

M. I. T. ANNUAL CATALOGUES AND BULLETINS

1933/34

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OF  
04

MASSACHUSETTS  
INSTITUTE OF TECHNOLOGY

CATALOGUE

INCLUDING  
THE GRADUATE SCHOOL

ACADEMIC YEAR  
1933-34

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



JUNE, 1933

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## CALENDAR FOR ACADEMIC YEAR 1933-1934

<i>1933</i>	
Entrance Examinations at Technology Begin . . . . .	Sept. 13
College Year Begins . . . . .	Sept. 25
Columbus Day (Holiday) . . . . .	Oct. 12
Armistice Day (Holiday) . . . . .	Nov. 11
Thanksgiving Day (Holiday) . . . . .	Nov. 30
Christmas Vacation . . . . .	Dec. 22-Jan. 1 (inclusive)

<i>1934</i>	
Last Exercises, First Term . . . . .	Jan. 20
Midyear Examination Period . . . . .	Jan. 22-Feb. 3 (inclusive)
Second Term Begins . . . . .	Feb. 5
Washington's Birthday (Holiday) . . . . .	Feb. 22
Spring Recess . . . . .	April 18-21 (inclusive)
Last Exercise, Second Term . . . . .	May 23
Annual Examinations Begin . . . . .	May 24
Memorial Day (Holiday) . . . . .	May 30
Commencement Day . . . . .	June 5
Summer Session 1934 Begins . . . . .	June 4

## CALENDAR FOR ACADEMIC YEAR 1934-1935

<i>1934</i>	
Entrance Examinations at Technology Begin . . . . .	Sept. 12
College Year Begins . . . . .	Sept. 24
Columbus Day (Holiday) . . . . .	Oct. 12
Armistice Day (Holiday) . . . . .	Nov. 11
Thanksgiving Day (Holiday) . . . . .	Nov. 29
Christmas Vacation . . . . .	Dec. 22-Jan. 1 (inclusive)

<i>1935</i>	
Last Exercises, First Term . . . . .	Jan. 19
Midyear Examination Period . . . . .	Jan. 21-Feb. 2 (inclusive)
Second Term Begins . . . . .	Feb. 4
Washington's Birthday (Holiday) . . . . .	Feb. 22
Spring Recess . . . . .	April 17-20 (inclusive)
Last Exercise, Second Term . . . . .	May 22
Annual Examinations Begin . . . . .	May 23
Memorial Day (Holiday) . . . . .	May 30
Commencement Day . . . . .	June 4
Summer Session 1935 Begins . . . . .	June 3

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 HAROLD CHRISTIAN WEBER, S.B., *Associate Professor of Chemical Engineering.*  
 HOYT CLARKE HOTTEL, B.A., S.M., *Associate Professor of Fuel Engineering; Assistant Director, Division Industrial Cooperation; Acting Director, Fuels Research Laboratory.*  
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 THOMAS KILGORE SHERWOOD, SC.D., *Assistant Professor of Chemical Engineering.*  
 ERNEST JOHN TAUCH, B.S., *Assistant Professor of Chemical Engineering; Director of the Buffalo Station of School of Chemical Engineering Practice.*

## Instructors

ROBERT LANDIS HERSHEY, S.M.  
 THOMAS BRADFORD DREW, S.M.  
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- AUGUSTUS HERMAN GILL, Ph.D., Sc.D., *Professor of Technical Chemical Analysis.*
- JAMES FLACK NORRIS, Ph.D., Sc.D., *Professor of Organic Chemistry; in charge of Graduate Students in Chemistry; Director of the Research Laboratory of Organic Chemistry.*
- MILES STANDISH SHERRILL, Ph.D., *Professor of Theoretical Chemistry.*
- SAMUEL PARSONS MULLIKEN, Ph.D., *Professor of Organic Chemistry.*
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- ARTHUR ALPHONZO BLANCHARD, Ph.D., *Professor of Inorganic Chemistry.*
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- JAMES ALEXANDER BEATTIE, Ph.D., *Associate Professor of Physico-Chemical Research.*
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- ERNEST HAMLIN HUNTRESS, Ph.D., *Assistant Professor of Chemistry.*
- LEIGHTON BRUERTON SMITH, Ph.D., *Assistant Professor of Physico-Chemical Research.*
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 NORMAN BOVELL CARTER, *Curator of Apparatus.*  
 CHARLES EWING COLE, *Lecture Demonstrator.*  
 CHARLES LEO GALLAGHER, *Senior Mechanician.*  
 KANUTE W. WILHELMSON, *Junior Mechanician.*

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 GEORGE EDMOND RUSSELL, S.B., *Professor of Hydraulics.*  
 GEORGE LEONARD HOSMER, *Professor of Geodesy.*  
 ROSS FRANCIS TUCKER, S.B., *Professor of Building Construction; in charge of the Course in Building Engineering and Construction (XVII).*  
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 WALTER CHARLES VOSS, B.S., *Professor of Building Construction.*  
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 WILLIAM ANDREW LIDDELL, S.B., *Assistant Professor of Hydraulic Engineering.*  
 EUGENE MIRABELLI, S.B., *Assistant Professor of Structural Design.*  
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## Research Associates

LEO JÜRGENSON, Sc.D.                      ARTHUR CLAUDE RUGE, S.M.

## Research Assistants

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DONALD SKEELE TUCKER, Ph.D., *Professor of Political Economy.*

OLIN INGRAHAM, Ph.B., A.M., *Assistant Professor of Economics.*

BRAINERD ALDEN THRESHER, S.B., A.M., *Assistant Professor of Economics.*

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## Instructor

LINCOLN FAIRLEY, Ph.D.

## Assistant

MARION COOPER GILBERT, A.M.

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

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

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CLIFFORD EARL LANSIL, S.B., *Associate Professor of Electrical Engineering.*

RALPH DECKER BENNETT, PH.D., *Associate Professor of Electrical Measurements.*

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HAROLD EUGENE EDGERTON, Sc.D., *Assistant Professor of Electrical Measurements.*

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*(Non-Resident)*

LYMAN MINER DAWES, S.B.

OVID WALLACE ESHBACH, E.E., M.S.

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#### Research Associates

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JOSEPH WARREN HORTON, S.B.

#### Research Assistants

KENNETH JOSEPH GERMESHAUSEN, S.B. CARL NEITZERT, B.S., M.A.

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WILLIAM HENRY RADFORD, S.M.

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#### Technical Assistant

CLIFFORD EUGENE HENTZ, *Curator of Apparatus.*

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ARCHER TYLER ROBINSON, A.M., *Professor of English; in charge of the Courses in History.*

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## GEOLOGY

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FREDERICK KUHNE MORRIS, B.S., M.A., *Professor of Geology.*

LOUIS BYRNE SLICHTER, PH.D., *Professor of Geophysics.*

WALTER HARRY NEUHOUSE, PH.D., *Associate Professor of Economic Geology.*

MARTIN JULIAN BUERGER, PH.D., *Assistant Professor of Mineralogy and Petrography.*

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WALDEMAR LINDGREN, M.E., SC.D., *Professor Emeritus*

## Lecturer

WALTER LUCIUS WHITEHEAD, PH.D. . . . . Coal and Petroleum

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HEREWARD CLARENCE HORWOOD, M.Sc.

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RALPH ILSLEY, S.B.

JOHN SINCLAIR STEVENSON, B.A.Sc.

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GEORGE W. MORSE, M.D., F.A.C.S., *Medical Director; in charge of the Department.*

HAROLD EDWARD LOBDELL, *Dean of Students.*

LOUIS WARD CROKE, M.D., *Assistant Medical Director.*

## INSTRUCTING STAFF

BENJAMIN ERNEST SIBLEY, M.D., *Assistant to Medical Director.*  
 HARLAND FRANCIS LANCASTER, M.D., *Assistant to Medical Director.*  
 HENRY PATRICK MCCARTHY, *Director of Physical Training.*  
 JOHN WEBSTER WILLIAMS, M.D., *Pathologist.*  
 SANFRID KNUT JOHNSON, *Assistant in Physical Training.*  
 JUSTIN MENNIS KEARNEY, *Student Assistant in Physical Training.*  
 OSCAR FREDERICK HEDLUND, *Track Coach.*  
 WILLIAM B. HAINES, *Crew Coach.*  
 JOHN H. SUMMERS, *Squash Coach.*  
 ROBERT BOWIE, *Field Coach.*

## MATHEMATICS

FREDERICK SHENSTONE WOODS, PH.D., *Professor of Mathematics; in charge of the Department.*  
 FREDERICK HAROLD BAILEY, A.M., *Professor of Mathematics.*  
 HENRY BAYARD PHILLIPS, PH.D., *Professor of Mathematics.*  
 FRANK LAUREN HITCHCOCK, PH.D., *Professor of Mathematics.*  
 NORBERT WIENER, PH.D., *Professor of Mathematics.*  
 NATHAN RICHARD GEORGE, A.M., *Associate Professor of Mathematics.*  
 LEONARD MAGRUDER PASSANO, A.B., *Associate Professor of Mathematics.*  
 GEORGE RUTLEDGE, PH.D., *Associate Professor of Mathematics.*  
 PHILIP FRANKLIN, PH.D., *Associate Professor of Mathematics.*  
 DIRK JAN STRUIK, PH.D., *Associate Professor of Mathematics.*  
 JESSE DOUGLAS, PH.D., *Assistant Professor of Mathematics.*  
 RAYMOND DONALD DOUGLASS, PH.D., *Assistant Professor of Mathematics.*  
 SAMUEL DEMITRY ZELDIN, PH.D., *Assistant Professor of Mathematics.*  
 EBERHARD HOPF, PH.D., *Assistant Professor of Mathematics.*

## Instructors

JAMES GRAHAM ESTES, PH.D.                      HORACE ALPHEUS GIDDINGS, B.S.

## MECHANICAL ENGINEERING

EDWARD FURBER MILLER, Sc.D.,\* *Professor of Steam Engineering; in charge of the Department; Director of Engineering Laboratories; 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.*  
 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 Advanced Machine Design; in charge of Textile Research.*  
 JOSEPH CAINS RILEY, S.B., *Professor of Heat Engineering.*  
 CHARLES WILLIAM BERRY, S.B., *Professor of Heat Engineering.*  
 GEORGE WRIGHT SWETT, S.B., *Professor of Machine Design.*  
 EARLE BUCKINGHAM, *Professor of Engineering Standards and Measurements.*

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WILHELM SPANNHAKE, DIPL.ING., *Professor of Hydraulics.*  
 THEODORE HOWARD TAFT, S.B., *Associate Professor of Heat Engineering.*  
 LAWRENCE SOUTHWICK SMITH, S.B., *Associate Professor of Theoretical and Applied  
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 Drawing.*  
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 DEAN ABNER FALES, S.B., *Associate Professor of Automotive Engineering.*  
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 DEAN PEABODY, JR., S.B., *Associate Professor of Applied Mechanics.*  
 WILLIAM HENRY JONES, S.B., *Associate Professor of Experimental Engineering.*  
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 RAYMOND WILSON COOK . . . . . Production  
 FRED DAVIS . . . . . Electric Arc Welding  
 GEORGE JAEGER . . . . . Oxy-Acetylene Welding  
 CLIFFORD LORING MUZZEY, S.B. . . . . Production  
 WILLIAM TAYLOR OBER . . . . . Electric Butt and Spot Welding  
 GEORGE ALGER PENNOCK, S.B. . . . . Production  
 LEWIS DANIEL SPENCE . . . . . Automatic Machinery  
 HAROLD LEMOYNE VAN KEUREN, B.S. . . . . Measuring with Light Waves

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HENRY FRANCIS KING, S.M.

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RALPH JOHN BOWLEY	JOHN WOODBURY LANE, S.B.
HEMENWAY REGNOLD BULLOCK	ROBERT WESTON VOSE, S.B.

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 FRANCIS WINFIELD PERKINS, *Constructor of Apparatus.*

## MILITARY SCIENCE AND TACTICS

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OSCAR JAMES GATCHELL, GRAD. U.S.M.A., Major, Ordnance Department (D.O.L.). *Associate Professor of Military Science and Tactics; Executive Officer; in charge of Ordnance Unit.*

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GEORGE ANTHONY BICHER, GRAD. U.S.M.A., 1st Lieutenant, Signal Corps (D.O.L.). *Assistant Professor of Military Science and Tactics; in charge of Signal Corps Unit.*

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ERIC HILMER FRITHIOF SVENSON, Warrant Officer, U.S.A., Ret.; *in charge of Band.*

ALFRED FLOYD TRUAX, Technical Sergeant, D.E.M.L., Signal Corps.

MARK BRADEN ASHLEY, Staff Sergeant, D.E.M.L., Coast Artillery Corps.

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

ALEXANDER HOLMES, Staff Sergeant, D.E.M.L., Coast Artillery Corps; *Armorer.*

SAMUEL LEROY FREY, Sergeant, D.E.M.L., Chemical Warfare Service.

JOHN BURKE FITZGERALD, Sergeant, D.E.M.L., Coast Artillery Corps; *Armorer.*

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- GEORGE BOOKER WATERHOUSE, PH.D., *Professor of Metallurgy; in charge of the Option of Metallurgy.*
- ROBERT SEATON WILLIAMS, PH.D., *Professor of Physical Metallurgy.*
- CHARLES E. LOCKE, S.B., *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.*
- VICTOR OLIVER HOMERBERG, SC.D., *Associate Professor of Physical Metallurgy.*
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- FRANKLIN LEROY FOSTER, S.M., *Assistant Professor of Mining.*
- JAMES WESTON PRATT, S.B., *Assistant Professor of Physical Metallurgy.*
- JOHN PALMER WALSTED, SC.D., *Assistant Professor of Physical Metallurgy.*

**Lecturer**

JAMES BIRKETT WATERFIELD

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RUFUS COOK REED, S.B.

CHARLES LADD NORTON, JR., S.B.

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LEONARD WHITMAN JOHNSTON, S.B.

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- ERNEST FELIX LANGLEY, PH.D., *Professor of French; in charge of the Department.*
- HERMAN RUDOLPH KURRELMAYER, PH.D., *Professor of German.*

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RICHARD FELIX KOCH, A.M.

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- HENRY HIRAM WHEATON KEITH, S.B., *Professor of Naval Architecture.*
- GEORGE OWEN, S.B., *Professor of Naval Architecture.*
- LAWRENCE BOYLSTON CHAPMAN, S.B., *Professor of Ship Operation and Marine Engineering.*
- HENRY EASTIN ROSSELL, S.M., GRAD. U.S.N.A., Commander (C.C.) U.S.N., *Professor of Naval Construction; in charge of course in Naval Construction (XIII-A).*
- EVERS BURTNER, S.B., *Associate Professor of Naval Architecture and Marine Engineering.*

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## Honorary Lecturer

WILLIAM HOVGAARD, ENG.D., *Professor Emeritus*

## Instructor

CHARLES GLENN MOODY, S.B.

## PHYSICS

(Including Electrochemical Engineering)

JOHN CLARKE SLATER, PH.D., *Professor of Physics; in charge of the Department; Director of Research in Theoretical Physics.*HARRY MANLEY GOODWIN, PH.D., *Professor of Physics and Electrochemistry; in charge of the course in Electrochemical Engineering; Dean of the Graduate School.*CHARLES LADD NORTON, S.B., *Professor of Industrial Physics; Director of Division of Industrial Cooperation.*WILLIAM JOHNSON DRISKO, S.B., *Professor of Physics.*NEWELL CALDWELL PAGE, S.B., *Professor of Electricity.*MAURICE DEKAY THOMPSON, PH.D., *Professor of Electrochemistry.*GORDON BALL WILKES, S.B., *Professor of Industrial Physics.*GEORGE RUSSELL HARRISON, PH.D., *Professor of Physics; Director of Research in Experimental Physics.*ARTHUR COBB HARDY, M.A., *Associate Professor of Optics and Photography.*MANUEL SANDOVAL VALLARTA, SC.D., *Associate Professor of Physics.*DONALD CHARLES STOCKBARGER, SC.D., *Assistant Professor of Physics.*HANS MULLER, D.Sc., *Assistant Professor of Physics.*JULIUS ADAMS STRATTON, D.Sc., *Assistant Professor of Physics.*FRANCIS WESTON SEARS, S.M., *Assistant Professor of Physics.*BERTRAM EUGENE WARREN, SC.D., *Assistant Professor of Physics.*NATHANIEL HERMAN FRANK, SC.D., *Assistant Professor of Physics.*VICTOR GUILLEMIN, JR., PH.D., *Assistant Professor of Physics.*PHILIP McCORD MORSE, PH.D., *Assistant Professor of Physics.*WAYNE BUCKLES NOTTINGHAM, PH.D., *Assistant Professor of Physics.*ERIK GUSTAF RUDBERG, PH.D., *Assistant Professor of Physics.*

## Instructors

WILLIAM PHELPS ALLIS, SC.D.

OVERTON LUHR, PH.D.

CLARENCE EDWIN BENNETT, PH.D.

HENRY MILES O'BRYAN, PH.D.

PAUL LAVERN COPELAND, PH.D.

JOHN CARL GAUDE WULFF, D.Sc.

NEWELL SHIFFER GINGRICH, PH.D.

## Research Associates

JOSEPH CANON BOYCE, PH.D.

ROBERT JEMISON VAN DE GRAAFF, PH.D.

EDWARD STONESTREET LAMAR, A.M.

ERVIN HICKS BRAMHALL, PH.D.

LESTER CLARE VAN ATTA, PH.D.

## Teaching Fellows

WALTER EDWARD ALBERTSON, A.B.	DAVID BULKELEY LANGMUIR, B.S.
HUBERT WERTS ALLEN, M.S.	DAVID LEWIS MACADAM, B.S.
SHERWOOD FISKE BROWN, S.M.	MILLARD FULLER MANNING, M.S.
PETER ALDRICH COLE, A.B.	DWIGHT PLUMER MERRILL, A.B.
RICHARD EDGAR EVANS, S.M.	ROBERT DAVIS RICHTMYER, M.A.
OLIVER MILLER GEORGE, M.S.	HOWARD ADDISON ROBINSON, S.B.
RALPH POOLE JOHNSON, M.A.	JAMES TYCHON SERDUKE, M.S.
HARRY CHARLES KELLY, B.S.	WILLIAM SHOCKLEY, B.Sc.
HARRY MAX KRUTTER, S.B.	HAROLD THOMAS SMYTH, M.Sc.

## Assistant

JAMES ELI FORBES, S.B.

## Technical Assistants

HARRY ERIC ANDERSON <i>Curator of Apparatus</i>	WALTER HARDY KALLENBACH <i>Instrument Maker</i>
CHARLES BYRON BRADLEY, S.B.	JOHN MARK KOLLIGIAN, S.M.
HENRY CHARLES BUNTSCHUH, S.B.	TEMPLE CHAPMAN PATTON, S.M.
NEILS HANSEN DALL, <i>Mechanician</i>	KENNETH HOOPER ROBES, B.S. <i>Mechanician</i>
JAMES WOODRUFF FARMER, B.E.E.	NEIL BAILEY REYNOLDS, M.A.
ROBERT HENDERSON FLETCHER <i>Curator of Apparatus</i>	JAMES EDWARD RYAN, <i>Glass Blower</i>
HARRY HILL, <i>Optical Worker</i>	CARL GUSTAV SELIG, <i>Instrument Maker</i>
	GEORGE PARSONS SWIFT, S.M.

