. E. Moore
M451	Fourier's Series and Integral Equations M22	VIII IX-C	4 G(A)	30-50 30-50	.. ..	Wiener
M452	Fourier's Series and Integral Equations	IX-C	G(A)	.. ..	30-90	Wiener
M46	Advanced Wing Theory M44	XVI, IX-C VIII (Elective)	G(A)	30-60	.. ..	C. L. E. Moore
M47	Advanced Wing Theory M46	XVI, IX-C VIII (Elective)	G(A)	.. ..	30-60	C. L. E. Moore
M51	Engineering Science M22	IX-B	3	45-90	.. ..	H. B. Phillips
M52	Engineering Science	IX-B	3	.. ..	45-90	H. B. Phillips
M53	Engineering Science	IX-B	4	45-90	.. ..	H. B. Phillips
M54	Mathematical Laboratory M22	IX-C	4	.. ..	45-75	Douglass
M561	Theory of Functions M22	IX-C	G(A)	30-90	.. ..	Rutledge
M562	Theory of Functions M22	IX-C	G(A)	.. ..	30-90	Rutledge
M57	Theory of the Gyroscope M22	II(O.D.), II(T.D.) IX-C	G G(A)	.. ..	15-30 15-30	H. B. Phillips
M571	Theory of the Gyroscope M22	II(A.O.)	4	.. ..	15 15	
M60	Vector Analysis M22	IX-C	G(A)	30-90	.. ..	Zeldin
M62	Modern Algebra M22	IX-C	G(A)	.. ..	30-60	Rice
M631	Differential Geometry M22	IX-C	G(A)	30-90	.. ..	Struik
M632	Differential Geometry M22	IX-C	G(A)	.. ..	30-90	Struik
M651	Analytical Mechanics M22	IX-C	G(A)	30-90	.. ..	P. Franklin

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
M652	Analytical Mechanics..... M651	IX-C	G(A)	.. ..	30–90	P. Franklin
M70	History of (Math.) Science. M12	Elective	4	30–60	..	H. W. Tyler
M72	Differential Equations.... M21	II(A.O.), Chem.War.Off.	4 G	Summer	195– 0 195– 0	H. B. Phillips
M731	Rigid Dynamics.......... M22	XIII-A	G	45–90	. ..	C. L. E. Moore
M732	Rigid Dynamics.......... M731	XIII-A	G	.. ..	45–90	C. L. E. Moore
M75	Exterior Ballistics........ M22	II(O.D.)	G	30–60	.. ..	P. Franklin
M77	Vector Analysis.......... M22	VI-C VI-A(A) (3) VI-A(B) (3)	3 4 4	. .. 45–75 Summer	45–75 45–75	H. B. Phillips
M78	Analytic Geometry M22	Elective		.. ..	30–60	P. Franklin
M80	Methods of Teaching Junior High School Mathematics			Summer	30–90	
M81	Methods of Teaching Senior High School Mathematics			Summer	30–90	
M82	Classroom Problems of the Junior and Senior High Schools			Summer	20–20	
M90	Mathematical Reading....	IX-C	G(A)	Both terms ✦		Woods

HYGIENE

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
PT1	Physical Training.......	All courses	1	20– 0	.. ..	
PT2	Physical Training.......	All courses	1	.. ..	20– 0	

MILITARY SCIENCE AND TACTICS

No.	Subject and Preparation	Taken by	Year	Term and Hours of Exercise and Preparation 1st Term	2d Term	Instructor in Charge
MS11	Military Science........	All courses	1	27– 0 18	.. ..	Cloke
MS12	Military Science........	All courses	1	.. ..	45– 0	Cloke
MS21	Military Science........	All courses	2	45– 0	.. ..	Cloke
MS221	Coast Artillery..........	All courses	2	.. ..	45– 0	Winslow
MS222	Engineer Unit	All courses	2	.. ..	45– 0	A. T. W. Moore
MS223	Signal Unit	All courses	2	.. ..	45– 0	Milan
MS224	Ordnance Unit	All courses	2	.. ..	45– 0	Bandholtz
MS225	Air Corps Unit.........	All courses except V	2	.. ..	45– 0	Woodward
MS226	Chemical Warfare Unit...	V, X, XIV XV_3 only	2	.. ..	45– 0	T. Phillips
MS311	Coast Artillery Unit, Adv. MS221.	All courses except V $XV_{1,2}$	3	45–45	.. ..	Winslow
MS312	Coast Artillery Unit, Adv. MS311	All courses except V $XV_{1,2}$	3	.. ..	45–45	Winslow
MS321	Engineer Unit, Adv...... MS222	All courses except V	3	45–45	.. ..	A. T. W. Moore
MS322	Engineer Unit, Adv...... MS321	All courses except V	3	.. ..	45–45	A. T. W. Moore
MS331	Signal Unit, Adv........ MS223	VI, VI-A, VIII IX-B, XIV	3	45–45	.. ..	Milan