## COURSE IN MILITARY ENGINEERING

## Committee in Charge of Course

SAMUEL CURTIS VESTAL, GRAD., U.S.N.A., Colonel, Coast Artillery Corps (D.O.L.),  
*Professor of Military Science and Tactics.*

HENRY HIRAM WHEATON KEITH, S.B., *Professor of Naval Architecture.*

## DIVISION OF GENERAL STUDIES

## (In Charge of Faculty Committee on General Studies)

F. ALEXANDER MAGOUN, S.M., *Associate Professor of Humanities.*

## Lecturer

IRVING CHAMBERLIN WHITTEMORE, PH.D. . . . . Psychology

## DIVISION OF INDUSTRIAL COÖPERATION

CHARLES LADD NORTON, S.B., *Professor of Industrial Physics; Director.*

EARL BOWMAN MILLARD, PH.D., *Professor of Theoretical Chemistry; Assistant Director.*

GORDON BALL WILKES, S.B., *Professor of Industrial Physics.*

HOYT CLARKE HOTTEL, B.A., S.M., *Associate Professor of Fuel Engineering; Assistant Director.*

LEROY FRANK MAREK, A.B., S.M., *Assistant Professor of Chemical Engineering; Assistant Director.*

FRANK LOVERING LOCKE, S.B., *Personnel Director.*

JOHN MAJOR NALLE, S.M., *Assistant Personnel Director.*

## INSTRUCTING STAFF

## Research Assistant

STEWART BRIDGE LUCE, S.M.

## Industrial Research Fellows

VICTOR JOSEPH DUPLIN, JR., S.M.      JOHN ALBERT FELLOWS, B.A., S.M.

## RESEARCH LABORATORY OF APPLIED CHEMISTRY

LEROY FRANK MAREK, A.B., S.M., *Assistant Professor of Chemical Engineering; Acting Director.*ELMER WORTHINGTON BRUGMANN, S.M., *Assistant Professor of Chemical Engineering; Assistant Director.*

## FUELS RESEARCH LABORATORY

HOYT CLARKE HOTTEL, A.B., S.M., *Associate Professor of Fuel Engineering; Acting Director.*

## Research Assistant

HAROLD GUSTAV MANGELSDORF, S.M.

## STAFF OF THE INSTITUTE LIBRARY

WILLIAM N. SEAVER, A.B.

MIRIAN S. SMITH, B.S.

BERTHA P. TRULL, A.B.

MARGUERITE CHAMBERLAIN, A.B., B.S.

KATHARINE MAYNARD, M.A.

## GUESTS AND RESEARCH FELLOWS

## Biology and Public Health

BRYCE PRINDLE, S.B., *Fellow in Textile Research.*

## Chemistry

ISADOR AMDUR, PH.D., *National Research Fellow.*EDWARD S. GILFILLAN, JR., PH.D., *National Research Fellow.*H. J. F. G. HICKS, JR., PH.D., *National Research Fellow.*RALPH HULTGREN, PH.D., *National Research Fellow.*GEORGE E. KIMBALL, PH.D., *National Research Fellow.*JOHN LAWRENCE ONCLEY, PH.D., *National Research Fellow.*PHILIP G. STEVENS, PH.D., *Guest of Research Laboratory of Organic Chemistry.*

## Physics

NORRIS E. BRADBURY, PH.D., *National Research Fellow.*CHARLES A. BRADLEY, PH.D., *National Research Fellow.*WILLIAM WEBSTER HANSEN, PH.D., *National Research Fellow.*WILHELM JOST, D.Sc., *International Research Fellow.*ANDREW MCKELLAR, PH.D., *National Research Fellow.*EDWARD W. SAMSON, PH.D., *National Research Fellow.*GEORGE W. SHORTLEY, PH.D., *National Research Fellow.*PHILIP T. SMITH, PH.D., *National Research Fellow.*CHESTER MURRAY VAN ATTA, PH.D., *National Research Fellow.*ROLAND M. ZABEL, PH.D., *National Research Fellow.*

## FACULTY COMMITTEES

1933-1934

## Graduate School

DEAN OF THE GRADUATE SCHOOL (Chairman)*	W. P. FISKE	
DIRECTOR OF ADMISSIONS (Secretary)*	J. F. NORRIS	
F. S. WOODS	H. W. SHIMER	
J. W. M. BUNKER	W. H. LAWRENCE	
C. E. FULLER	W. M. FIFE	
W. S. HUTCHINSON	J. C. SLATER	
J. R. JACK	R. H. SMITH	
	O. G. C. DAHL	

## Undergraduate Courses

	(Term Expires)		(Term Expires)
G. W. SWETT (Chairman)	1934	L. F. MAREK	1937
N. C. PAGE	1935	R. F. ELDER	1938
J. A. STRATTON	1936	H. L. HAZEN	1939

## Admissions

DIRECTOR OF ADMISSIONS (Chairman)*	REGISTRAR*	
DEAN OF STUDENTS*	H. L. SEAVER	1934
SECRETARY*	E. B. MILLARD	1936

## Petitions

SECRETARY (Chairman)*		C. R. HAYWARD	1936
DEAN OF STUDENTS*		J. W. HOWARD	1937
G. RUTLEDGE	1934	K. C. REYNOLDS	1938
A. F. HOLMES	1935		

## Provisional Students and Discipline

DEAN OF STUDENTS (Chairman)*	H. B. PHILLIPS	1934
SECRETARY*	R. C. EDDY	1935
REGISTRAR*		

The Committees on First, Second, Third, and Fourth Year Students are determined according to rule.

## Undergraduate Scholarships

DEAN OF STUDENTS (Chairman)*	J. HOLT	1936	
E. MIRABELLI	1934	K. D. FERNSTROM	1937
S. OBER	1934	H. C. WEBER	1937
B. E. PROCTOR	1935	B. A. THRESHER	1938
A. A. BLANCHARD	1935	A. L. TOWNSEND	1938
C. E. TUCKER	1936		

## Course IX

R. G. HUDSON (Chairman)*		W. H. McADAMS	1936
G. R. HARRISON	1934	E. R. SCHWARZ	1937
G. E. RUSSELL	1935		

\*Ex officio

## INSTRUCTING STAFF

## General Studies

<i>(Term Expires)</i>		<i>(Term Expires)</i>	
DEAN OF ARCHITECTURE ( <i>Chairman</i> )*		W. H. TIMBIE	1937
W. H. LAWRENCE	1934	F. K. MORRIS	1938
T. L. DAVIS	1936		

## Committee on the Library

W. K. LEWIS ( <i>Chairman</i> )	1936	T. K. SHERWOOD	1935
LIBRARIAN ( <i>Secretary</i> )*		P. FRANKLIN	1935
F. M. MORSE	1934	W. A. CROSBY	1936
G. B. WATERHOUSE	1934		

## Nominating Committee

1933-1934

W. H. TIMBIE ( <i>Chairman</i> )	H. W. GARDNER
J. F. NORRIS	D. S. TUCKER
J. B. BABCOCK	

## Committee on Conduct of Examinations

L. F. HAMILTON	L. M. DAWES
A. L. TOWNSEND	G. G. MARVIN
J. D. MITSCH	A. S. NORCROSS

## COMMITTEES ON JOINT PROJECTS

## Corrosion

W. K. LEWIS (*Chairman*)  
 R. S. WILLIAMS  
 M. DEK. THOMPSON  
 \_\_\_\_\_  
 E. B. MILLARD  
 L. B. CHAPMAN  
 J. S. NEWELL  
 C. L. NORTON  
 J. H. ZIMMERMAN  
 C. M. WAREHAM  
 L. C. PESKIN

## Heat Transfer

W. H. McADAMS (*Chairman*)  
 C. W. BERRY  
 C. F. TAYLOR  
 G. B. WILKES  
 O. G. C. DAHL  
 \_\_\_\_\_  
 W. H. LAWRENCE  
 W. C. VOSS  
 P. FRANKLIN  
 E. BURTNER  
 H. C. HOTTEL  
 E. R. SCHWARZ  
 J. G. KIRKWOOD

## Acoustics

R. D. FAY (*Chairman*)  
 P. M. MORSE  
 \_\_\_\_\_  
 H. B. PHILLIPS

E. BUCKINGHAM  
 M. P. HORWOOD  
 E. S. TAYLOR  
 E. N. GELOTTE

\*Ex officio

## OTHER COMMITTEES AND BOARDS

## Graduation Exercises

R. G. HUDSON (*Chairman*)  
 H. M. GOODWIN  
 R. S. WILLIAMS  
 J. W. M. BUNKER  
 R. C. EDDY  
 J. C. MACKINNON  
 H. S. FORD

## Student-Faculty

S. C. PRESCOTT (*Chairman*)  
 C. E. FULLER  
 J. W. PHELAN  
 W. M. FIFE  
 K. D. FERNSTROM  
 J. A. STRATTON

## Instruction of Superior Students

C. E. FULLER (*Chairman*)  
 H. H. W. KEITH  
 E. B. MILLARD  
 R. E. FREEMAN  
 R. H. FRAZIER

## Summer Session

F. S. WOODS  
 C. L. NORTON  
 G. R. HARRISON  
 A. F. HOLMES  
 J. C. MACKINNON

## Patent Policy

V. BUSH (*Chairman*)  
 J. W. M. BUNKER  
 C. L. NORTON  
 F. G. KEYES

## Dormitory Board

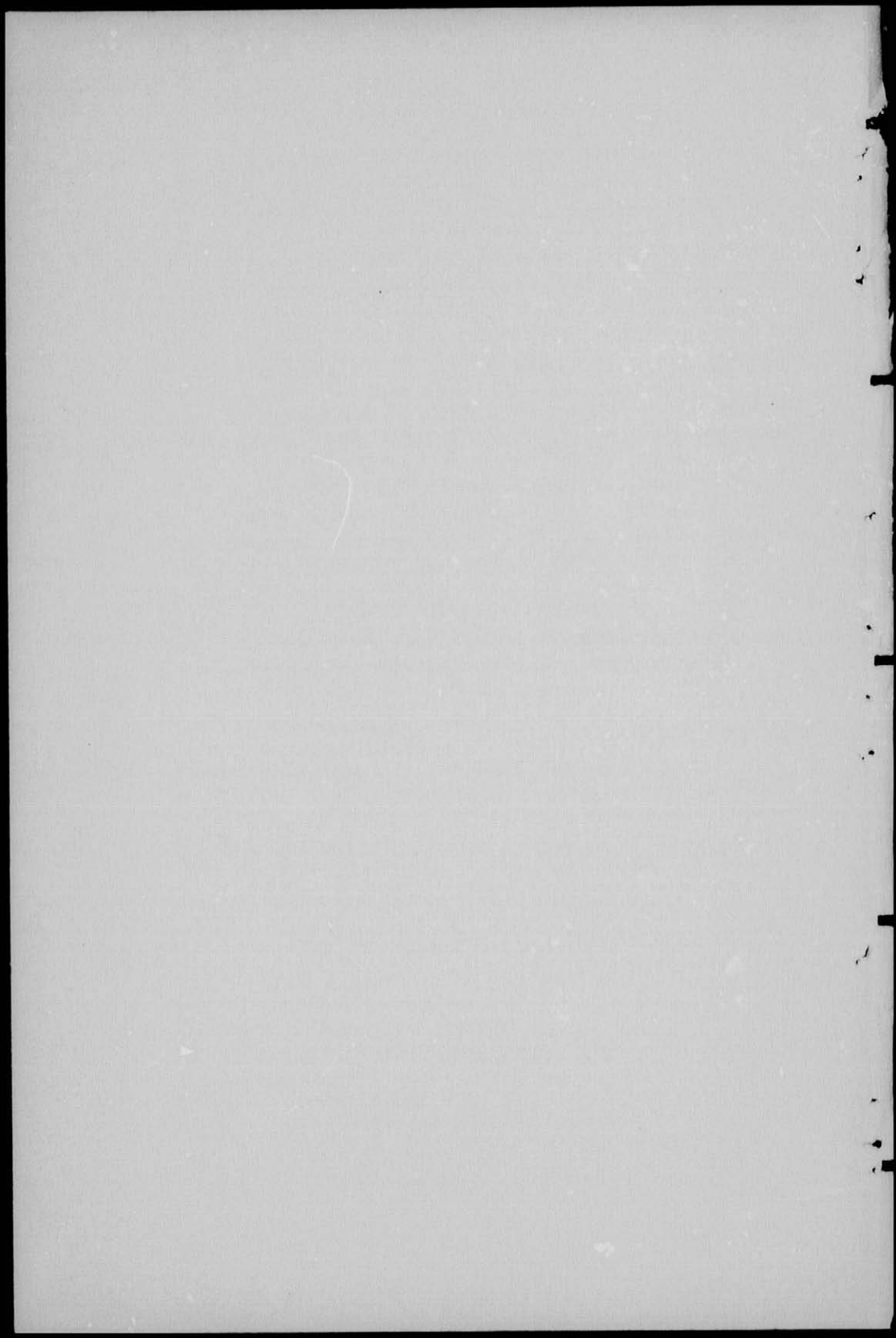
L. F. HAMILTON (*Chairman*)  
 H. E. LOBDELL  
 H. S. FORD  
 A. A. ASHDOWN

Revision of Third and Fourth  
Year Curriculum

D. C. JACKSON  
 S. C. PRESCOTT  
 C. B. BREED  
 J. C. MACKINNON

## Loan Board

H. E. LOBDELL (*Chairman*)  
 K. T. COMPTON  
 J. L. TRYON  
 H. S. FORD  
 D. L. RHIND (*Secretary*)



## 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 Institute offers 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 of Science, Master in Architecture, 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 special research laboratories.

**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 of students 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.

**Administrative Organization.** In order most effectively to administer and to develop the educational and research work of the Institute, and also in order better to coördinate the work of those departments which are naturally similar in outlook, the work of the Institute is divided into the following groups: The School of Architecture, The School of Science, The School of Engineering, The Division of Humanities, and The Division of Industrial Coöperation.

In the three schools are grouped those departments of study which lead to degrees and which embody the primary educational objectives of the Institute. In the Division of Humanities are grouped those additional studies which are particularly selected on account of their supplemental value in giving a well-rounded and balanced cultural attitude toward life. In the Division of Industrial Coöperation there are centered the organized activities of departments and individual members of the staff whose activities are devoted wholly or in part to the assistance of industry in solving its problems or developing new products and methods.

Although thus divided into these five groups for administrative purposes, the educational policies of the Institute remain under the control of the Faculty as a whole.

**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. Here are located the educational buildings, the infirmary, 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 Institute Library, which is one of the leading libraries of the United States in scientific and engineering subjects, contains about two hundred and seventy-seven thousand volumes and receives regularly more than twelve hundred current periodicals. It includes the Central Library and a number of branch libraries and reading rooms.

The main collection of books is in the Central Library under the great dome (building 10, fifth floor). This room, easily reached by the elevator from the main lobby, affords a convenient place for reading and study. It is open on week days during term time from 9 a.m. to 7.30 p.m., except Saturdays, when it is closed at four o'clock. Books may be borrowed for two weeks' use; periodicals for one week.

Seniors and others engaged on theses or other research may apply for a special card of admission to the bookstack.

Individual reference service, and aid in research problems and in the use of the catalogue, will be given at the two Reference Desks in the Central Library and in the larger branch libraries.

Boston Public Library cards are given to non-resident students on the presentation of applications endorsed by the Institute Librarian.

**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.

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 Institute dormitories, accommodating a total of 625 men, consist of twelve halls: six named for former members of the Faculty, Ware, Atkinson, Runkle, Holman, Nichols and Crafts, and six for Alumni of the Institute, Walcott, Bemis, Goodale, Munroe, Hayden and Wood. These halls are on the Institute campus adjacent to

Walker Memorial, which houses the dining service and is the headquarters of all student activities.

**Graduate Halls.** Holman, Nichols and Crafts of the Faculty Group are reserved exclusively for graduate students. These graduate halls are under the general supervision of a house master, a qualified young member of the Faculty with an adequate knowledge of graduate subjects to discuss intelligently the problems of students. A house committee elected by the students assists in supervision. The rooms are generally double suites, consisting of bedroom, dressing room with lavatory and large study. There are a limited number of single rooms. All of the rooms in these halls have been newly furnished and equipped.

**Undergraduate Halls.** All of the rooms in the other halls are reserved exclusively for undergraduate students. Most of these rooms are reserved for single occupancy, some interconnecting with a limited number of double and triple suites. They are fully equipped for immediate occupancy. The government of the undergraduate dormitories is administered as a part of the general plan of student self-government at the Institute with the coöperation of the Dormitory Board appointed by the President and acting in an advisory capacity.

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

### EXPENSES

An estimate of expenses for the school year 1933-1934, a period of 38 weeks, exclusive of personal expenditures such as transportation, clothing, recreation, etc., is given below:

#### For a Period of 38 Weeks

Tuition.....	\$500
Board.....	320
Room.....	190
Books and materials.....	70
	<hr/>
	\$1,080

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 a 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, and rooms for handball. 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.

Adjacent to this building are tennis courts; a football field; 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 outdoor board track is provided. There is near the athletic field another gymnasium with a regulation basketball court. In addition there is a movable boxing ring, wrestling mats and indoor jumping pits. Also connected with this building are eight squash courts. On the grounds west of Massachusetts Avenue are fields for soccer, lacrosse and baseball; also additional tennis 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 cooperate 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 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 coaching the few men composing a single varsity team, but 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, basketball, boxing, fencing, golf, gymnastics, hockey, rifle shooting, soccer, swimming, tennis, squash racquets, 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.

**Combined Musical Clubs.** The Combined Musical Clubs of the Institute consist of the Glee Club, the Instrumental Club, the Banjo Club, and the Techtonians. 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 twice a week throughout the academic year.

*Technique* is the yearbook of the Institute and forms a permanent record of all the notable undergraduate activities.

*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 6. 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, November 11, Thanksgiving Day and December 25.

**Summer Session.** Subjects are offered which correspond to most of those given during the regular school year. Certain entrance subjects are also given at the Institute in the summer, the passing of any one of which will excuse an applicant from taking the regular entrance examination in that subject.

Professional summer schools in Civil Engineering, Mining Engineering, Metallurgy, Chemistry and Geology are also carried on. This work is supplementary to that given during the regular terms.

**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 considered as provisional students in such subjects. Students whose work is generally low and students readmitted to the Institute after dismissal or after withdrawal incident to low standing are considered as provisional in all subjects. Provisional admission to 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. to 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 during the second term on Saturday afternoons beginning in March; those received at the end of the second term must be made up the following September. A student not taking an examination at the time stated forfeits the right to 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. A clinic is held by a

doctor every morning 8.30-9.30 and 10-12, and every afternoon 1-3 and 4-5 for the care of the sick. Students in the first year are required to take physical exercise, and have the option of taking routine gymnastic work in the gymnasium or substituting one of the competitive sports. Gymnastic facilities are available for all students.