✦Time specially arranged.

No.	Subject and Preparation	Taken by	Term and Hours of Exercise and Preparation Year	1st Term	2d Term	Instructor in Charge
MS3311	Signal Unit, Adv......... MS223	VI-C	3	30–15	.. ..	Milan
MS332	Signal Unit, Adv... .... MS331	VI, VI-A, VIII IX-B, XIV	3	.. ..	33–45 12	Milan
MS3321	Signal Unit, Adv........ MS3311	VI-C	3	.. ..	30–15	Milan
MS341	Ordnance Unit, Adv..... MS224	II, III$_2$, VI-A, X, XV$_2$	3	15–15	.. ..	Bandholtz
MS342	Ordnance Unit, Adv...... MS341	II, III$_2$, VI-A, X, XV$_2$	3	.. ..	15–15	Bandholtz
MS35	Air Corps Units, Adv. ... MS225	All courses except V	3	.. ..	45–45	Woodward
MS351	Air Corps Unit, Adv..... MS225, 2'15	All courses except V	3	Register for 16'015		Woodward
MS352	Air Corps Unit, Adv..... MS315	All courses except V		Register for MS35		Woodward
MS361	Military Science........ MS226	V, X, XIV, XV$_3$	3	Covered by Institute Subjects		T. Phillips
MS362	Chemical Warfare Unit, Adv.................. MS226	V, X, XIV, XV$_3$	3	.. ..	45–45	T. Phillips
MS411	Coast Artillery Unit, Adv. MS312	All courses except V, XV$_{1,2}$	4	45–45	.. ..	Winslow
MS412	Coast Artillery Unit, Adv. MS411	All courses except V XV$_{1,2}$	4	.. ..	45–45	Winslow
MS421	Engineer Unit, Adv...... MS322	All courses except V	4	Covered by Institute Subjects		A. T. W. Moore
MS422	Engineer Unit, Adv...... MS421	All courses except V	4	Covered by Institute Subjects		A. T. W. Moore
MS431	Signal Unit, Adv........ MS332	VI, VI-A, VI-C VIII, IX-B, XIV	4	(See 6'281)	.. ..	Milan
MS432	Signal Unit, Adv........ MS431	VI, VI-A, VI-C VIII, IX-B, XIV	4	.. ..	(See 6'282)	Milan
MS441	Ordnance Unit, Adv...... MS342	II, III$_2$, VI-A, X-B, XV$_2$	4	Covered by Institute Subjects		Bandholtz
MS442	Ordnance Unit, Adv..... MS441	II, III$_2$, VI-A, X, X-A, X-B, XV$_2$	4	Covered by Institute Subjects		Bandholtz
MS451	Air Corps Unit, Adv..... MS35	All courses except V	4	Covered by Institute Subjects		Woodward
MS452	Air Corps Unit, Adv.....	All courses except V	4	Covered by Institute Subjects		Woodward
MS461	Chemical Warfare Unit, Adv.................. MS362	V, X, XIV, XV$_3$	4	Covered by Institute Subjects		T. Phillips
MS462	Chemical Warfare Unit, Adv.................. MS461	V, X, XIV, XV$_3$	4	Covered by Institute Subjects		T. Phillips

LABORATORY FEES

The following Laboratory Fees will become effective on and after September 15, 1927. These fees are subject to revision due to any additions or changes in subjects, etc. No refunds will be made for subjects cancelled after the sixth week of the term.