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

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

With a view to correcting certain physical defects a course in gymnastics is given by an instructor especially trained in this work. Students who are found to be markedly unfit physically 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.

**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 of Students is the general consulting officer for all students, and coöperates with the President in matters touching discipline and general student relations. 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, undergraduate or graduate, is \$500 per year and must be paid *in advance* as follows: \$250 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. 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.

The tuition fees for students taking Course I-A or VI-A after the second year or X-A are \$166 for the Summer term and \$167 for the two succeeding terms.

Sons of regular Army, Navy and Marine Corps Officers who are admitted to the Institute as undergraduate students will pay one-half the regular tuition, upon the recommendation of the Faculty Committee on Undergraduate Scholarships, the total number not to

exceed ten each year. Preference will be given to qualified applicants admitted to the first year class. Holders of these awards, if recommended by the Committee, may continue at the half tuition rate during their second and succeeding undergraduate years.

The tuition for members of the teaching staff working for the Master's degree is at the special rate of \$4.75 per "unit" for all subjects, including research, for which they are registered. A "unit" signifies 15 hours work, and applies to both exercise and preparation. Thus for a subject listed as 2-4 units, the fee would be  $6 \times \$4.75 = \$28.50$ .

Members of the teaching staff on full-time appointment, pursuing courses leading to the Doctor's degree, and taking more than one subject or engaged in research, pay \$85 for each term for which they are registered as proceeding toward the degree. If taking but a single subject, the fee shall be at the staff rate of \$4.75 per "unit." Those on half-time appointment pay \$125 for each term for which they are registered as proceeding toward the degree. The above fees admit members of the staff working for the Doctor's degree to all subjects, both undergraduate and graduate, which are approved by their respective Departmental Committees, and to thesis work.

No fee is charged for carrying on research for a Doctor's degree during the Summer Session.

Candidates for the Doctor's degree who have been absent from the Institute and who return for the final examination on their thesis must register for the examination and pay a fee of \$25.

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

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

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

**Deposits to Cover Chemical Supplies, Military Uniforms, etc.** To cover chemical supplies and military uniforms, all first-year men will be required to make a deposit of \$15, from which the laboratory supplies charges and damage to military uniforms are to be deducted.

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

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

If the total of the supplies, 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.

**Graduate and Undergraduate Dues.** From the tuition fee of all students registered the Institute will appropriate the sum of \$4.00 per term per student (\$8 per year) to be used as follows: the proceeds 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 . . . . .	\$0.36	Athletics . . . . .	\$6.80
Class Dues . . . . .	.44	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.*

## LOANS, SCHOLARSHIPS, FELLOWSHIPS AND PRIZES

### LOANS

Funds available for loans to assist undergraduate and graduate students to meet their tuition fees have existed for a number of years. The establishment of the Technology Loan Fund in June, 1930, markedly increased the Institute's resources from which such assistance can be rendered.

The regulations governing the administration of the Technology Loan Fund provide that it will be the general policy to make a loan

only to a student who has completed at least one year of residence at the Institute with a good academic record. Only in *exceptional* cases will applications be considered from a student after one semester of residence and only in *very special and unusual* cases from entering students who have met, with high standing, all entrance requirements.

The maximum amount loaned to an individual in a single year may not exceed the tuition fee, less any scholarship grant, or other award, from Institute funds.

To receive favorable consideration an applicant must:

1. Be endorsed as to character and personality by: (a) an alumnus of the Institute from the community in which he has resided, or by some other citizen of standing in that community; (b) the Principal or Head Master of the high school or preparatory school, or the President or Dean of the college or university he has previously attended; (c) his Registration Officer or the Head of the Course in which he is enrolled.

2. Have passed with a standing satisfactory to the Board, the physical examination required annually of all Institute students.

3. Submit a statement of his financial needs and such other information as the Board may deem necessary, on the application form supplied by the Board, such application to have the approval of his parent or guardian.

A recipient of a loan will be required to sign promissory notes in \$50 units up to the amount of his loan, each note carrying interest at two per cent per annum from the date of its issue to a date not exceeding two years after he leaves the Institute, and at five per cent per annum thereafter. Interest is to be paid semi-annually. Each note shall have a definite maturity, such maturities to be spaced at intervals of six months, beginning on or before the December thirty-first following the recipient's expected date of graduation, but payments may be anticipated.

Upon signing notes, the student will be supplied with copies thereof. After leaving the Institute he will be required to advise the Board annually, or at more frequent intervals, as to his whereabouts, the character of the work in which he is engaged, the remuneration he is receiving and his plans for the repayment of his obligations to this Fund.

### 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 over \$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 students as possible by assigning, in general, amounts less than full tuition. Awards are made, except those designated below as open to freshmen, only to students who have completed at least a year of satisfactory work at the Institute.

In making assignments the ability of the student as indicated by his scholastic record is the primary consideration. However, account is also taken of the applicant's evidences of need for financial assistance of his good character and of his general worthiness and professional promise.

Applications for undergraduate scholarship aid should, except as noted below, be made not later than February 15 on blanks to be obtained at Room 3-108. Applications by an entering student for the Cambridge Scholarships should be filed with the Head Master or Principal of the applicant's school not later than June 1 of the year in which he plans to enter the Institute.

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

**Army and Navy Scholarships (1930).** Sons of regular Army, Navy and Marine Corps Officers, who are admitted as undergraduate students to the Institute, will pay one-half the regular tuition, \$250, upon the recommendation of the Faculty Committee on Undergraduate Scholarships, the total number not to exceed ten each year. Preference will be given to qualified applicants admitted to the first-year class. Applications should be addressed to the Office of the Dean of Students, M. I. T., and should be accompanied by documentary evidence that the applicant's father is a commissioned officer in the regular Army, Navy or Marine Corps. It is the policy of the Faculty Committee on Undergraduate Scholarships not to recommend a man for one of these awards unless he has satisfied with high standing all entrance requirements of the Institute. Holders of these scholarships, if recommended by the Faculty Committee on Undergraduate Scholarships, may continue at the half tuition rate during their second and succeeding undergraduate years.

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

**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."

**Albert G. Boyden Fund (1931).** By the will of Elizabeth R. Stevens, the Institute received a bequest of \$40,000 as a permanent fund, to be known as the Albert G. Boyden Fund, "income only to be awarded as scholarships to assist worthy and needy students, preference to be given to young men or women residents of the Town of Swansea or the City of Fall River."

**Bridgeport Scholarship (1932).** Established by the Institute through a bequest received by the will of Horace T. Smith of the Class of 1898, to be known as the Horace T. Smith Scholarship Fund. A scholarship, carrying a stipend of full tuition for the freshman year, is annually offered to a graduate of the High Schools of Bridgeport, Connecticut, recommended by the Superintendent of Schools, to whom application must be made not later than June 1 of the year in which the applicant plans to enter the Institute. Preference will be given to individuals who have, as of July 1, fulfilled all entrance requirements of the Institute, with the further stipulation that no individual will be eligible to receive a Bridgeport Scholarship until he has fulfilled all entrance requirements of the Institute.

**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 scholarship . . . the income to be given to such needy and deserving young women desiring to become students at M. I. T. as would otherwise be unable to attend; and in case of two or more applicants of equal merit, preference shall be given to a native of either Massachusetts or New Hampshire."

**Cambridge Scholarships (1916).** A limited number of scholarships is granted to students entering the first year class at the Institute, who are graduates of schools in Cambridge and children of legal residents of that city. These Cambridge Scholarships, which carry a stipend of full tuition, are confined to students who make application furnishing evidence of need. An award may be continued in the second, third and fourth years upon annual reapplication, providing the holder maintains a satisfactory scholastic record and continues to furnish evidence of need. Original application for a Cambridge Scholarship should be made through the Head Master, or Principal, of the applicant's school, and such application must be filed with the Head Master, or Principal, not later than June 1 of the year in which the applicant plans to enter the Institute. Awards will be by competition, but no successful candidate will be entitled to benefit from an award unless he or she satisfies, prior to admission, all entrance requirements of the Institute.

**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 Teshler 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."

**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).** 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 repaid by the recipients when and if able.

**Fred L. and Florence L. Coburn Fund** (1932). By the will of Fred L. Coburn, the Institute received a bequest of \$5,000, the income of which "shall be expended by said Trustees in giving aid and assistance to students of M. I. T. . . . preference being given by said Trustees to students residing in Somerville, Massachusetts."

**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."

**Dormitory Fund** (1903). Raised by miscellaneous subscriptions and formerly known as Students' Aid Fund.

**Thomas Messenger Drown Scholarships** (1928). By the will of Mary Frances Brown, the Institute received a bequest of \$50,000, the net income of which was "to be used to establish scholarships for deserving undergraduate students, to be known as the Thomas Messenger Drown Scholarships."

**East Bridgewater Scholarship** (1932). Established by the Institute through a bequest received by the will of Horace T. Smith of the Class of 1898, to be known as the Horace T. Smith Scholarship Fund. A scholarship, carrying a stipend of full tuition for the freshman year, is annually offered to a graduate of the High School of East Bridgewater, Massachusetts, recommended by the Principal to whom application must be made not later than June 1 of the year in which the applicant plans to enter the Institute. Preference will be given to individuals who have, as of July 1, fulfilled all entrance requirements of the Institute, with the further stipulation that no individual will be eligible to receive an East Bridgewater Scholarship until he has fulfilled all entrance requirements of the Institute.

**Fall River and Swansea Scholarships** (1932). Established by the Institute through a bequest received by the will of Elizabeth R. Stevens, known as the Albert G. Boyden Fund. Five scholarships for the freshman year, three carrying stipends of full tuition and two carrying stipends of half tuition, are annually offered to qualified applicants residing in Fall River or Swansea, Massachusetts. Application must be made to the Superintendent of Schools, either of Fall River or of Swansea, not later than June 1 of the year in which the applicant plans to enter the Institute. Preference will be given to individuals who have, as of July 1, fulfilled all entrance requirements of the Institute, with a further stipulation that no individual will be eligible to receive one of these scholarships until he has fulfilled all entrance requirements of the Institute.

**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."

**Freshmen Competitive Scholarships** (1931). A limited number of scholarships is granted to students entering the freshman class at the Institute by examination from secondary schools. These scholarships are for full or half tuition for the first year, and awards will be made by the Faculty Committee on Under-

graduate Scholarships based primarily upon the entrance records. They are confined to students who make application to the Office of the Dean before July 1 of the year in which they plan to enter, and who have, prior to the time of application, satisfied all entrance requirements for admission to the Institute.

**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."

**John A. Grimmons Perpetual Loan Scholarship Fund (1930).** In memory of John A. Grimmons of the Class of 1921 through a deed of trust executed by the late C. Lillian Moore, the Institute received a sum of money to be "used in making loans to undergraduates who are preparing to make Electrical Engineering their life work; such loans to be known as given from the John A. Grimmons Perpetual Loan Scholarship; such loans are not to exceed six hundred (600) dollars to any one student in any one year and are to be made on condition that the loans shall bear interest at five per cent, and shall be repaid within ten years, and that repaid loans shall be treated as income to revert into the Perpetual Loan Fund and to be reloaned from time to time; such loans are to be protected by life insurance . . . . Loans are to be awarded to male, white, native born citizens of the United States, who are loyal to the State and Nation, are of sound physical body and show steadiness of purpose and zeal in educational acquirements."

**James H. Haste Fund (1930).** By the will of James H. Haste of the Class of 1896 the Institute received a bequest, the income of which is "for the aid of deserving students . . . of insufficient means, said fund, together with any other sums which said institution may receive under this will, to be known as the James H. Haste Fund."

**Health Education Scholarships (1928).** Two scholarships carrying full tuition open to young women preparing themselves for professional work in Health Education have been established by the Institute. These scholarships are awarded before the last day of July each year upon the basis of previous academic record, professional accomplishment in the field of health or of education, need, and likelihood of future contribution to Health Education. Application for these scholarships should be made directly to the Head of the Department of Biology and Public Health.

**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."

**David L. Jewell Fund (1928).** By the will of Col. David L. Jewell, of Wollaston, Quincy, Norfolk County, Massachusetts, the Institute received a bequest of \$25,000 "to establish a fund to be known as the David L. Jewell Fund, the income therefrom to be used to pay the tuition charges of five young men who may be selected by the President or Board of Trustees of the Institute as worthy of assistance, and who, were it not for such assistance, might be unable to pursue their studies at such Institute."

**Joy 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."

**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 Master of the Newton High Schools." Beneficiaries under this fund, who may be entering freshmen, 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 pupils of the Milton High School in good standing at the Institute as the Master of that school and the School Committee of the town may select. Entering freshmen are eligible to receive this award.

**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."

**New England C. M. T. C. Scholarship (1931).** This Scholarship was established by the Institute and carries a stipend of full tuition for the freshman year. It is awarded to a member of one of the Citizens' Military Training Camps of the First Corps Area, United States Army, selected from the "Whites" or the "Blues," based upon the reports and records transmitted to the Headquarters of the First Corps Area. Application must be made to the Commanding General of the First Corps Area not later than July 1 of the year in which the applicant plans to enter the Institute. The applicant must furnish evidence to the Commanding General that he has not sufficient funds to defray all expenses at the Institute together with such other information as may be requested. Preference will be given to individuals who, at the time of making application, have fulfilled all entrance requirements of the Institute with the further stipulation that no man will be eligible to receive the New England C. M. T. C. Scholarship until he has fulfilled all entrance requirements of the Institute.

**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 making 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."

**Sons and Daughters of New England Puritan Colony Scholarship Fund (1931).** Founded with a gift of \$600 from the Sons and Daughters of New England Puritan Colony. Holders of this scholarship must be of New England ancestry.

**Alumni Regional Scholarships (1926).** As a means of obtaining the cooperation 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.

**William Barton Rogers Scholarship (1904).** In commemoration of the early association of President William Barton Rogers with the College of William and Mary, the Institute established a scholarship with the value of \$400 a year, to be known as the William Barton Rogers Scholarship. It is granted to a student nominated by the faculty of the College of William and Mary.

**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.

**Horace T. Smith Scholarship Fund (1931).** By the will of Horace T. Smith of the Class of 1898, the Institute received a bequest, the income of which is to provide scholarships to worthy students, preference to be given to graduates of the East Bridgewater and Bridgeport High Schools.

**Stevenson Taylor Scholarship (1928).** The American Bureau of Shipping has established a scholarship in memory of Stevenson Taylor, its late President. The scholarship, which is tenable for two years, carries an annual stipend of \$500 and is awarded in alternate years to a deserving third-year student (who must be an American citizen) in the course in Ship Operation of the Department of Naval Architecture and Marine Engineering. Applications should be made directly to the Head of the Department of Naval Architecture and Marine Engineering.

**Samuel E. Tinkham 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. Applications should be made directly to the Head of the Department of Geology.

**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."

**Samson R. Urbino Fund (1927).** By the will of Samson R. Urbino, the Institute received a bequest of \$1,000, the income of which is "to be used to aid students who need assistance, Germans preferred."

**Vermont Scholarship (1924).** From Redfield Proctor of the Class of 1902, the Institute received a gift of \$6,000 (in 1928 increased to \$8,000) 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 by the alumni of the State of Vermont 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."

**Amasa J. Whiting Fund (1927).** By the will of Mary W. C. Whiting, the Institute received a bequest of \$2,000 "to constitute a fund to be known as Amasa J. Whiting Fund . . . the income . . . to pay or help to pay tuition of deserving students whose means are limited. . . . Preference shall be given to students coming from the town of Hingham, Massachusetts."

**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."

## FELLOWSHIPS AND GRADUATE SCHOLARSHIPS

Fellowships and graduate scholarships amounting to approximately fifty-five thousand dollars will be available in 1933-34 to assist students in pursuing graduate work leading to the Master's and Doctor's degrees.

Applications for financial aid must be filed with the Secretary of the Committee on the Graduate School *on or before the first of March*. This rule applies to renewal of previous grants as well as to new applications. Late applications will receive consideration only if funds become available subsequent to the first allotment of awards.

An application for scholarship aid must be accompanied by an application for a course of advanced study leading to the Master's

or Doctor's degree, and except for Institute students an official transcript of the applicant's college record, and at least three letters from persons personally acquainted with his academic work. Both applications must be made on forms which may be obtained from the Secretary of the Committee of the Graduate School.

Awards to students who have not been in residence at least one semester will not exceed the amount of full tuition (\$500 for the school year). Fellowships carrying stipends in excess of tuition are in general awarded only to students who have demonstrated their ability to carry on graduate study and research in residence.

In the award of graduate scholarships the committee considers first, the ability of the applicant 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.

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

#### TEACHING FELLOWS AND ASSISTANTS

Graduate students desiring appointments as Teaching Fellows or Assistants, with the intention of pursuing at the same time graduate work leading to a higher degree, should apply directly to the head of the department in which they wish to enter. All staff appointments of this kind are made upon recommendation of the head of the department. Staff members may apply, however, in the usual way for scholarship grants to defray their tuition, and such applications, if endorsed by departmental committees, usually receive favorable consideration by the Committee on the Graduate School to the extent that scholarship funds are available. For this reason it is important that applications be filed not later than March 1.

#### TRAVELING FELLOWSHIPS

A limited number of traveling scholarships are open to Institute graduates and to members of the instructing staff. Students planning to study abroad should consult the Dean of the Graduate School

in regard to special privileges offered by universities and technical schools of various countries in coöperation with the Institute of International Education.

Holders of Institute Traveling Fellowships are expected to present to the Dean of the Graduate School on or before 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.

#### HONORARY FELLOWS

A student who is working for the degree of Doctor of Philosophy, Doctor of Science or Doctor of Public Health, either at the Institute or under an Institute 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. The appointment being honorary carries no stipend.

#### ENDOWMENT FUNDS APPLICABLE TO FELLOWSHIPS AND GRADUATE SCHOLARSHIPS 1933-1934

**Austin Fund (1899).** Founded by a bequest of Edward Austin, to assist meritorious students and teachers in the pursuit of their studies. From this fund approximately \$18,500 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 toward the Master's or Doctor's degrees, and for special Fellowships.

**Austin Research Fellowship (1909).** Carrying an award of \$1,000 open to candidates for the Doctor's degrees who have shown exceptional ability in the field of research.

**Jonathan Whitney Fund (1912).** The income from this fund, established by Mrs. Frances B. Greene, is available for the purpose of aiding students who need financial assistance in obtaining an education at the Institute; \$22,000 available for tuition of graduate students.

**William Sumner Bolles Fellowship (1924).** Founded by William P. Bolles, to establish and maintain either a fellowship, a traveling scholarship or a resident scholarship, the recipient to have character, ability or promise. Stipend \$1,100.

**Malcolm Cotton Brown Fellowship (1922).** 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 Fellowship is available for study abroad as well as for graduate work at the Institute of Technology. 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. (Not available 1933-34.)

**Henry Saltonstall Fellowship** (1901). Founded by the bequest of Henry Saltonstall. The income to be used to aid students, whether undergraduates or graduates, pursuing advanced courses. Stipend \$500.

**James Savage Fellowship** (1873). Founded by 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 \$500.

**Susan H. Swett Fellowship** (1888). Founded by Susan H. Swett, the income to support a graduate student. Awarded annually to a student specially fitted to pursue advanced study. Holder to be a graduate of the Institute, or of some similar institution of equal standing, and to be reeligible for a second year. Stipend \$500.

**Louis Francisco Verges Fellowship** (1924). Established by Caroline A. Verges, 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.

**Charles H. Dalton Scholarship** (1896). Founded by Charles H. Dalton, the income to be used for the payment of fees of American male students, graduate, of the Institute, who may wish to pursue advanced chemical study and research especially applicable to textile industries. Stipend \$300.

**Moore Traveling Fellowship** (1914). 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 \$1,500.

**Frank Hall Thorp Fellowship in Industrial Chemistry** (1932). Established as a memorial to Professor Frank Hall Thorp, the income from \$10,000 to be awarded on nomination by the Department of Chemical Engineering to a member of the graduate class of the Massachusetts Institute of Technology to enable him to pursue advanced study and research in the field of Industrial Chemistry. Stipend \$400.

**Ellen H. Richards Memorial Research Fund** (1912). Established by subscription. 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 Russell Fund** (1904). Founded by Theodore E. Russell in memory of his brother Richard Lee Russell. The income to be devoted to assisting some worthy student of high standing in the Department of Civil Engineering to continue his studies either as postgraduate or undergraduate. Stipend \$150.

**Wilfred Lewis Fellowship** (1930). Established by Mrs. Wilfred Lewis as a Graduate Fellowship in the Department of Mechanical Engineering. Stipend \$200.

**Willard B. Perkins Fund** (1898). Founded by a bequest of Willard B. Perkins, of the Class of '72. The income, amounting to fifteen hundred dollars, available every fourth year for a traveling scholarship in Architecture. (Not available 1933-34.)

**Rebecca R. Joslin Graduate Scholarship Fund** (1924). 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** (1916). Bequest of Helen Collamore, the income to be applied primarily to the aid of women students in graduate courses; \$600 available.

**Henry Bromfield Rogers Fund** (1921). Founded by Anna Perkins Rogers. 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; \$1,000 available.

**SPECIAL FELLOWSHIPS AND GRADUATE SCHOLARSHIPS  
1933-1934**

**Traveling Fellowship in Architecture.** For 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. Stipend \$1,500.

**Redfield Proctor Traveling Fellowship.** Offered by Redfield Proctor, for graduate study abroad in an English-speaking university, approved by the Dean of the Graduate School. Open to any graduate of the Massachusetts Institute of Technology, or in case there is no suitably qualified candidate among the graduates of the Institute, open to any graduate student who has been in residence for at least one year. Stipend \$1,500.

**Sloan Fellowship in Automotive Engineering.** Offered by Alfred P. Sloan, Jr., for Graduate Study and Research in the field of Automotive Engineering. Stipend \$1,000.

**Textile Research Fellowship.** Offered by the Arkwright Club to encourage properly qualified students to pursue graduate study and research in the field of textiles; \$2,000 available.

**THE TECHNOLOGY LOAN FUND**

The Institute also offers financial assistance to graduate students through the Technology Loan Fund established in 1930. Inquiries regarding the Loan Fund (see page 42) and applications for loans (not exceeding tuition, \$500), should be addressed to the Chairman, Technology Loan Fund Board, Room 3-108. If an application is made at the same time for a graduate scholarship *both* applications should be sent to the Secretary, Committee on the Graduate School, Room 3-105.

**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 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, fifth and graduate years.

**The "Class of 1904" Prize.** The gift of the Class of 1904. Three prizes of five dollars each awarded to students in the third year class in Design for sketch problems.

**Fontainebleau Prize.** One scholarship of five hundred dollars, at the Fontainebleau School of Fine Arts. Awarded in either the fourth or fifth years.

**Freehand Drawing Prize.** Fifty dollars. Awarded to the student whose work is judged to be the best in a competition at the end of the year.

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

**Student Medal of the American Institute of Architects.** This medal is awarded on the recommendation of the Department to the member of the fifth-year 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, also to students in Grades V and VI with the highest number of "medal" values.

**Summer Sketching Prizes.** A prize of twenty-five dollars for the best set of outdoor summer sketches in pencil or pen and ink or measured drawings 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.

The following prize is offered to students in Aeronautical Engineering:

**James Means Memorial Prize.** A medal is given annually for a paper on an aeronautical subject.

The following annual prize is offered to students in the Department of Chemical Engineering:

**Hunneman Prize.** An award of fifty dollars to the most meritorious senior who has shown outstanding originality in his work in the regular course in Chemical Engineering. Established by William Cooper Hunneman in memory of his son, Roger DeFriez Hunneman, A.B. Harvard 1917, S.M. Massachusetts Institute of Technology 1923.

**Robert A. Boit Prizes.** By the will of Robert A. Boit the sum of \$5,000 was left to the Institute, the interest of which is to be used in annual prizes, "to stimulate the interest in the best use of the English language." The prizes are awarded on the basis of the written work done in the course.

## 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 in small sections, 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 deferred until the graduate year; 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 are required to devote a specified amount of time to elective work in General Studies.

Special attention is 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.

Courses of study leading to the Bachelor's degree are offered in the several branches of science and engineering named on following page. (See pages 74 to 139 for course schedules.)

**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 (1a), Biology (1b), Industrial Biology (2), and Public Health Engineering (3).

**Building Engineering and Construction, Course XVII.**

**Business and Engineering Administration, Course XV,** with options in Engineering and Chemistry.

**Chemical Engineering**, Course X, and Chemical Engineering Practice, X-B.

**Chemistry**, Course V.

**City Planning**, Course IV-B.

**Civil Engineering**, Course I, with options. General (1), Transportation Engineering (2), Hydroelectric Engineering (3), and Geodesy and Seismology (4).

**Electrical Engineering**, Course VI. Also option in Communications Engineering, VI-C, and Coöperative Course in Electrical Engineering, VI-A.

**Electrochemical Engineering**, Course XIV.

**General Science**, Course IX-A.

**General Engineering**, Course IX-B.

**Geology**, Course XII.

**Mathematics**, Course XVIII.

**Mechanical Engineering**, Course II.

**Mining Engineering and Metallurgy**, Course III, with options in Mining Engineering (1), Petroleum Production (2), Metallurgy (3), and Physical Metallurgy (4).

**Military Engineering**.

**Naval Architecture and Marine Engineering**, Course XIII.

**Physics**, Course VIII.

**Sanitary Engineering**, Course XI.

**Ship Operation**, Course XIII-C.

In most of these courses distinct options or electives in professional subjects 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.

The course in Architecture 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 Business and 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, 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, 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, Mining and Metallurgy, Public Health Engineering, Geology and Building Construction. The students, accompanied by instructors, give their time to fieldwork, or visit and report on mines or industrial establishments.

**Summer School of Civil Engineering.** With the exception of brief courses in the manipulation and use of the tape, compass, transit and level, the entire fieldwork in surveying and railroad engineering required of students in courses mentioned below 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 fieldwork 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 fieldwork 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 staff 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. A geodetic observatory is located in a separate building at a distance of about one-quarter of a mile from the main buildings, and near-by is a seismograph building built upon an outcropping ledge. The seismograph building is constructed in such a way as to protect the seismograph instrument from unnecessary temperature change. Sleeping quarters for students are provided in eight wooden barracks, each containing six double rooms. Sleeping quarters for the faculty members of the instructing staff are provided in a separate building. Another large wooden building provides drafting space for twenty-four students. 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, VII<sub>3</sub>,

XI, XV Option 1a and XVII, but students from other courses will be admitted.

The tuition fee is \$100. The cost of operating the camp during the session is shared equally by those in attendance. Deposit for board and incidental expenses is \$80.

**Summer School of Surveying for Mining Engineers and Geologists.** Surveying, 1·10, which is given at the Summer Mining Camp at the Scrub Oaks Mine near Dover, N. J., includes topographic surveying, leveling and mine surveying. It is required for students in Course III, Options 1 and 2, between their second and third year; and for students in Course XII, between their third and fourth year. The camp, which is about one hour's 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 2, either between the second and third or between the third and fourth years, is given at the Summer Mining Camp. The fee is \$15; deposit for board and incidental expenses, \$20.

**Summer School in Petroleum Production.** Oil Field Visits 3·89, required of all students in Course III, Option 2, either between the second and third or between the third and fourth years, is given in the oil fields of western Pennsylvania. The fee is \$15 and each student will pay his own expenses estimated at \$30 for the trip.

**Summer School of Metallurgy.** Plant Visits 3·60, required of all students in Course III, Options 3 and 4, 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. The fee is \$15 and each student will pay his own expenses estimated at \$75 round trip from Boston.

**Summer School of Surveying.** Students in Courses III, Option 3, VI, and XV<sub>c</sub> are required to take Surveying, 1·02, in the early part of the summer following their second year; students in VI-A, following their first year. The instruction is given in Cambridge and vicinity. The fee for this course is \$15.

**Summer School in Field Geology.** A ten-day summer course in an area in the vicinity of the Delaware Water Gap, Pennsylvania, where an interesting geological history is presented, and where Cam-

brian and Ordovician sediments are conspicuously folded and faulted. Instruction and practice are given in detailed geological mapping and in field methods of geological work. September 14 to 24 inclusive. Tuition fee \$40. Each student will pay his own expenses, estimated at \$30 for the trip.

## REQUIREMENTS FOR ADMISSION

*(For Admission with Advanced Standing see page 71)*

**Admission to First Year.** Since the Institute desires to admit only those students who can pursue its courses with success and profit, it has established certain minimum entrance requirements which afford the applicant, as well as the Institute, an opportunity to determine whether his preparation and qualifications are adequate. The applicant should possess those qualities, both of character and intellect, which indicate his adaptability to an academic environment and which show promise of his developing into a useful and forceful citizen.

For the greater convenience of those who seek admission as first-year students, the Institute offers two courses of procedure: (1) admission by examination; (2) admission without examination. Both of these plans are described in detail below, but applicants are invited to correspond with the Director of Admissions if additional information or explanation is needed.

**Plan I. Admission by Examination.** Applicants may take the College Entrance Examination Board examinations (offered in June), the Massachusetts Institute of Technology examinations (offered in September), or the New York State Regents examinations. Only records of 80 per cent, or better, will be accepted in the latter. Applicants planning to take the Regents examinations should notify the Director of Admissions.

The methods of meeting the requirements for the individual subjects are given below. (Numbers in parentheses indicate ordinary "unit" rating.)

1. Pass examinations in:

Algebra (2).

Plane Geometry (1).

Solid Geometry ( $\frac{1}{2}$ ).

Trigonometry ( $\frac{1}{2}$ ).

Physics (1).

English (3).

\*Foreign Language — **One** of the combinations below (*a*, *b* or *c*) except as indicated in footnote:

- (*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. Present school **record of certificate grade** or pass **examination** in: History (1)

3. Present school **record of passing grade** or pass **examination** in: Chemistry (1)

Electives.

**Two units** if language group (*a*) or (*b*) is offered.

**One unit** 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 Director of Admissions.)

Biology (1).	History, additional (1).
Botany (1).	Latin (2). (Not less than two
English, additional (1).	units accepted.)
French, Intermediate† (1).	Spanish (1).
German, Intermediate† (1).	Zoölogy (1).

**Plan II. Admission without Examinations.** The Institute is now admitting as an experiment a *limited* number of students without examinations. The requirements which an applicant must fulfill in order to obtain admission without examinations are as follows:

1. The applicant must have been graduated from a secondary school accredited by the Institute and have ranked in the upper fifth of his class.

The upper fifth ranking should be based on the applicant's relative standing during his last two years of attendance and must be certified by the Principal or Head Master. This plan of admission will not apply unless the graduating class has a minimum of ten students.

\***Substitutions in Foreign Language.** The Institute prefers that a candidate fulfill the language requirements by presenting one of the complete groups (*a*), (*b*), or (*c*). In any case, elementary French or Elementary German is required, but the remainder of the requirement may be met by offering one of the following subjects, provided a record of 80 per cent in the Regents, or of 60 per cent, or better, in the C. E. E. B. or Technology examination is obtained.

Elementary Spanish (College Board Cp. 2)  
 Elementary Italian (College Board Cp. 2)  
 Elementary Latin (College Board Cp. 2)  
 (If Latin is offered, a College Board or Regents examination should be taken, as no examination in Latin is given by the Institute.)

† If offered in excess of the requirement under *c*.

2. The applicant must have completed the program of subjects required for admission as stated under Plan I (page 61).
3. In addition to the above requirements, the applicant must present letters of recommendation from his principal and from two persons (not relatives) of recognized standing in his community who are acquainted with his personal qualities and ability.

Letters of recommendation should state the outstanding qualities of the prospective student.

The evidence of preparation as outlined above should be submitted before April 15 of the year in which the applicant plans to enter.

**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, Geneva and other foreign centers. Applicants taking examinations under the College Entrance Examination Board should do so under "Plan A." 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.

In September the Institute conducts its own examinations which are held in Cambridge only. Correspondence in regard to these examinations and questions relating to admission or courses of study should be addressed to the Director of 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 19-24, 1933.** 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, 1933, is 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*

Algebra  
Chemistry  
English  
French (Elementary)  
French (Intermediate)  
Geometry, Plane  
Geometry, Solid  
German (Elementary)  
German (Intermediate)

*C. E. E. B. Subjects*

Mathematics A, or A1 and A2  
Chemistry  
English Cp or 1-2  
French Cp 2  
French B  
Mathematics C  
Mathematics D  
German Cp 2  
German B

*M. I. T. Subjects*

History  
Physics  
Plane Trigonometry

*C. E. E. B. Subjects*

History A, B, C, or D.\*  
Physics  
Mathematics E

Electives:

History A, B, C or D; 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 (major requirement) will be accepted. If the single examination in Geometry CD is taken, a record of at least 70 is required.

Records in Mathematics Cp 3 and Mathematics Cp H are not accepted.

Candidates are expected to take, if practicable, the divided examinations in French or 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.

The Scholastic Aptitude Test is not required.

\*No examination in American History without Civil Government will be offered.

**Schedule of Examinations at Institute in September 1933**

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

**Wednesday, September 13**

Algebra . . . . .	9.00 a.m. to 12.00 m.
*French (Elementary) . . . . .	2.00 p.m. to 5.00 p.m.

**Thursday, September 14**

English . . . . .	9.00 a.m. to 12.00 m.
*German (Elementary) . . . . .	2.00 p.m. to 5.00 p.m.

**Friday, September 15**

Trigonometry . . . . .	9.00 a.m. to 10.45 a.m.
Physics . . . . .	11.00 a.m. to 1.00 p.m.
*French (Intermediate) . . . . .	2.00 p.m. to 5.00 p.m.
*German (Intermediate) . . . . .	2.00 p.m. to 5.00 p.m.

**Saturday, September 16**

Plane Geometry . . . . .	9.00 a.m. to 10.45 a.m.
Solid Geometry . . . . .	11.00 a.m. to 1.00 p.m.
History, United States or Ancient . . . . .	2.00 p.m. to 5.00 p.m.

**Monday, September 18**

Chemistry . . . . .	9.00 a.m. to 11.00 a.m.
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**Schedule of Examinations at Institute in September 1934**

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

**Wednesday, September 12**

Algebra . . . . .	9.00 a.m. to 12.00 m.
*French (Elementary) . . . . .	2.00 p.m. to 5.00 p.m.

**Thursday, September 13**

English . . . . .	9.00 a.m. to 12.00 m.
*German (Elementary) . . . . .	2.00 p.m. to 5.00 p.m.

**Friday, September 14**

Trigonometry . . . . .	9.00 a.m. to 10.45 a.m.
Physics . . . . .	11.00 a.m. to 1.00 p.m.
*French (Intermediate) . . . . .	2.00 p.m. to 5.00 p.m.
*German (Intermediate) . . . . .	2.00 p.m. to 5.00 p.m.

**Saturday, September 15**

Plane Geometry . . . . .	9.00 a.m. to 10.45 a.m.
Solid Geometry . . . . .	11.00 a.m. to 1.00 p.m.
History, United States or Ancient . . . . .	2.00 p.m. to 5.00 p.m.

**Monday, September 17**

Chemistry . . . . .	9.00 a.m. to 11.00 a.m.
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\* Separate examinations must be taken in elementary and intermediate language.

**Entrance Examination Fee.** (See Page 41.)

**Division of Entrance Examinations.** Candidates may spread their entrance examinations over three consecutive years.

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 he may not repeat in September any examinations which he 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 Director of Admissions for 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 applicant 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 a student may not benefit fully from the Institute curriculum if he must divert a portion of his time to making 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.

## 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 textbooks, 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  $30^\circ$  and the  $45^\circ$  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 textbooks, 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  $0^\circ$ ,  $30^\circ$ ,  $45^\circ$ ,  $60^\circ$ ,  $90^\circ$ , and of angles differing from these by multiples of  $90^\circ$ . (2) Determination, by means of a diagram of such functions as in  $(A+90^\circ)$  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. (3) 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 (5'00) 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 lead to rejection, provided the school from which the student comes is unable to furnish such instruction.

The laboratory work should consist of 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 summer course (8'00) 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; conditional sentences; 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 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.*

*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.

**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, Zoology 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 those subjects. Mathematics beyond that required for entrance is essential as a basis for transfer. In case a student is lacking some of the required entrance subjects he will, unless especially excused, be expected to make them up 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 Architecture, Course IV, will be graded in design in accordance with their performance in their first problem.

**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. 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.

To become eligible for the Traveling Fellowship the special student must, in addition to securing satisfactory records in the undergraduate courses in English E11 and 12, graphics, shades and shadows, perspective freehand drawing, architectural history, modeling, theory of architecture, European civilization and

art, philosophy of architecture and design, obtain a satisfactory record in graduate design.

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 BACHELOR'S DEGREE**

To receive the Degree of Bachelor of Science or Bachelor in Architecture, the student must have attended the Institute not less than one academic year, which must in general be that next preceding his graduation. He must have satisfactorily completed the prescribed subjects of his professional course or equivalent work.

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

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

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

The Institute offers courses in 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 Corps and Chemical Warfare. For information and course schedules, see pages 140 to 145.

**UNDERGRADUATE COURSE SCHEDULES FOR 1933-1934**  
**THE NUMBERING SYSTEM**

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

For description of subjects see pages 223-318.