CIVIL ENGINEERING

Subject No.	*Subject*	*Fee Each Term*
1·36	Testing of Highway Materials	$3.00

MECHANICAL ENGINEERING

Subject No.	*Subject*	*Fee Each Term*
2·305	Materials and Testing	$12.00
2·333	Physical Metallurgy	6.00
2·341	Physical Metallurgy	15.00
2·342	Physical Metallurgy	15.00
2·35	Testing Materials Laboratory	12.00
2·36	Testing Materials Laboratory	6.00
2·361	Testing Materials Laboratory	6.00
2·362	Testing Materials Laboratory	6.00
2·37	Testing Materials Laboratory	4.00
2·371	Testing Materials Laboratory	4.00
2·381	Testing and Examination of Materials, Advanced	12.00
2·382	Testing and Examination of Materials, Advanced	12.00
2·390	Reinforced Design, Laboratory	6.00
2·601	Engineering Laboratory	12.00
2·602	Engineering Laboratory	12.00
2·603	Engineering Laboratory	6.00
2·611	Engineering Laboratory	6.00
2·612	Engineering Laboratory	6.00
2·613	Engineering Laboratory	6.00
2·614	Engineering Laboratory	12.00
2·615	Engineering Laboratory	6.00
2·62	Engineering Laboratory	12.00
2·621	Engineering Laboratory	9.00
2·63	Engineering and Hydraulic Laboratory	6.00
2·631	Engineering and Hydraulic Laboratory	9.00
2·64	Refrigeration Laboratory	6.00
2·65	Power Laboratory	6.00
2·66	Automobile Laboratory	6.00
2·671	Engine Testing	12.00
2·672	Motor Vehicle Testing	13.00
2·681	Aero Engine Laboratory	12.00
2·691	Aero Engine Laboratory	6.00
2·84	Heat Treatment	6.00
2·841	Heat Treatment	6.00
2·842	Heat Treatment	6.00
2·843	Heat Treatment	6.00
2·856	Heat Treatment	9.00
2·857	Heat Treatment	6.00
2·86	Heat Treatment and Metallography	9.00
2·861	Heat Treatment	9.00
2·87	Textile Engineering	6.00
2·90	Forging	9.00

Subject No	Subject	Fee Each Term
2·901	Forging	6.00
2·902	Forging	6.00
2·91	Foundry	12.00
2·911	Foundry	6.00
2·912	Foundry	6.00
2·92	Pattern Making	6.00
2·921	Carpentry	6.00
2·941	Machine Tool Laboratory	9.00
2·942	Machine Tool Laboratory	5.00
2·951	Machine Tool Laboratory	12.00
2·952	Machine Tool Laboratory	9.00
2·96	Machine Tool Laboratory	9.00
2·961	Machine Tool Laboratory	4.00
2·971	Machine Tool Laboratory	7.00
2·972	Machine Tool Laboratory	6.00

MINING ENGINEERING AND METALLURGY

Subject No.	Subject	Fee Each Term
3·22	Ore Dressing Laboratory	$6.00
3·23	Ore Dressing	3.00
3·251	Theory and Practice of Flotations	2.00
3·252	Theory and Practice of Flotations	2.00
3·31	Fire Assaying	6.00
3·32	Fire Assaying and Metallurgical Laboratory	3.00
3·331	Fire Assaying, Advanced	10.00
3·332	Fire Assaying, Advanced	10.00
3·41	Metallurgy, Copper and Lead	7.00
3·411	Metallurgy, Copper and Lead	3.00
3·412	Metallurgy, Copper and Lead	3.00
3·42	Metallurgy, Gold and Silver	5.00
3·61	Metallography	9.00
3·611	Metallography	6.00
3·612	Metallography	3.00
3·651	Physical Metallurgy, Advanced	3.00
3·652	Physical Metallurgy, Advanced	3.00
3·666	Applications of Metallography	15.00

CHEMISTRY

Subject No.	Subject	Fee Each Term
5·01	Chemistry	$4.00
5·02	Chemistry	4.00
5·08	Preparation of Inorganic Compounds	3.00
5·10	Qualitative Analysis	9.00
5·101	Qualitative Analysis	7.00
5·11	Qualitative Analysis	4.00
5·12	Quantitative Analysis	4.00
5·121	Quantitative Analysis	5.00
5·13	Quantitative Analysis	4.00
5·131	Quantitative Analysis	4.00
5·132	Quantitative Analysis	3.00
5·16	Analytical Chemistry	3.00
5·17	Methods of Electrochemical Analysis	3.00
5·18	Advanced Qualitative Analysis	6.00
5·20	Water Supplies	2.00
5·21	Industrial Water Analysis	2.00
5·22	Water Supplies and Wastes Disposal	2.00
5·25	Chemistry of Foods	3.00