<b>Department</b>	<b>Subject Numbers</b>
Civil Engineering	1.00 to 1.99
Mechanical Engineering	2.00 to 2.99
Mining and Metallurgy	3.00 to 3.99
Architecture and Architectural Engineering	4.00 to 4.99
Chemistry	5.00 to 5.99
Electrical Engineering	6.00 to 6.99
Biology and Public Health	7.00 to 7.99
Physics	8.00 to 8.99
Chemical Engineering	10.00 to 10.99
Geology	12.00 to 12.99
Naval Architecture and Marine Engineering and Ship Operation	13.00 to 13.99
Aeronautical Engineering	16.00 to 16.99
Building Engineering and Construction	17.00 to 17.99
Drawing	D1 to D99
Economics and Business and Engineering Administration	Ec1 to Ec99
English and History	E1 to E99
General Studies	G1 to G99
Languages	L1 to L99
Mathematics	M1 to M99
Military Science and Tactics	MS1 to MS99
Hygiene	PT1 to PT2

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

FIRST YEAR. All Courses (Except IV and IV-B)

<i>First Term</i>		<i>Second Term</i>			
5:01	Chemistry, General.....	7-4	5:02	Chemistry, General.....	7-4
8:01	Physics.....	6-5	8:02	Physics.....	6-5
D11	Drawing & Desc. Geom...	6-1	D12	Drawing & Desc. Geom...	6-1
E11	English.....	2-4	E12	English.....	2-4
M11	Calculus.....	3-6	M12	Calculus.....	3-6
MS11	Military Science.....	3-0	MS12	Military Science.....	3-0
PT1	Physical Training.....	1-0	PT2	Physical Training.....	1-0
Units of exercise and preparation:		28-20	Units of exercise and preparation:		28-20

FIRST YEAR. COURSES IV and IV-B

<i>First Term</i>		<i>Second Term</i>			
4:06	Graphics.....	6-0	2:232T	Structural Mechanics, E1..	3-6
4:11	Shades and Shadows.....	3-0	4:312	Theory of Architecture...	2-2
4:12	Perspective.....	3-0	4:412	Architectural History....	2-3
4:311	Theory of Architecture...	2-2	4:712	Design I.....	12-0
4:411	Architectural History....	2-3	E12	English.....	2-4
E11	English.....	2-4	L64	French.....	3-6
L63	French.....	3-6	MS12	Military Science.....	3-0
M111	Mathematics.....	3-6	PT2	Physical Training.....	1-0
MS11	Military Science.....	3-0	Units of exercise and preparation:		28-19
PT1	Physical Training.....	1-0	Units of exercise and preparation:		28-19

SECOND YEAR

In the Second Year, courses are divided into two groups, Engineering and Chemistry. In each group the basic subjects are common to all courses. In individual courses the remaining units are given to introductory professional subjects.

Engineering Group

<i>First Term</i>		<i>Second Term</i>			
2:00	Applied Kinematics.....	5-3	2:15	Applied Mechanics.....	3-5
8:03	Physics.....	5-5	8:04	Physics.....	6-4
E21	English and History.....	3-5	E22	English and History.....	3-5
M21	Calculus.....	3-6	M22	Differential Equations...	3-6
MS21	Military Science.....	3-0	(Omitted in XIII-C)		
Int. Prof. Subjects.....		12	MS22	Military Science.....	3-0
Total Units.....		50	Int. Prof. Subjects.....		12
			Total Units.....		50

Chemistry Group

<i>First Term</i>		<i>Second Term</i>			
5:11	Qualitative Analysis or		*5:12 or 5:13	Quantitative Anal..	7-2
5:12	Qualitative Analysis.....	7-2	8:04	Physics.....	6-4
8:03	Physics.....	5-5	E22	English and History.....	3-5
E21	English and History.....	3-5	MS22	Military Science.....	3-0
M21	Calculus.....	3-6	Int. Prof. Subjects.....		20
MS21	Military Science.....	3-0	Total Units.....		50
Int. Prof. Subjects.....		11			
Total Units.....		50			

\*Omitted in Courses VIII and XVIII

## I. CIVIL ENGINEERING

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. It covers surveying, methods and practice, including topographic, geodetic and hydrographic surveying, and surveys for engineering construction; transportation engineering, consisting of the building and operation of railroads, highways, canals, docks, harbors, airports, and other similar works; municipal engineering, including the construction of sewers, waterworks, roads, and streets; structural engineering, including the design and 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 four 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 dealing principally with railway and highway transportation and to some extent with air and water transportation, an option in hydroelectric engineering in which special consideration is given to the subject of water power development and an option in geodesy and seismology. The work in all the options is the same for the first three years.

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

I. CIVIL ENGINEERING

FIRST YEAR. See page 75

SECOND YEAR. All Options

<i>First Term</i>		<i>Second Term</i>			
1:00	Surveying . . . . .	2-2	1:01	Surveying and Top. Draw.	4-0
1:39	Graphic Statics . . . . .	3-1	1:12	Astronomy and Spher. Trig.	3-4
2:00	Applied Kinematics . . . . .	5-3	2:15	Applied Mechanics . . . . .	3-5
8:03	Physics . . . . .	5-5	8:04	Physics . . . . .	6-4
E21	English and History . . . . .	3-5	E22	English and History . . . . .	3-5
M21	Calculus . . . . .	3-6	M22	Differential Equations . . . . .	3-6
MS21	Military Science . . . . .	3-0	MS22	Military Science . . . . .	3-0
	General Study . . . . .	2-2		Units of exercise and preparation:	25-24
	Units of exercise and preparation:	26-24			

Required during Summer 1933. At Camp Technology

1:05	Plane Surveying . . . . .	6-1
1:06	Geod. and Top. Surveying	6-0
1:20	Rail. and High. Fieldwork	5-0
1:60	Hydrographic Surveying .	5-0

THIRD YEAR. All Options

<i>First Term</i>		<i>Second Term</i>			
1:13	Geodesy . . . . .	2-2	1:25	Eng. Construction . . . . .	4-4
1:21	Rail. & High. Curves . . . . .	2-2	1:40	Structures . . . . .	3-5
1:43	Materials . . . . .	1-2	1:62	Hydraulics . . . . .	3-5
2:20	Applied Mechanics . . . . .	3-6	2:36	Testing Materials . . . . .	2-1
6:40	Electrical Eng. Elem. . . . .	4-6	6:89	Electrical Eng. Lab. . . . .	2-2
12:321	Geology . . . . .	2-1	12:322	Geology . . . . .	4-4
Ec31	Political Economy . . . . .	3-3	Ec32	Political Economy . . . . .	3-3
Ec50	Accounting . . . . .	4-2		General Study . . . . .	2-2
	General Study . . . . .	2-2		Units of exercise and preparation:	23-26
	Units of exercise and preparation:	23-26			

FOURTH YEAR

Option 1. General

<i>First Term</i>		<i>Second Term</i>			
1:35	Roads and Pavements . . . . .	2-1	1:42	Structures . . . . .	4-8
1:41	Structu.es . . . . .	4-8	1:502	Bridge Design . . . . .	5-0
1:48	Foundations . . . . .	3-4	1:65	Hydraulic Machinery . . . . .	2-2
1:501	Bridge Design . . . . .	7-0	1:76	Sanitary Eng. . . . .	2-3
1:75	Hydraulic and San. Eng. . . . .	4-6	1:79	Hydraulic & San. Design. . . . .	2-0
2:46	Heat Engineering . . . . .	4-7	2:47	Heat Engineering . . . . .	2-3
	Units of exercise and preparation:	24-26	2:63	Eng. and Hydraulic Lab. . . . .	2-2
				Thesis . . . . .	7
				General Study . . . . .	2-2
				Units of exercise and preparation:	48

I. CIVIL ENGINEERING — *Continued*

## FOURTH YEAR

## Option 2. Transportation Engineering

<i>First Term</i>		<i>Second Term</i>	
1'271 Transportation Eng.....	5-5	1'272 Transportation Eng.....	3-3
1'35 Roads and Pavements.....	2-1	1'42 Structures.....	4-8
1'41 Structures.....	4-8	1'502 Bridge Design.....	5-0
1'48 Foundations.....	3-4	2'47 Heat Engineering.....	2-3
1'501 Bridge Design.....	7-0	2'63 Eng. and Hydraulic Lab..	2-2
2'46 Heat Engineering.....	4-7	General Study.....	2-2
Units of exercise and preparation:	25-25	Elective.....	5
		Thesis.....	7
		Units of exercise and preparation:	48

## FOURTH YEAR

## Option 3. Hydroelectric Engineering

<i>First Term</i>		<i>Second Term</i>	
1'41 Structures.....	4-8	1'42 Structures.....	4-8
1'48 Foundations.....	3-4	1'512 Bridge Design.....	6-0
1'511 Bridge Design.....	4-0	1'71 Water Power Eng.....	6-3
1'70 Water Power Eng.....	6-3	2'47 Heat Engineering.....	2-3
2'46 Heat Engineering.....	4-7	2'631 Eng. and Hydraulic Lab..	3-3
6'44 Elec. Trans. & Con.....	2-4	Thesis.....	7
Units of exercise and preparation:	23-26	General Study.....	2-2
		Units of exercise and preparation:	49

## FOURTH YEAR

## Option 4. Geodesy and Seismology

<i>First Term</i>		<i>Second Term</i>	
1'131 Geodesy.....	2-4	1'132 (a) Geod., Astron. & Nav.	3-6
1'135 Seismom. & Vibra. Meas...	3-2	1'133 Geodetic Laboratory.....	2-0
1'41 Structures.....	4-8	1'134 Adjust. of Observations..	3-6
1'48 Foundations.....	3-4	1'138 Seismological Lab.....	4-0
8'161 Optics.....	3-6	1'421 Structures.....	2-4
8'162 Optical Measurements...	3-2	12'87 (b) Geophysics.....	2-2
12'86 Seismology.....	2-2	Elective.....	6
Units of exercise and preparation:	20-28	General Study.....	2-2
		Thesis..... (a)	8
		(b)	13
		Units of exercise and preparation:	48

## I-A. RAILROAD OPERATION\*

## GRADUATE YEAR 1933-1934

<i>First Term</i>	At M. I. T.	<i>Second Term</i>	At M. I. T.
Graduate Study and		Ec63 Business Law and Org.....	3-5
Research.....	48	G10 Dev. of Transportation...	2-2
		Grad. Study and Research	36

\* No additional students will be admitted to this course.

## II. MECHANICAL ENGINEERING

Mechanical engineering, next to the oldest and earliest developed branches of the engineering professions, is essentially the engineering of design and production in industry.

The course in Mechanical Engineering is so broadly fundamental as to prepare the student to enter successfully any of the various branches of this profession whether it be automotive design, engine design, locomotive construction, steam turbine engineering, power plant design, mill engineering, refrigeration, heating and ventilation, hydraulic engineering, factory design and construction, or production methods and industrial management.

Much time is spent during the first two years upon basic courses in chemistry, physics, mechanics, applied kinematics and drawing, and applied mechanics, a thorough knowledge of which is essential in all of the engineering professions.

The student is trained in the mechanic arts sufficiently to familiarize him with the use of modern machine tools, foundry practice, forging and pattern work, a practical knowledge of which is necessary for the successful designer of machinery. He is also given sufficient training in electrical engineering to enable him to handle the ordinary electrical problems which come to the mechanical engineer.

About one-seventh of the curriculum is devoted to the pursuit of general cultural subjects such as English and history, political economy, and general elective courses in this field.

The professional work of the third and fourth years includes lectures and laboratory work in heat engineering, thermodynamics, heat transmission, more advanced work in mechanics, theory of elasticity, machine design and power plant design and lectures and laboratory work dealing with the materials of engineering and the effect of heat treatment and other processes.

In the fourth year the student is offered the choice of one or more of several professional electives.

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

## II. MECHANICAL ENGINEERING

FIRST YEAR. See page 75

### SECOND YEAR

<i>First Term</i>		<i>Second Term</i>		
1'02	Surveying . . . . .	3-1	2'04 Mech. Eng. Equipment . . . . .	3-3
2'00	Applied Kinematics . . . . .	5-3	2'15 Applied Mechanics . . . . .	3-5
2'10	Mech. Eng. Draw . . . . .	5-0	2'90 Forge Shop . . . . .	3-0
2'91	Foundry . . . . .	3-0	2'92 Pattern Making . . . . .	3-0
8'03	Physics . . . . .	5-5	8'04 Physics . . . . .	6-4
E21	English and History . . . . .	3-5	E22 English and History . . . . .	3-5
M21	Calculus . . . . .	3-6	M22 Differential Equations . . . . .	3-6
MS21	Military Science . . . . .	3-0	MS22 Military Science . . . . .	3-0
Units of exercise and preparation: 29-21		Units of exercise and preparation: 27-23		

### Required during Summer, 1933

2'13 Machine Drawing . . . . . 8-0

### THIRD YEAR

<i>First Term</i>		<i>Second Term</i>		
2'05	Mechanism of Machines . . . . .	3-2	2'21 Applied Mechanics . . . . .	3-5
2'20	Applied Mechanics . . . . .	3-6	2'42 Eng. Thermodynamics . . . . .	4-5
2'30	Materials of Engineering . . . . .	2-2	2'70 Machine Design . . . . .	4-0
2'40	Eng. Thermodynamics . . . . .	4-5	2'952 Machine Tool Lab. . . . .	4-0
2'41	Boilers and Engines . . . . .	2-2	6'40 Electrical Eng. Elem. . . . .	4-6
2'951	Machine Tool Lab. . . . .	6-0	6'89 Electrical Eng. Lab. . . . .	2-2
Ec31	Political Economy . . . . .	3-3	Ec32 Political Economy . . . . .	3-3
	General Study . . . . .	2-2	General Study . . . . .	2-2
Units of exercise and preparation: 25-22		Units of exercise and preparation: 26-23		

II. MECHANICAL ENGINEERING — *Continued*

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>			
1'64	Hydraulics . . . . .	3 - 6	2'26	Mechanics of Eng. . . . .	3 - 6
2'251	Dynamics of Machines. . . . .	2 - 4	2'58	Power Plant Design. . . . .	4 - 0
2'35	Testing Materials Lab. . . . .	4 - 2	2'781	Industrial Plants. . . . .	3 - 3
2'43	Refrigeration. . . . .	2 - 4	2'98	Production Methods. . . . .	1 - 1
2'601	Engineering Lab. . . . .	4 - 4	2'602	Engineering Laboratory. . . . .	3 - 3
2'71	Machine Design. . . . .	5 - 0		General Study (G47). . . . .	2 - 2
3'712	Eng. Heat Treatment. . . . .	2 - 0		Professional Electives. . . . .	12
5'683	Physical Chemistry. . . . .	2 - 2		Thesis. . . . .	7
	General Study. . . . .	2 - 2		Units of exercise and preparation:	50
	Units of exercise and preparation:	26 - 24			

## Professional Electives\* — Second Term

2'49	Refrigeration. . . . .	3 - 5	2'331	Eng. Metals. . . . .	2 - 2
2'603	Engineering Laboratory. . . . .	3 - 3	2'782	Industrial Plant Design. . . . .	4 - 0
2'64	Refrigeration Lab. . . . .	2 - 2	2'850	Automatic Machinery. . . . .	2 - 2
2'66	Automotive Laboratory. . . . .	2 - 2	2'853	Locomotive Engineering. . . . .	2 - 2
2'77	Engine Design. . . . .	6 - 2	2'854	Mech. Equip. of Bldgs. . . . .	2 - 2
2'79	Gasoline Automobile. . . . .	4 - 4	2'855	Steam Turbine Eng. . . . .	2 - 2
2'851	Fire Protection Eng. . . . .	2 - 2	2'983	Production Design. . . . .	2 - 2
2'87	Textile Engineering. . . . .	6 - 2	3'714	Heat Treatment. . . . .	4 - 2
2'877	Textile Microscopy. . . . .	5 - 2			

For Automotive work, Electives 2'79 and 2'66 are advised.

For Refrigeration, 2'49 and 2'64.

For Textiles, 2'87 and 2'851.

For Engine Design, 2'77 and 2'983 or 2'331.

\* A professional elective may not be given unless there are at least seven applicants for the subject.

II. MECHANICAL ENGINEERING — *Continued*

## ARMY ORDNANCE

## Summer Term (1933)

2:271 Theory of Elasticity . . . . .	5-9
2:891 Mechanics . . . . .	3-0
5:04 Chemistry, General . . . . .	3-3
5:412 Organic Chemistry . . . . .	6-3

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## FOURTH YEAR (1933-34)

*First Term*

2:03 Mechanisms . . . . .	8-3
2:461 Thermodynamics . . . . .	3-6
5:413 Organic Chemistry . . . . .	6-0
6:42 Electrical Eng. Elem. . . . .	5-5
6:88 Electrical Eng. Lab. . . . .	4-6
10:38 Chemical Engineering . . . . .	5-2
Units of exercise and preparation:	<u>31-22</u>

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### III. MINING AND METALLURGY INCLUDING CERAMICS

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. Four optional courses are open to students in mining engineering and metallurgy.

**Option 1. Mining Engineering.** The field of mining engineering 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. Petroleum Production.** Emphasizes 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. Stress is placed on statistics of importance in the study of petroleum economics from a world viewpoint.

**Option 3. 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 are made to mills, foundries and shops in the vicinity, and are followed by conferences and reports.

**Option 4. Physical Metallurgy.** Designed to give special training in the structures, properties, uses and methods of testing of the ferrous and non-ferrous metals and alloys. Metallography, mechanical treatment and testing, heat treatment, X-ray examination of metals and allied subjects are included. Training in production metallurgy is also given.

**Ceramics.** The instruction and research in Ceramics is mainly intended for graduate work leading to a Master's or Doctor's degree.

However, it is possible for an undergraduate student interested in this subject to register in Course IX-B, General Engineering, and take as electives subjects bearing on Ceramics. This procedure will also give an excellent foundation for graduate work. The subjects dealing with Ceramics are intended to give a fundamental training in the usual manufacturing processes as well as the testing of raw materials and finished ware.

Option 1 and Option 2 lead to the degree of Bachelor of Science in Mining Engineering; Option 3 and Option 4 lead to the degree of Bachelor of Science in Metallurgy.