Subject No.	*Subject*	*Fee Each Term*
5·251	Chemistry of Foods	2.00
5·26	Food Analysis	4.00
5·29	Optical Methods	2.00
5·30	Proximate Analysis	4.00
5·31	Gas Analysis	1.00
5·32	Gas Analysis	1.00
5·37	Chemistry of Road Materials	3.00
5·38	Lubricating and Fuel Oil Testing	2.00
5·40	Special Methods and Instruments	2.00
5·55	Organic Qualitative Analysis	8.00
5·61	Organic Chemical Laboratory	7.00
5·611	Organic Chemical Laboratory	7.00
5·612	Organic Chemical Laboratory	6.00
5·613	Organic Chemical Laboratory	5.00
5·614	Organic Chemical Laboratory	3.00
5·615	Organic Chemical Laboratory	4.00
5·62	Organic Chemical Laboratory	10.00
5·621	Organic Chemical Laboratory	7.00
5·622	Organic Chemical Laboratory	3.00
5·623	Organic Chemical Laboratory	3.00
5·624	Organic Chemical Laboratory	3.00
5·631	Organic Laboratory Practice Advanced	3.00
5·632	Organic Laboratory Practice Advanced	3.00
5·651	Chemical Principles	1.00
5·652	Chemical Principles	1.00
5·66	Chemical Principles	1.00

ELECTRICAL ENGINEERING

Subject No.	*Subject*	*Fee Each Term*
6·330	Communication Electrical Laboratory	$9.00
6·331	Communication Electrical Laboratory	14.00
6·332	Communication Electrical Laboratory	14.00
6·512	Electric Circuits	3.00
6·561	Principles of Electrical Communication	14.00
6·562	Principles of Electrical Communication	14.00
6·70	Electrical Engineering Laboratory	18.00
6·70a	Electrical Engineering Laboratory	9.00
6·70b	Electrical Engineering Laboratory	9.00
6·71	Electrical Engineering Laboratory	14.00
6·71a	Electrical Engineering Laboratory	7.00
6·71b	Electrical Engineering Laboratory	7.00
6·72	Electrical Engineering Laboratory	16.00
6·72a	Electrical Engineering Laboratory	4.00
6·72b	Electrical Engineering Laboratory	12.00
6·73	Electrical Testing Advanced	30 cents a laboratory hour
6·74	Electrical Engineering Laboratory	30 cents a laboratory hour
6·75	Electrical Engineering Laboratory	6.00
6·76	Electrical Engineering Laboratory	9.00
6·77	Electrical Engineering Laboratory	6.00
6·77T	Electrical Engineering Laboratory	6.00
6·771	Electrical Engineering Laboratory	14.00
6·772	Electrical Engineering Laboratory	14.00
6·78	Electrical Engineering Laboratory	11.00
6·782	Electrical Engineering Laboratory	15.00
6·80	Electrical Engineering Laboratory	30 cents a laboratory hour
6·81	Electrical Engineering Laboratory	8.00

Subject No.	Subject	Fee Each Term
6·82	Electrical Engineering Laboratory	8.00
6·83	Electrical Engineering Laboratory	8.00
6·85	Electrical Engineering Laboratory	9.00
6·86	Electrical Engineering Laboratory	5.00
6·89	Electrical Engineering Laboratory	9.00

BIOLOGY AND PUBLIC HEALTH

Subject No.	Subject	Fee Each Term
7·01	General Biology	$3.00
7·06	Botany	3.00
7·07	Mycology	2.00
7·10	Zoology	3.00
7·11	Anatomy and Histology	8.00
7·12	Anatomy and Histology	8.00
7·20	Physiology	9.00
7·28	Biology and Bacteriology	2.00
7·29	Biology and Bacteriology	4.00
7·291	Biology and Bacteriology	2.00
7·301	Bacteriology	6.00
7·302	Bacteriology	6.00
7·361	Industrial Microbiology	6.00
7·362	Industrial Microbiology	5.00
7·37	Industrial Microbiology	6.00
7·421	Food Fishes	6.00
7·422	Food Fishes	5.00
7·442	Technology of Fishery Products	4.00
7·551	Public Health Laboratory Methods	2.00
7·552	Public Health Laboratory Methods	3.00
7·701	Technology of Food Supplies	3.00
7·702	Technology of Food Supplies	4.00
7·712	Technology of Food Products	3.00
7·80	Biochemistry	8.00

PHYSICS

Subject No.	Subject	Fee Each Term
8·01	Physics	$3.00
8·012	Physics	2.00
8·02	Physics	3.00
8·03	Physics	3.00
8·034	Physics	2.00
8·04	Physics	3.00
8·10	Heat Measurements	9.00
8·11	Heat Measurements	6.00
8·12	Heat Measurements	6.00
8·13	Heat Measurements	12.00
8·14	Heat Measurements	20 cents a laboratory hour
8·151	Photographic Laboratory	9.00
8·18	Physical Optics	6.00
8·191	Microscope Theory and Photomicrography	6.00
8·192	Optics, Advanced	20 cents a laboratory hour
8·201	Electricity	9.00
8·202	Electricity	9.00
8·21	Elements of Electron Theory and Electron Apparatus	6.00
8·25	Spectroscopy	6.00
8·33	X-Rays and Radiology	6.00
8·36	Radiation Measurements	9.00
8·432	Photoelasticity	6.00
8·44	Application of X-Ray and Photoelasticity	6.00
8·46	Industrial Radiology	6.00

Subject No.	*Subject*	*Fee Each Term*
8·86	Electrochemical Laboratory	14.00
8·871	Applied Electrochemical Laboratory	7.00
8·872	Applied Electrochemical Laboratory	7.00
8·89	Electric Furnaces	6.00
8·90	Electrochemistry, Elements of	6.00
8·98	Glass Blowing	3.00

CHEMICAL ENGINEERING

Subject No.	*Subject*	*Fee Each Term*
10·26	Industrial Chemical Laboratory	$4.00
10·27	Industrial Chemical Laboratory	3.00
10·37	Chemical Engineering Laboratory	3.00
10·951	Applied Colloid Chemical Laboratory	3.00
10·952	Experimental Problems in Colloid Chemistry	3.00

GEOLOGY

Subject No.	*Subject*	*Fee Each Term*
12·01	Mineralogy	$10.00
12·02	Mineralogy	6.00
12·03	Mineralogy	3.00
12·04	Mineralogy Advanced	10.00
12·151	Petrography	8.00
12·152	Petrography	7.00
12·161	Petrography Advanced	10.00
12·162	Petrography Advanced	10.00
12·20	Optical Examination of Chemical Pricipitates	3.00
12·211	Optical Crystallography	5.00
12·212	Optical Crystallography	4.00
12·22	Optical Ceramics	5.00
12·30	Geology	2.00
12·31	Geology	3.00
12·38	Physiography	2.00
12·41	Economic Geology Laboratory	9.00
12·431	Economic Geology Laboratory, Advanced	6.00
12·432	Economic Geology Laboratory, Advanced	6.00
12·46	Economic Geology of Non-Metallic Deposits	3.00
12·47	Economic Geology of Non-Metallic Deposits, Advanced	5.00
12·50	Historical Geology	3.00
12·511	Paleontology	3.00
12·512	Paleontology	2.00
12·521	Paleontology, Advanced	5.00
12·522	Paleontology Advanced	5.00
12·53	Index Fossils	6.00

NAVAL ARCHITECTURE AND MARINE ENGINEERING

Subject No.	*Subject*	*Fee Each Term*
13·42	Ship Design (Modeling only)	$10.00

AERONAUTICAL ENGINEERING

Subject No.	*Subject*	*Fee Each Term*
16·51	Rigging and Maintenance of Aircraft	$9.00
16·62	Aeronautical Laboratory	6.0
16·67	Aeronautical Laboratory	3.0
16·90	Aeronautical Engine Laboratory	9.0

FUEL AND GAS ENGINEERING

Subject No.	*Subject*	*Fee Each Ter*
F4	Gas Engine Laboratory	9.0

ALPHABETICAL LIST OF SUBJECTS

(With reference to pages containing description)

ALPHABETICAL INDEX

5-27-10,000-T.P.

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