## III. MINING AND METALLURGY

## Option 1. Mining Engineering

## FIRST YEAR. See page 75

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>			
3:00	Int. to Mining & Metal. . . . .	2-0	2:00	Applied Kinematics. . . . .	5-3
5:11	Qualitative Analysis. . . . .	7-2	5:12	Quantitative Analysis. . . . .	7-2
8:03	Physics. . . . .	5-5	8:04	Physics. . . . .	6-4
12:01	Mineralogy. . . . .	8-2	12:30	Geology. . . . .	4-2
E21	English and History. . . . .	3-5	E22	English and History. . . . .	3-5
M21	Calculus. . . . .	3-6	MS22	Military Science. . . . .	3-0
MS21	Military Science. . . . .	3-0		General Study. . . . .	2-2
Units of exercise and preparation: 31-20		Units of exercise and preparation: 30-18			

## Required during Summer 1933. At Summer Mining Camp

1:10	Surveying. . . . .	23-1
3:08	Mining Practice. . . . .	3-0

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>			
2:15	Applied Mechanics. . . . .	3-5	2:20	Applied Mechanics. . . . .	3-6
3:01	Mining Methods. . . . .	5-4	3:02	Mining Methods. . . . .	5-5
3:31	Fire Assaying. . . . .	6-2	3:21	Ore Dressing. . . . .	3-2
5:13	Quantitative Analysis. . . . .	7-2	3:22	Ore Dressing Lab. . . . .	5-2
12:31	Geology. . . . .	5-3	12:40	Economic Geology. . . . .	4-3
Ec31	Political Economy. . . . .	3-3	Ec32	Political Economy. . . . .	3-3
Units of exercise and preparation: 29-19		General Study. . . . .		2-2	Units of exercise and preparation: 25-23

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>			
2:36	Testing Materials Lab. . . . .	2-1	1:44	Stationary Structures. . . . .	2-3
3:03	Economics of Mining. . . . .	4-4	1:63	Hydraulics. . . . .	2-3
3:13	Geophysical Pros., Elem. . . . .	4-0	3:04	Mining, Principles of. . . . .	3-4
3:412	Metallurgy. . . . .	5-3	3:421	Metallurgy. . . . .	3-1
3:432	Metallurgy. . . . .	2-1	17:46	Building Construction. . . . .	8-0
6:40	Electrical Eng., Elem. . . . .	4-6		Thesis. . . . .	11
6:85	Electrical Eng. Lab. . . . .	2-3		General Study. . . . .	4-4
12:33	Field Geology. . . . .	3-2	Units of exercise and preparation: 48		
12:47	Microst. of Ores & Met. . . . .	3-0			
Units of exercise and preparation: 29-20					

III. MINING AND METALLURGY — *Continued*

## Option 2. Petroleum Production

FIRST YEAR. See page 75

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>	
3:00	Int. to Mining & Metal... 2-0	2:00	Applied Kinematics... 5-3
5:11	Qualitative Analysis... 7-2	5:12	Quantitative Analysis... 7-2
8:03	Physics... 5-5	8:04	Physics... 6-4
12:01	Mineralogy... 8-2	12:30	Geology... 4-2
E21	English and History... 3-5	E22	English and History... 3-5
M21	Calculus... 3-6	MS22	Military Science... 3-0
MS21	Military Science... 3-0		General Study... 2-2
Units of exercise and preparation: 31-20		Units of exercise and preparation: 30-18	

## Required during Summer 1933. At Summer Mining Camp

1:10	Surveying... 23-1
3:08	Mining Practice... 3-0
3:89	Oil Field Visits... 3-0

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>	
2:15	Applied Mechanics... 3-5	2:20	Applied Mechanics... 3-6
3:05	Mining, Elements of... 2-2	3:23	Ore Dressing... 3-2
3:432	Metal. of Iron & Steel... 2-1	3:82	Petroleum Eng., Elem... 5-4
3:81	Petroleum Eng. Elem... 5-4	12:40	Economic Geology... 4-3
5:381	Oil Test. & Petrol. Refin... 5-2	12:80	Geology of Coal & Petrol... 4-3
12:31	Geology... 5-3	Ec32	Political Economy... 3-3
Ec31	Political Economy... 3-3		General Study... 2-2
	General Study... 2-2	Units of exercise and preparation: 24-23	
Units of exercise and preparation: 27-22			

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>	
2:36	Testing Materials Lab... 2-1	1:44	Stationary Structures... 2-3
3:031	Economics of Mining... 2-2	1:63	Hydraulics... 2-3
3:13	Geophysical Pros., Elem... 4-0	3:04	Mining, Principles of... 3-4
3:61	Metallography... 4-1	3:86	Petroleum Production... 3-2
3:85	Petroleum Production... 4-2	17:46	Building Construction... 8-0
6:40	Electrical Eng., Elem... 4-6		Thesis... 11
6:85	Electrical Eng. Lab... 2-3		Elective... 3
12:33	Field Geology... 3-2		General Study... 2-2
12:47	Microst. of Ores & Met... 3-0	Units of exercise and preparation: 48	
Units of exercise and preparation: 28-17			

III. MINING AND METALLURGY — *Continued*

## Option 3. Metallurgy

FIRST YEAR. See page 75

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>	
3:00	Int. to Mining & Metal. . . . .	2:00	Applied Kinematics . . . . .
5:11	Qualitative Analysis . . . . .	2:91	Foundry . . . . .
8:03	Physics . . . . .	5:12	Quantitative Analysis . . . . .
12:01	Mineralogy . . . . .	8:04	Physics . . . . .
E21	English and History . . . . .	E22	English and History . . . . .
M21	Calculus . . . . .	M22	Differential Equations . . . . .
MS21	Military Science . . . . .	MS22	Military Science . . . . .
Units of exercise and preparation: 31 -20		Units of exercise and preparation: 30 -20	

## Required during Summer 1933

1:02	Surveying & Plotting . . . . .	3 -1
2:12	Machine Drawing . . . . .	6 -0

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>	
2:15	Applied Mechanics . . . . .	2:20	Applied Mechanics . . . . .
2:40	Eng. Thermodynamics . . . . .	2:611	Engineering Laboratory . . . . .
3:05	Mining, Elements of . . . . .	2:901	Forging . . . . .
3:31	Fire Assaying . . . . .	3:23	Ore Dressing . . . . .
5:13	Quantitative Analysis . . . . .	3:611	Metallography . . . . .
5:31	Gas Analysis . . . . .	Ec32	Political Economy . . . . .
8:12	Heat Measurements . . . . .	Ec50	Accounting . . . . .
Ec31	Political Economy . . . . .		General Study . . . . .
Units of exercise and preparation: 30 -20			Elective . . . . .
		Units of exercise and preparation: 48	

## Required during Summer 1933

3:60	Metallurgical Plant Visits . . . . .	3 -1
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## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>	
2:36	Testing Materials Lab. . . . .	1:63	Hydraulics . . . . .
3:41	(b) Metallurgy . . . . .	3:42	Metallurgy . . . . .
3:411	(a) Metallurgy . . . . .	3:44	Metallurgy . . . . .
3:43	(a) Metallurgy . . . . .	3:45	Met. & Heat Tr. of Steel . . . . .
3:431	(b) Metallurgy . . . . .	8:90	Electrochemistry, Elem. . . . .
5:611	Physical Chemistry I . . . . .		Thesis . . . . .
6:40	Electrical Eng., Elem. . . . .		General Study . . . . .
6:85	Electrical Eng. Lab. . . . .		Elective . . . . .
	General Study . . . . .	Units of exercise and preparation: 48	
Units of exercise and preparation: 27 -22			

III. MINING AND METALLURGY — *Continued*

## Option 4. Physical Metallurgy

## FIRST YEAR. See page 75

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>			
3:00	Int. to Mining & Metal . . .	2-0	2:96	Machine Tool Laboratory	3-0
5:11	Qualitative Analysis . . . . .	7-2	5:12	Quantitative Analysis . . . . .	7-2
8:03	Physics . . . . .	5-5	8:04	Physics . . . . .	6-4
E21	English and History . . . . .	3-5	E22	English and History . . . . .	3-5
M21	Calculus . . . . .	3-6	M22	Differential Equations . . . . .	3-6
MS21	Military Science . . . . .	3-0	MS22	Military Science . . . . .	3-0
	Language . . . . .	3-5		Language . . . . .	3-5
Units of exercise and preparation: 26-23			Units of exercise and preparation: 28-22		

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>			
2:15	Applied Mechanics . . . . .	3-5	2:12	Machine Drawing . . . . .	6-0
3:621	Metallography . . . . .	9-3	2:20	Applied Mechanics . . . . .	3-6
5:13	Quantitative Analysis . . . . .	7-2	2:96	Machine Tool Laboratory . . . . .	3-0
5:611	Physical Chemistry I . . . . .	4-4	3:622	Metallography . . . . .	9-3
12:25	Physical Crystallography . . . . .	3-2	3:656	X-Ray Metallography . . . . .	3-3
Ec31	Political Economy . . . . .	3-3	Ec32	Political Economy . . . . .	3-3
				General Study . . . . .	4-4
Units of exercise and preparation: 29-19			Units of exercise and preparation: 31-19		

## Required during Summer 1933

3:60 Metallurgical Plant Visits . . 3-1

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>			
2:36	Testing Materials Lab . . . . .	2-1	3:422	Metallurgy . . . . .	2-2
3:41	(b) Metallurgy . . . . .	10-3	3:44	Metallurgy . . . . .	4-3
3:411	(a) Metallurgy . . . . .	6-3	3:642	Physical Metallurgy . . . . .	5-2
3:43	(a) Metallurgy . . . . .	7-3	3:67	Physics of Metals . . . . .	2-4
3:431	(b) Metallurgy . . . . .	3-3	6:75	Electrical Eng. Lab. . . . .	2-2
3:641	Physical Metallurgy . . . . .	5-2		Thesis . . . . .	13
6:40	Electrical Eng. Elem. . . . .	4-6		Elective . . . . .	6
8:12	Heat Measurements . . . . .	3-1	Units of exercise and preparation: 47		
	Elective . . . . .	7			
Units of exercise and preparation: 50					

#### IV. ARCHITECTURE

The School of Architecture comprises Course IV, Architecture; Course IV-A, Architectural Engineering (see page 92); Course IV-B, City Planning (see page 94) and the Division of Drawing.

The method of teaching followed in the School is founded upon individual criticism. This applies particularly to the courses in design, modeling, color and freehand drawing where criticism at the drafting board is accompanied by careful direction in the use of the library material.

In order that the students may acquire self-reliance and sound critical judgment, they are increasingly thrown upon their own resources as they advance from year to year. Thus in the last years in design criticism is given only when satisfactory progress has been made since the instructor's last visit.

Frequent opportunities for the comparison of student work in Course IV 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 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 in Course IV is supplemented by many cash prizes given throughout the year, and conspicuous ability is rewarded by a Fontainebleau Scholarship and a Traveling Scholarship entitling the student to one year's travel in Europe.

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

The course in Architecture covers a period of five years and leads to the degree of Bachelor in Architecture.

## IV. ARCHITECTURE

## FIRST YEAR

<i>First Term</i>		<i>Second Term</i>	
4 06	Graphics . . . . .	6 - 0	2'232T Structural Mechanics, El. 3 - 6
4'11	Shades and Shadows . . . . .	3 - 0	4'312 Theory of Architecture . . . . . 2 - 2
4'12	Perspective . . . . .	3 - 0	4'412 Architectural History . . . . . 2 - 3
4'311	Theory of Architecture . . . . .	2 - 2	4'712 Design I . . . . . 12 - 0
4'411	Architectural History . . . . .	2 - 3	E12 English . . . . . 2 - 4
E11	English . . . . .	2 - 4	L64 French . . . . . 3 - 6
L63	French . . . . .	3 - 6	MS12 Military Science . . . . . 3 - 0
M111	Calculus . . . . .	3 - 6	PT2 Physical Training . . . . . 1 - 0
MS11	Military Science . . . . .	3 - 0	Units of exercise and preparation: 28 - 21
PT1	Physical Training . . . . .	1 - 0	
Units of exercise and preparation: 28 - 21			

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>	
2'231	Mechanics . . . . .	3 - 6	2'232 Mechanics . . . . . 3 - 6
4'021	Freehand Drawing . . . . .	4 - 0	4'022 Freehand Drawing . . . . . 4 - 0
4'211	Office Practice . . . . .	5 - 0	4'212 Office Practice . . . . . 5 - 0
4'321	Theory of Architecture . . . . .	1 - 1	4'322 Theory of Architecture . . . . . 1 - 1
4'421	Architectural History . . . . .	2 - 2	4'422 Architectural History . . . . . 2 - 2
4'721	Design II . . . . .	10 - 0	4'722 Design II . . . . . 10 - 0
E21	English and History . . . . .	3 - 5	E22 English and History . . . . . 3 - 5
L65	French . . . . .	2 - 3	L66 French . . . . . 2 - 3
MS21	Military Science . . . . .	3 - 0	MS22 Military Science . . . . . 3 - 0
Units of exercise and preparation: 33 - 17		Units of exercise and preparation: 33 - 17	

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>	
4'031	Freehand Drawing . . . . .	4 - 0	4'032 Freehand Drawing . . . . . 4 - 0
4'071	Modeling . . . . .	3 - 0	4'072 Modeling . . . . . 3 - 0
4'331	Theory of Architecture . . . . .	2 - 0	4'332 Theory of Architecture . . . . . 2 - 0
4'461	European Civilization . . . . .	3 - 4	4'462 European Civilization . . . . . 3 - 4
4'61	City Planning . . . . .	2 - 3	4'732 Design III . . . . . 17 - 0
4'731	Design III . . . . .	12 - 0	4'812 Construction . . . . . 7 - 0
4'811	Construction . . . . .	7 - 0	E42 Problem Analysis . . . . . 2 - 2
E41	Problem Analysis . . . . .	2 - 2	Ec32 Political Economy . . . . . 3 - 3
Ec31	Political Economy . . . . .	3 - 3	Units of exercise and preparation: 41 - 9
Units of exercise and preparation: 38 - 12			

IV. ARCHITECTURE — *Continued*

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>	
2:595 Mech. Equip. of Bldgs.....	2-2	4:042 Freehand Drawing.....	4-0
4:041 Freehand Drawing.....	4-0	4:082 Color, Comp., Th. & App..	1-3
4:081 Color, Comp., Th. & App..	1-3	4:342 Theory of Architecture....	1-1
4:341 Theory of Architecture....	1-1	4:472 European Civilization.....	2-3
4:471 European Civilization.....	2-3	4:742 Design IV.....	29-0
4:741 Design IV.....	21-0	G652 General Science.....	2-2
G651 General Science.....	2-2	Units of exercise and preparation:	39-9
General Study.....	2-2		
Units of exercise and preparation:	35-13		

## FIFTH YEAR

<i>First Term</i>		<i>Second Term</i>	
4:051 Free. Draw. & Fig. Comp..	6-0	4:052 Free. Draw. & Fig. Comp. ...	6-0
4:091 Color, Comp., Th. & App..	1-4	4:092 Color, Comp., Th. & App..	1-4
4:481 European Civilization....	2-3	4:24 Professional Relations....	1-1
4:53 Architectural Humanities..	1-1	4:482 European Civilization....	2-3
4:751 Design V.....	30-0	4:752 Design V.....	12-0
Units of exercise and preparation:	40-8	Thesis.....	18
		Units of exercise and preparation:	48

#### 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 a new profession, architectural engineering.

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. In addition to these three there must also be the construction element represented by the contractor. The contractor, however, is usually not a part of the architectural organization and is called in after the building has been designed.

The course in Architectural Engineering is 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.

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

## IV-A. ARCHITECTURAL ENGINEERING

FIRST YEAR. See page 75

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>		
1:02	Surveying . . . . .	3-1	2:15 Applied Mechanics . . . . .	3-5
2:00	Applied Kinematics . . . . .	5-3	4:412 Architectural History . . . . .	2-3
4:13	Perspective . . . . .	2-2	4:90 Structural Drawing . . . . .	4-0
4:411	Architectural History . . . . .	2-3	8:04 Physics . . . . .	6-4
8:03	Physics . . . . .	5-5	12:49 Geology of Materials . . . . .	2-2
E21	English and History . . . . .	3-5	E22 English and History . . . . .	3-5
M21	Calculus . . . . .	3-6	M22 Differential Equations . . . . .	3-6
MS21	Military Science . . . . .	3-0	MS22 Military Science . . . . .	3-0
Units of exercise and preparation:		26-24	Units of exercise and preparation: 26-25	

## Required during Summer 1933

2:20	Applied Mechanics . . . . .	3-6
4:22	Office Practice . . . . .	6-0

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>		
2:21	Applied Mechanics . . . . .	3-5	1:40 Structures . . . . .	3-5
2:30	Materials of Engineering . . . . .	2-2	2:912 Structural Castings . . . . .	1-0
4:421	Architectural History . . . . .	2-2	4:422 Architectural History . . . . .	2-2
4:461	European Civilization . . . . .	3-4	4:462 European Civilization . . . . .	3-4
4:80	Building Construction . . . . .	1-1	4:78 Planning Principles . . . . .	4-8
4:911	Structural Analysis . . . . .	12-0	4:912 Structural Analysis . . . . .	8-0
8:06	Acoustics, Ill. & Color . . . . .	1-2	Ec32 Political Economy . . . . .	3-3
E33	Report Writing . . . . .	2-2	General Study . . . . .	2-2
Ec31	Political Economy . . . . .	3-3	Units of exercise and preparation: 26-24	
Units of exercise and preparation:		29-21		

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>		
1:41	Structures . . . . .	4-8	1:422 Structures . . . . .	2-4
1:48	Foundations . . . . .	3-4	2:392 Rein. Concrete Design . . . . .	6-0
1:63	Hydraulics . . . . .	2-3	2:59 Mech. Equip. of Bldgs . . . . .	4-3
2:36	Testing Materials Lab. . . . .	2-1	4:25 Estimating . . . . .	1-3
2:362	Test. Mat. Lab. (Con.) . . . . .	3-2	4:922 Structural Design . . . . .	9-0
2:301	Rein. Concrete Design . . . . .	7-0	17:50 Job Management . . . . .	1-1
4:921	Structural Design . . . . .	9-0	Thesis . . . . .	10
Units of exercise and preparation:		30-18	General Study . . . . .	2-2
			Units of exercise and preparation: 48	

#### IV-B. CITY PLANNING

A course in City Planning will be available to students enrolling in the Department of Architecture in September 1933. The object of the new course is to encourage in the architectural student a breadth of outlook which will enable him to see city planning problems in a broad perspective, and to equip him with the habits of thought necessary for the proper working out of constructive solutions.

Such a training should enable the student to enter upon his apprenticeship in the professional world with a confidence born of a sound acquaintance with the essentials of his problem. So equipped, he is qualified to cooperate intelligently with engineers, landscape architects, lawyers, economists and sociologists in the planning or replanning of urban areas.

The value of an architectural training as a basis for a study of city planning lies in the methods of attacking problems of planning acquired by the architect during his work in design, in which he is taught to think along both aesthetic and practical lines and to keep these two phases in their correct relationship. Moreover, he becomes accustomed to representing his ideas in graphic form — both in the initial stages of studying the problem and in the final presentation.

Students who desire to take the above course are required to complete the first three years of the Architectural curriculum or an acceptable equivalent, and, after a summer course in Surveying, to devote two years to specialized study of city planning.

The instruction given in the fourth and fifth years is divided into two major divisions. The first consists of lectures dealing with the various technical and cultural elements entering into the practice of city planning, and instruction in the fundamental principles of planning as applied to concrete problems. Much of this is covered by the course on Theory and Practice of City Planning, a comprehensive subject which aims to unify the economic, sociological and engineering phases and relate them to the drafting room work in design. The design of highways and earthworks, the working out of gradients and curves and other engineering problems, are dealt with in courses given in the Department of Civil Engineering.

The second is the work done in the drafting room in City Planning Design. Here actual problems in the planning of urban and suburban areas are worked out under supervision, the student being encouraged to develop his imagination and initiative in arriving at the solutions. The method of teaching is the same as that used in the advanced courses on architectural design.

Through the generosity of the Carnegie Corporation, a fund is available for the promotion of research work in city planning in the Department of Architecture, and particularly for the offering of a scholarship to a promising graduate of the city planning course for a year's constructive research study in this country or in Europe.

The course in City Planning covers a period of five years and leads to the degree of Bachelor in Architecture.

## IV-B. CITY PLANNING

Same as regular Course IV to the end of the third year

## Required during the Summer (Following the Third Year)

1'041	Surveying.....	12-1
1'181	Map Read. & Top. Draw..	5-0
1'20	Rail. & High. Fieldwork...	5-0

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>			
1'21	Rail. & High. Curves ....	2-2	1'25	Eng. Construction.....	4-4
4'081	Color, Comp., Th. & App.	1-3	4'082	Color, Comp., Th. & App.	1-3
4'471	European Civilization ...	2-3	4'472	European Civilization ...	2-3
4'641	Th. & Prac. City Plan....	3-6	4'642	Th. & Prac. City Plan....	3-6
4'671	City Planning Design....	20-0	4'672	City Planning Design....	20-0
	General Study.....	2-2			
Units of exercise and preparation: 30-16			Units of exercise and preparation: 30-16		

## FIFTH YEAR

Not offered in 1933-34

<i>First Term</i>		<i>Second Term</i>			
4'481	European Civilization....	2-3	4'482	European Civilization....	2-3
4'53	Architectural Humanities.	1-1	4'652	Th. & Prac. City Plan....	3-6
4'651	Th. & Prac. City Plan....	3-6	4'682	City Planning Design.....	16-0
4'681	City Planning Design.....	28-0		Thesis.....	18
	General Study.....	2-2			
Units of exercise and preparation: 36-12			Units of exercise and preparation: 48		

## V. CHEMISTRY

The curriculum in Chemistry includes a number of individual subjects in Chemistry, most of which are general and fundamental in character. The aim of the course is to give the student thorough instruction by means of lectures, recitations and laboratory practice, in the fundamental principles of inorganic, analytical, organic, physical and industrial chemistry. Instruction in mathematics, physics, English and German is included in the course. In the second term of the third year six hours each week are assigned for review, study and conference with instructors. This is followed by special comprehensive examinations to determine to what extent students have assimilated and correlated the work of 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 "Thesis" coming in the fourth year is intended to develop ability in research. In this subject each student is assigned a problem of no great difficulty which he is expected to plan and execute, with reasonable aid from an instructor. He 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.

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

## V. CHEMISTRY

## FIRST YEAR. See page 75

Required during Summer (Following First Year)

5:10 Qualitative Analysis . . . . . 14-4

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>			
5:12	Quantitative Analysis . . . . .	7-2	5:13	Quantitative Analysis . . . . .	7-2
8:03	Physics . . . . .	5-5	8:04	Physics . . . . .	6-4
E21	English and History . . . . .	3-5	E22	English and History . . . . .	3-5
G60	Geology . . . . .	2-2	M22	Differential Equations . . . . .	3-6
M21	Calculus . . . . .	3-6	MS22	Military Science . . . . .	3-0
MS21	Military Science . . . . .	3-0		Language . . . . .	3-5
	Language . . . . .	3-5		General Study . . . . .	2-2
Units of exercise and preparation: 26-25			Units of exercise and preparation: 27-24		

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>			
5:141	Analytical Chem. . . . .	3-2	5:142	Analytical Chem. . . . .	3-1
5:41	Organic Chemistry I. . . . .	4-3	5:42	Organic Chemistry I. . . . .	3-2
5:414	Organic Chem. Lab. . . . .	9-0	5:424	Organic Chem. Lab. . . . .	11-0
5:61	Physical Chemistry I. . . . .	5-5	5:62	Physical Chemistry II . . . . .	4-5
5:81	Chemical Literature I. . . . .	3-2	5:82	Chemical Literature II. . . . .	1-1
7:01	Biology . . . . .	5-2	5:89	Chemistry . . . . .	6
Ec31	Political Economy . . . . .	3-3	10:203	Industrial Chemistry . . . . .	3-4
Units of exercise and preparation: 32-17			Ec32		Political Economy . . . . . 3-3
			Units of exercise and preparation: 50		

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>			
3:611	Metallography . . . . .	4-1	5:062	Inorganic Chemistry . . . . .	2-3
5:061	Inorganic Chemistry . . . . .	2-3	5:64	Physical Chemistry IV. . . . .	3-4
5:63	Physical Chemistry III. . . . .	4-4	5:83	History of Chemistry . . . . .	2-2
5:961	Thesis . . . . .	15	5:96	Thesis Conference . . . . .	1-1
10:21	Industrial Chemistry . . . . .	2-2	5:962	Thesis . . . . .	15
	Elective . . . . .	4		Elective . . . . .	10
	General Study . . . . .	2-2		General Study . . . . .	2-2
Units of exercise and preparation: 45			Units of exercise and preparation: 47		

Elective subjects in the Fourth Year must be approved by the Fourth Year Registration Officer.

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

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## VI. ELECTRICAL ENGINEERING

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

The theoretical work runs parallel with an extended course in the laboratories, which begins with the work in chemistry and physics and extends through all of the scientific branches studied. The electrical measurements laboratories and the laboratories devoted to electrical machinery are component parts of the equipment. These laboratories are extensively provided with apparatus adapted to the needs of undergraduate and advanced study. The 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.

Under present regulations no students are assured admittance to Course VI in the second year with incomplete records in any entrance subject or an incomplete record in any first-year subject. No admissions to the third year are assured without clear records in first and second-year subjects and in entrance requirements.

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

## VI. ELECTRICAL ENGINEERING

FIRST YEAR. See page 75

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>	
2'00 Applied Kinematics.....	5-3	2'15 Applied Mechanics.....	3-5
2'941 Machine Tool Laboratory	4-0	6'00 Electrical Eng. Prin.....	4-4
8'03 Physics.....	5-5	6'75 Electrical Eng. Lab.....	2-2
E21 English and History.....	3-5	8'04 Physics.....	6-4
Ec31 Political Economy.....	3-3	E22 English and History.....	3-5
M21 Calculus.....	3-6	M22 Differential Equations....	3-6
MS21 Military Science.....	3-0	MS22 Military Science.....	3-0
Units of exercise and preparation: 26-22		Units of exercise and preparation: 24-26	

## Required during Summer 1933

1'02 Surveying..... 3-1

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>	
2.20 Applied Mechanics.....	3-6	2'22 Applied Mechanics.....	3-5
2'40 Eng. Thermodynamics....	4-5	2'42 Eng. Thermodynamics ..	4-5
6'01 Electrical Eng., Prin.....	3-4	6'02 Electrical Eng., Prin.....	5-6
6'39 Engineering Electronics...	5-4	6'71 Electrical Eng. Lab. ....	5-5
6'76 Electrical Eng. Lab.....	3-4	Ec56T Economics of Corporations	3-3
M31 Differential Equa. of Elec..	2-4	General Study.....	2-2
Units of exercise and preparation: 20-27		Units of exercise and preparation: 22-26	

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>	
1'64 Hydraulics.....	3-6	6'04 Electrical Eng., Prin.....	6-9
2'621 Engineering Laboratory ..	3-2	G51 Biography in Science ....	3-5
6'03 Electrical Eng., Prin.....	6-8	Thesis.....	15
6'72 Electrical Eng. Lab.....	4-4	Professional Elective.....	3-6
Professional Elective.....	3-6	Units of exercise and preparation: 47	
General Study.....	2-2		
Units of exercise and preparation: 21-28			
<i>Electives</i>		<i>Electives</i>	
6'221 Central Stations.....	3-6	6'20 Power Trans. Equip. ....	3-6
6'241 Electric Railways.....	3-6	6'21 Ind. App. of Elec. Prin....	3-6
6'251 Electric Machine Design..	3-6	6'222 Central Stations.....	3-6
6'26 Elec. Insul. & its Behavior.	5-4	6'242 Electric Railways.....	3-6
6'27 Illumination.....	3-6	6'252 Electric Machine Design..	3-6
6'281 Prin. Wire Com.....	3-6	6'282 Prin. Radio Com.....	3-6
6'29 Storage Batteries.....	1-1	6'29 Storage Batteries.....	1-1
6'80 Electrical Eng. Lab.....	Time arr.	6'48 Elec. Equip. of Bldgs.....	1-2
		6'80 Electrical Eng. Lab.....	Time arr.

### VI-C. ELECTRICAL ENGINEERING

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

The option embraces the scientific work covering telegraphy and telephony, by wire and radio. Electromagnetic wave theory, the properties and engineering applications of electron tubes and acoustics are included as a natural part of the work in this field.

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

#### Option VI-C. Electrical Communications

Same as regular Course VI to the beginning of third year

#### THIRD YEAR

<i>First Term</i>		<i>Second Term</i>	
2:20 Applied Mechanics . . . . .	3-6	6:02 Electrical Eng., Prin. . . . .	5-6
6:01 Electrical Eng., Prin. . . . .	3-4	6:302 Electrical Com. Prin. . . . .	3-6
6:301 Electrical Com. Prin. . . . .	3-6	6:71 Electrical Eng. Lab. . . . .	5-5
6:39 Engineering Electronics . . . . .	5-4	Ec56T Economics of Corporations	3-3
6:76 Electrical Eng. Lab. . . . .	3-4	M77 Vector Analysis . . . . .	3-5
M31 Differential Equa. of Elec. . . . .	2-4	General Study . . . . .	2-2
Units of exercise and preparation:	19-28	Units of exercise and preparation:	21-27

#### FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>	
6:03 Electrical Eng., Prin. . . . .	6-8	6:312 Electrical Com. Prin. . . . .	3-5
6:311 Electrical Com. Prin. . . . .	3-5	6:332 Electrical Com. Lab. . . . .	3-4
6:331 Electrical Com. Lab. . . . .	5-6	8:05 Sound, Speech and Aud. . . . .	3-6
6:83 Electrical Eng. Lab. . . . .	3-3	8:542 Electromag. Wave Prop. . . . .	2-4
8:541 Electromagnetic Theory . . . . .	2-4	G51 Biography in Science. . . . .	3-5
General Study . . . . .	2-2	Thesis . . . . .	10
Units of exercise and preparation:	21-28	Units of exercise and preparation:	48

**VI-A. ELECTRICAL ENGINEERING**

**Option 1, Manufacturing.** In coöperation with the General Electric Company.

**Option 2, Public Utilities.**

(a) **Light and Power.** In coöperation with the Edison Electric Illuminating Company of Boston.

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

**Option 3, Communications.** In coöperation with the Bell Telephone System in New York City.

The Institute offers three distinct coöperative courses in Electrical Engineering. Option 1 affords training for the technical and executive responsibilities of electrical manufacturing industries. The manufacturing practice is taken at the 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. For those desiring to go into electric railway work, experience with the Boston Elevated Railway is available. For communications work, the coöperation is with the shops of the Western Electric Company, Inc., the plants of the New York Telephone Company and the laboratories of the Bell Telephone Laboratories, Inc., coördinated through the American Telephone and Telegraph Company.

Each course covers a period of five years, the first two being identical with Course VI, and 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, the Boston Elevated Railway, or the Bell Telephone System.

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

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

The number of men who may be admitted to the coöperative training each year is at present limited to forty-six. Candidates for admission are subject to the approval of both the Institute and the coöperating companies. On account of the limitations of number and the unitary nature of the training, men who are admitted to a course with the approval of both parties are expected to carry it through to completion unless prevented by exceptional circumstances. Well qualified students who have completed at other institutions the substantial equivalent of the work of the first two years of Course VI may be admitted to advanced standing at the beginning of the coöperative training. Students in training at the plants are subject to the usual regulations of the company. They receive regular compensation for their work, the total of which approximates the tuition charges for the three years of coöperation. The work in the shops, testing departments and engineering divisions is supplemented by conferences with department heads in which technical and administrative problems arising in the work are discussed, while at the shops students also devote a maximum of four hours a week to classroom work in electrical theory and general studies, for which ten hours of preparation per week is expected. At the conclusion of the course, graduates are free to accept employment wherever offered without further obligation to the coöperating 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 coöperating company while the other is at the Institute in Cambridge.

Under present business conditions when it is not practicable to arrange for industrial practice of the proper kind and in sufficiently long periods to justify placing coöperative students at the works, the Institute substitutes laboratory and class work in residence for the industrial practice at the plants. Men, as usual, will be selected from the second-year class by the coöperating companies, and probably all such students selected in 1933 will be assigned to the group scheduled to remain at the Institute for the summer of that year. Assignments to the works will not be made until the level of industrial employment rises sufficiently to enable assignments of appropriate character to be made.

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

## VI-A. ELECTRICAL ENGINEERING

FIRST YEAR. See page 75

Required during Summer (Following First Year)

1-02 Surveying . . . . . 2-2

SECOND YEAR. Same as Course VI

## THIRD YEAR

Group A		Group B	
<i>Summer Term 1933</i>	<i>At M. I. T.</i>	<i>Summer Term 1933</i>	<i>At Works</i>
2-20 Applied Mechanics . . . . .	3-6	6-01 Electrical Eng., Prin. . . . .	2-5
2-40 Eng. Thermodynamics . . . . .	4-5	E45 Business English . . . . .	1-3
6-01 Electrical Eng., Prin. . . . .	3-4	(1) Manufacturing Prac. . . . .	48 h.p.w.
6-76 Electrical Eng. Lab. . . . .	3-4	6-901 General Electric Co.	
		(2) Public Utility Prac. . . . .	48 h.p.w.
<i>First Term</i>	<i>At Works</i>	6-911 Edison Elec. Ill. Co.	
6-021 Electrical Eng., Prin. . . . .	2-4	6-921 Boston Elevated Ry.	
E44 Committee Work. . . . .	2-4	(3) Communications Prac. . . . .	48 h.p.w.
(1) Manufacturing Prac. . . . .	48 h.p.w.	6-941 Western Electric Co.	
6-901 General Electric Co.		<i>First Term</i>	<i>At M. I. T.</i>
(2) Public Utility Prac. . . . .	48 h.p.w.	2-20 Applied Mechanics . . . . .	3-6
6-911 Edison Elec. Ill. Co. . . . .		2-40 Eng. Thermodynamics . . . . .	4-5
6-921 Boston Elevated Ry. . . . .		6-02 Electrical Eng., Prin. . . . .	5-6
(3) Communications Prac. . . . .	48 h.p.w.	6-76 Electrical Eng. Lab. . . . .	3-4
6-941 Western Electric Co. . . . .		Ec56T Economics of Corporations . . . . .	3-3
<i>Second Term</i>	<i>At M. I. T.</i>	M31 Differential Equa. of Elec. . . . .	2-4
2-22 Applied Mechanics . . . . .	3-5	<i>Second Term</i>	<i>At Works</i>
2-36 Testing Materials Lab. . . . .	2-1	6-031 Elec. Eng., Prin. . . . .	2-5
2-42 Eng. Thermodynamics . . . . .	4-5	E46 Modern Forms of Lit. . . . .	2-4
6-023 Electrical Eng., Prin. . . . .	5-6	(1) Manufacturing Prac. . . . .	48 h.p.w.
6-77 Electrical Eng. Lab. . . . .	3-2	6-902 General Electric Co.	
Ec56T Economics of Corporations . . . . .	3-3	(2) Public Utility Prac. . . . .	48 h.p.w.
M31 Differential Equa. of Elec. . . . .	2-4	6-912 Edison Elec. Ill. Co.	
		6-922 Boston Elevated Ry.	
		(3) Communications Prac. . . . .	48 h.p.w.
		6-942 N. Y. Telephone Co.	

VI-A. ELECTRICAL ENGINEERING — *Continued*

## FOURTH YEAR

Group A		Group B	
<i>Summer Term 1933</i>		<i>Summer Term 1933</i>	
6'032 Electrical Eng., Prin. . . . .	At Works 2-5	2'22 Applied Mechanics . . . . .	At M. I. T. 3-5
E45 Business English . . . . .	1-3	2'36 Testing Materials Lab. . . . .	2-1
(1) Manufacturing Prac. . . . .	48 h.p.w.	2'42 Eng. Thermodynamics . . . . .	4-5
6'902 General Electric Co.		6'032 (1, 2) Elec. Eng., Prin. . . . .	3-4
(2) Public Utility Prac. . . . .	48 h.p.w.	6'39 (3) Engineering Electronics . . . . .	5-4
6'912 Edison Elec. Ill. Co.		6'77 Electrical Eng. Lab. . . . .	3-2
6'922 Boston Elevated Ry.			
(3) Communications Prac. . . . .	48 h.p.w.	<i>First Term</i>	<i>At Works</i>
6'942 N. Y. Telephone Co.		6'032 (3) Electrical Eng., Prin. . . . .	2-5
		6'041 (1, 2) Elec. Eng., Prin. . . . .	2-6
<i>First Term</i>	<i>At M. I. T.</i>	E44 Committee Work . . . . .	2-4
1'64 Hydraulics . . . . .	3-6	(1) Manufacturing Prac. . . . .	48 h.p.w.
2'621 (1, 2) Engineering Lab. . . . .	3-2	6'903 General Electric Co.	
6'041 (1, 2) Elec. Eng., Prin. . . . .	3-5	(2) Public Utility Prac. . . . .	48 h.p.w.
6'330 (3) Electrical Com. Lab. . . . .	4-4	6'913 Edison Elec. Ill. Co.	
6'39 Engineering Electronics . . . . .	5-4	6'923 Boston Elevated Ry.	
6'78 (1, 2) Electrical Eng. Lab. . . . .	4-6	(3) Communications Prac. . . . .	48 h.p.w.
6'781 (3) Electrical Eng. Lab. . . . .	3-4	6'943 Bell Telephone Lab.	
G51 Biography in Science . . . . .	3-5		
M77 (3) Vector Analysis. . . . .	3-5	<i>Second Term</i>	<i>At M. I. T.</i>
		1'64 Hydraulics . . . . .	3-6
<i>Second Term</i>	<i>At Works</i>	2'621 (1, 2) Engineering Lab. . . . .	3-2
E46 Modern Forms of Lit. . . . .	2-4	6'042 (1, 2) Elec. Eng., Prin. . . . .	3-5
6'042 (1, 2) Elec. Eng., Prin. . . . .	2-6	6'312 (3) Electrical Com. Prin. . . . .	3-5
6'312 (3) Elec. Com. Prin. . . . .	2-6	6'330 (3) Electrical Com. Lab. . . . .	4-4
(1) Manufacturing Prac. . . . .	48 h.p.w.	6'39 (1, 2) Eng. Electronics . . . . .	5-4
6'903 General Electric Co.		6'78 (1, 2) Electrical Eng. Lab. . . . .	4-6
(2) Public Utility Prac. . . . .	48 h.p.w.	6'781 (3) Electrical Eng. Lab. . . . .	3-4
6'913 Edison Elec. Ill. Co.		G51 Biography in Science . . . . .	3-5
6'923 Boston Elevated Ry.		M77 (3) Vector Analysis. . . . .	3-5
(3) Communications Prac. . . . .	48 h.p.w.		
6'943 Bell Telephone Lab.			

## GRADUATE YEAR (1933-34)

Group A		Group B	
<i>Summer Term 1933</i>		<i>Summer Term 1933</i>	
Graduate Study & Research	At M. I. T. 34	Graduate Study & Research	At Works 10
		(1) Manufacturing Prac. . . . .	48 h.p.w.
<i>First Term</i>	<i>At Works</i>	6'904 General Electric Co.	
Graduate Study & Research	14	(2) Public Utility Prac. . . . .	48 h.p.w.
(1) Manufacturing Prac. . . . .	48 h.p.w.	6'914 Edison Elec. Ill. Co.	
6'904 General Electric Co.		6'924 Boston Elevated Ry.	
(2) Public Utility Prac. . . . .	48 h.p.w.	(3) Communications Prac. . . . .	48 h.p.w.
6'914 Edison Elec. Ill. Co.		6'944 Bell Telephone System	
6'924 Boston Elevated Ry.			
(3) Communications Prac. . . . .	48 h.p.w.	<i>First Term</i>	<i>At M. I. T.</i>
6'944 Bell Telephone System		Graduate Study & Research	48
<i>Second Term</i>	<i>At M. I. T.</i>	<i>Second Term</i>	<i>At M. I. T.</i>
Ec63 Business Law and Org. . . . .	3-5	Ec63 Business Law and Org. . . . .	3-5
Graduate Study & Research	40	Graduate Study & Research	40

## VII. BIOLOGY AND PUBLIC HEALTH

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

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

The field of Public Health Administration includes a wide variety of positions, such as those of Health Officer, Epidemiologist, Sanitary Inspector, or experts in other phases of Municipal Sanitation, as well as specialists in Industrial Hygiene, which involves the study of the basic sciences on which public health depends, supplemented by special inquiry into the hygiene and sanitation of industry, occupational accidents, industrial hazards, defective ventilation, and control of communicable diseases, and the special health problems in the factory or industrial plant.

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

**Option 1b. Biology.** Students looking forward to graduate work in Biology without reference to its technical application may be allowed to substitute advanced courses in biology, physics, and chemistry for public health subjects of the fourth year. To such students the degree of Bachelor of Science in Biology may be awarded on satisfactory completion of an approved program.

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

The problems of utilization of microbes in productive enterprises and of the prevention of economic loss through the activity of microorganisms in many branches of industry demand a knowledge of both microbiology and biochemistry which can be obtained here. Graduates in this option are especially well fitted to enter the industries dealing with food technology and conservation; the fisheries; the fermentations processes yielding glycerin, industrial alcohols and other solvents, acids or commercial products; and the preservation of wood

and textiles and numerous other technical applications of biochemistry, enzymes, and microbiology.

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

**Option 3. Public Health Engineering.** This option is arranged to meet the increasing demand for men who have knowledge of bacteriology and the principles of sanitation, public health, industrial hygiene and public health administration, together with sound basic training in engineering. It prepares men for the type of work known as public health engineering. It includes the planning, supervising and control of water supplies and waste disposal systems; the engineering supervision of milk supply; the development of engineering projects for securing healthful environment through proper housing; the elimination of dangerous pests; drainage, etc. In addition the problems of industrial hygiene receive particular attention. This type of engineer will probably find a most useful field in factory sanitation and control and in the type of work carried out by the United States Public Health Service and some of the large private health organizations.

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

## VII. BIOLOGY AND PUBLIC HEALTH

Option 1 (a) Biology and Public Health  
(b) Biology\*

FIRST YEAR. See page 75

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>	
5-11	Qualitative Analysis . . . . .	7-2	5-12 Quantitative Analysis . . . . .
7-01	Biology, General . . . . .	5-2	7-06 Botany . . . . .
8-03	Physics . . . . .	5-5	7-10 Zoology . . . . .
E21	English and History . . . . .	3-5	8-04 Physics . . . . .
M21	Calculus . . . . .	3-6	E22 English and History . . . . .
MS21	Military Science . . . . .	3-0	MS22 Military Science . . . . .
	General Study . . . . .	2-2	
Units of exercise and preparation: 28-22		Units of exercise and preparation: 30-18	

## Required during Summer 1933

5-41	Organic Chemistry . . . . .	4-3
5-428	Organic Chemistry Lab . . . . .	10-0

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>	
5-20	Chem. of Water and Sew.* 4-1	5-25	Chemistry of Foods . . . . .
5-684	Physical Chem., Elem. . . . .	3-3	7-12 Anatomy and Histology . . . . .
7-11	Anatomy and Histology . . . . .	8-4	7-20 Physiology . . . . .
7-301	Bacteriology . . . . .	6-4	7-302 Bacteriology . . . . .
7-50	Communicable Diseases . . . . .	3-3	7-57 Municipal Sanitation* . . . . .
Ec31	Political Economy . . . . .	3-3	Ec32 Political Economy . . . . .
	General Study . . . . .	2-2	
Units of exercise and preparation: 29-20		Units of exercise and preparation: 31-20	

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>	
7-22	Personal Hygiene and Nut. . . . .	2-2	7-03 Theoretical Biology . . . . .
7-36	Microbiology . . . . .	3-2	7-08 Parasitology . . . . .
7-541	Public Health Admin.* . . . . .	2-3	7-52 Industrial Hygiene* . . . . .
7-551	Public Health Lab. Meth. . . . .	8-3	7-542 Public Health Admin.* . . . . .
7-58	Vital Statistics* . . . . .	2-3	7-552 Serological Methods . . . . .
7-80	Biochemistry . . . . .	8-5	7-92 Biological Colloquium . . . . .
7-91	Biological Colloquium . . . . .	1-1	Thesis . . . . .
	General Study . . . . .	2-2	General Study . . . . .
Units of exercise and preparation: 28-21		Units of exercise and preparation: 50	

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

VII. BIOLOGY AND PUBLIC HEALTH — *Continued*

## Option 2. Industrial Biology

FIRST YEAR. See page 75

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>			
5:11	Qualitative Analysis.....	7-2	5:12	Quantitative Analysis....	7-2
7:01	Biology, General.....	5-2	7:06	Botany.....	7-3
8:03	Physics.....	5-5	7:10	Zoology.....	5-3
E21	English and History.....	3-5	8:04	Physics.....	6-4
M21	Calculus.....	3-6	E22	English and History.....	3-5
MS21	Military Science.....	3-0	MS22	Military Science.....	3-0
	General Study.....	2-2		Units of exercise and preparation:	31-17
	Units of exercise and preparation:	28-22			

## Required during Summer 1933

5:41	Organic Chemistry I.....	4-3
5:428	Organic Chemistry Lab. . .	10-0

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>		
5:20	Chem. of Water and Sew... 4-1	5:25	Chemistry of Foods..... 5-1	
5:684	Physical Chem. Elem..... 3-3	7:20	Physiology..... 6-5	
7:07	Mycology..... 3-2	7:302	Bacteriology..... 6-3	
7:15	Essentials of Anatomy... 3-3	7:33	Plant Diseases..... 1-2	
7:301	Bacteriology..... 6-4	7:57	Municipal Sanitation... 4-4	
7:701	Technology Food Supplies. 4-2	7:702	Technology Food Supplies. 4-4	
Ec31	Political Economy..... 3-3	Ec32	Political Economy..... 3-3	
	General Study..... 2-2		Units of exercise and preparation:	29-22
	Units of exercise and preparation:	28-20		

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>		
2:491	Refrigeration..... 1-2	7:03	Theoret. Biology..... 2-3	
7:22	Personal Hyg. & Nutrition 2-2	7:362	Industrial Microbiology... 4-4	
7:361	Industrial Microbiology.. 5-2	7:52	Industrial Hygiene..... 4-4	
7:711	Technology Food Prod.... 4-4	7:712	Technology Food Products 5-4	
7:80	Biochemistry..... 8-5	7:92	Biological Colloquium... 1-1	
7:91	Biological Colloquium... 1-1		Thesis..... 12	
	Thesis..... 6		General Study..... 2-2	
	Elective..... 5		Units of exercise and preparation:	48
	Units of exercise and preparation:	48		

VII. BIOLOGY AND PUBLIC HEALTH — *Continued*

## Option 3. Public Health Engineering

FIRST YEAR. See page 75

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>	
5-11	Qualitative Analysis.....	7-2	2-15 Applied Mechanics.....
7-01	Biology, General.....	5-2	5-12 Quantitative Analysis....
8-03	Physics.....	5-5	8-04 Physics.....
E21	English and History.....	3-5	E22 English and History.....
M21	Calculus.....	3-6	M22 Differential Equations....
MS21	Military Science.....	3-0	MS22 Military Science.....
	General Study.....	2-2	Units of exercise and preparation:
	Units of exercise and preparation:	28-22	25-22

## Required during Summer 1933. At Camp Technology

1-041	Surveying.....	12-1
1-60	Hydrographic Survey.....	5-0
7-34	Limnological Fieldwork....	5-0

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>	
2-20	Applied Mechanics.....	3-6	1-25 Eng. Construction.....
5-20	Chem. of Water and Sew..	4-1	1-40 Structures.....
5-41	Organic Chemistry I.....	4-3	1-62 Hydraulics.....
7-301	Bacteriology.....	6-4	7-302 Bacteriology.....
7-50	Communicable Diseases....	3-3	7-57 Municipal Sanitation....
7-53	Air Examination.....	3-1	Ec32 Political Economy.....
Ec31	Political Economy.....	3-3	General Study.....
Units of exercise and preparation:	26-21	Units of exercise and preparation:	25-25

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>	
1-41	Structures.....	4-8	1-421 Structures.....
1-75	Hydraulic and San. Eng..	4-6	1-78 Sanitary Engineering....
1-801	Sanitary Design.....	3-0	1-802 Sanitary Design.....
7-541	Public Health Admin....	2-3	2-59 Mech. Equip. of Bldgs....
7-58	Vital Statistics.....	2-3	7-52 Industrial Hygiene.....
7-59	Sanitation.....	4-4	7-542 Public Health Admin....
7-91	Biological Colloquium....	1-1	7-92 Biological Colloquium....
	General Study.....	2-2	Thesis.....
Units of exercise and preparation:	22-27	Units of exercise and preparation:	51

### VIII. PHYSICS

The course in Physics is intended to be sufficiently broad to provide for the needs of those who desire to prepare for graduate work and research in pure physics, either experimental or theoretical, as well as for those who desire to go into work in industrial and applied physics. Students are given a sound fundamental training in the various branches of physics, as well as in mathematics, chemistry, and liberal subjects. Laboratory instruction is given in the more important phases of experimental physics, including modern physics, and training in theoretical physics is provided.

In the third and fourth years considerable elective work is included, some of which may be taken in other departments. Suggested types of electives follow:

Experimental or theoretical subjects in physics, such as optics, heat measurements, acoustics, electricity and electronics, x-rays, spectroscopy, radiation measurements; various topics in theoretical physics. Mathematical subjects, as analysis, advanced calculus, higher algebra. Chemical subjects, as organic chemistry laboratory, quantitative analysis, physical chemistry. Subjects from other branches of science and engineering, as metallography, geology, biology, meteorology, textiles, electrical communications.

Electives are to be chosen in consultation with the registration officer, who can give specific suggestions regarding them. In some cases minor rearrangements of the required subjects between the third and fourth years may be made to fit in with programs of electives. By suitable choice of electives, the undergraduate training of Course VIII may be made a preparation both for professional work or graduate study in physics, and for other branches of industry, science, and engineering, for which physics is fundamental.

The department reserves the right to limit admission to Course VIII above the second year to that number of students who may be properly trained with the professional equipment available. The limitation if necessary will be effected by selection of the applicants of highest grade.

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

## VIII. PHYSICS

FIRST YEAR. See page 75

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>			
5'11	Qualitative Analysis . . . . .	7-2	8'04	Physics . . . . .	6-4
8'03	Physics . . . . .	5-5	8'091	Physical Measurements . .	3-2
E21	English and History . . . . .	3-5	8'45	Introd. to Phys. Science . .	3-2
M21	Calculus . . . . .	3-6	E22	English and History . . . . .	3-5
MS21	Military Science . . . . .	3-0	M22	Differential Equations . . .	3-6
	Language . . . . .	3-5	MS22	Military Science . . . . .	3-0
Units of exercise and preparation:	24-23		Language . . . . .	3-5	
			Units of exercise and preparation:	24-24	

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>			
5'41	Organic Chemistry . . . . .	4-3	8'201	Electricity and Electronics .	3-5
8'092	Physical Measurements . . .	3-2	8'202	Electronic Laboratory . . . .	3-2
8'161	Optics . . . . .	3-6	8'311	Atomic Structure . . . . .	3-5
8'162	Optical Measurements . . . .	3-2	8'312	Atomic Structure Lab . . . . .	3-2
8'50	Heat and Thermodynamics . .	3-4	Ec32	Political Economy . . . . .	3-3
Ec31	Political Economy . . . . .	3-3	M77	Vector Analysis . . . . .	3-5
	Elective . . . . .	6		Elective . . . . .	6
	General Study . . . . .	2-2		General Study . . . . .	2-2
Units of exercise and preparation:	49		Units of exercise and preparation:	48	

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>			
8'461	Int. to Theoret. Phys.* . . .	4-8	8'462	Int. to Theoret. Phys.* . . .	4-8
8'471	Hist. Develop. of Physics . .	3-6	8'472	Rec. Develop. of Physics . .	3-6
	Elective and Thesis . . . . .	23		Elective and Thesis . . . . .	23
	General Study . . . . .	2-2		General Study . . . . .	2-2
Units of exercise and preparation:	48		Units of exercise and preparation:	48	

\* Students of the class of 1934, who have taken 8'461, 8'462 in the third year, will substitute 12 units of electives in the fourth year.

## IX-A. GENERAL SCIENCE

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 humanistic studies such 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.

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

## IX-A. GENERAL SCIENCE

FIRST YEAR. See page 75

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>			
5'11	Qualitative Analysis . . . . .	7-2	5'12	Quantitative Analysis . . . . .	7-2
8'03	Physics . . . . .	5-5	8'04	Physics . . . . .	6-4
E21	English and History . . . . .	3-5	E22	English and History . . . . .	3-5
M21	Calculus . . . . .	3-6	M22	Differential Equations . . . . .	3-6
MS21	Military Science . . . . .	3-0	MS22	Military Science . . . . .	3-0
	Language . . . . .	3-5		Language . . . . .	3-5
Units of exercise and preparation:		24-23	Units of exercise and preparation:		25-22

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>			
5'41	Organic Chemistry . . . . .	4-3	12'30	Geology . . . . .	4-2
5'418	Organic Chemistry Lab . . . . .	6-0	Ec32	Political Economy . . . . .	3-3
7'01	Biology, General . . . . .	5-2	G64	Organic Evolution . . . . .	2-2
8'11	Heat Measurements . . . . .	2-1		Elective . . . . .	6
12'01	Mineralogy . . . . .	8-2		Professional Elective . . . . .	26
Ec31	Political Economy . . . . .	3-3	Units of exercise and preparation:		48
	Electives . . . . .	10			
Units of exercise and preparation:		49			

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>			
12'31	Geology . . . . .	5-3	G66	Descriptive Astronomy . . . . .	2-2
	Major Prof. Elective . . . . .	9		Major Prof. Elective . . . . .	9
	Prof. Elective and Thesis . . . . .	27		Prof. Elective and Thesis . . . . .	35
	General Study . . . . .	2-2	Units of exercise and preparation:		48
Units of exercise and preparation:		48			

## IX-B. GENERAL ENGINEERING

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.

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

## IX-B. GENERAL ENGINEERING

FIRST YEAR. See page 75

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>	
2:00	Applied Kinematics.....	5	-3
2:12	Machine Drawing.....	6	-0
8:03	Physics.....	5	-5
E21	English and History.....	3	-5
M21	Calculus.....	3	-6
MS21	Military Science.....	3	-0
	Elective.....	6	
Units of exercise and preparation:		50	
1:02	Surveying.....	3	-1
2:15	Applied Mechanics.....	3	-5
2:96	Machine Tool Laboratory.....	3	-0
8:04	Physics.....	6	-4
E22	English and History.....	3	-5
M22	Differential Equations.....	3	-6
MS22	Military Science.....	3	-0
	Elective.....	5	
Units of exercise and preparation:		50	

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>	
2:20	Applied Mechanics.....	3	-6
2:40	Eng. Thermodynamics.....	4	-5
Ec31	Political Economy.....	3	-3
	Electives.....	20	
	General Study.....	2	-2
Units of exercise and preparation:		48	
1:40	Structures.....	3	-5
1:62	Hydraulics.....	3	-5
2:42	Eng. Thermodynamics.....	4	-5
6:40	Electrical Eng. Elem.....	4	-6
Ec32	Political Economy.....	3	-3
	Electives.....	3	
	General Study.....	2	-2
Units of exercise and preparation:		48	

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>	
2:62	Engineering Laboratory.....	4	-2
6:85	Electrical Eng. Lab.....	2	-3
	Elective and Thesis.....	33	
	General Study.....	2	-2
Units of exercise and preparation:		48	
	Elective and Thesis.....	44	
	General Study.....	2	-2
Units of exercise and preparation:		48	

## X. CHEMICAL ENGINEERING

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 falls naturally into three groups: first, subjects which provide a thorough knowledge of the fundamental principles of chemistry; second, those which furnish a sound knowledge of mechanical engineering subjects, both in theory and in practice; third, those 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 chemistry course except in the case of some of the laboratory subjects. In the second term of the third year six hours each week are assigned for review, study, and conference with instructors. This is followed by special comprehensive examinations to determine to what extent students have assimilated and correlated the work of the first three years. The training in applied mechanics and testing materials laboratory is given with special reference to the particular needs of this course. This is true also of the work of the course which is given in Electrical Engineering. 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.

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

### X-B. CHEMICAL ENGINEERING PRACTICE

The privileges of the School of Chemical Engineering Practice are available for a selected group of undergraduates the last part of the senior year. Students desiring this course should apply the first term of the fourth year and those accepted will spend the second term at the Field Station of the School of Chemical Engineering Practice.

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

## X. CHEMICAL ENGINEERING

FIRST YEAR. See page 75

Required during Summer 1933 (Following First Year)

5'10 Qualitative Analysis. . . . . 14-4

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>		
5:12	Quantitative Analysis . . . . .	7-2	2:15 Applied Mechanics . . . . .	3-5
8:03	Physics . . . . .	5-5	5:13 Quantitative Analysis . . . . .	7-2
10:11	Prob. of the Chem. Engr. . . . .	1-0	8:04 Physics . . . . .	6-4
E21	English and History . . . . .	3-5	E22 English and History . . . . .	3-5
M21	Calculus . . . . .	3-6	MS22 Military Science . . . . .	3-0
MS21	Military Science . . . . .	3-0	Language . . . . .	3-5
	Language . . . . .	3-5	General Study (G54) . . . . .	2-2
Units of exercise and preparation: 25-23		Units of exercise and preparation: 27-23		

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 and 10:192.

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>		
2:20	Applied Mechanics . . . . .	3-6	2:36 Testing Materials Lab. . . . .	2-1
5:41	Organic Chemistry I . . . . .	4-3	5:42 Organic Chemistry I . . . . .	3-2
5:416	Organic Chemistry Lab. . . . .	9-0	5:426 Organic Chemistry Lab. . . . .	5-0
5:61	Physical Chemistry I . . . . .	5-5	5:62 Physical Chemistry . . . . .	4-5
10:17	Industrial Chemistry . . . . .	3-2	5:89 Chemistry . . . . .	6
Ec31	Political Economy . . . . .	3-3	10:18 Industrial Chemistry . . . . .	3-4
	General Study . . . . .	2-2	10:28 Chemical Engineering . . . . .	3-6
Units of exercise and preparation: 29-21		Units of exercise and preparation: 50		

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>		
6:40	Electrical Eng. Elem. . . . .	4-6	2:622 Engineering Laboratory . . . . .	3-3
10:21	Industrial Chemistry . . . . .	2-2	6:85 Electrical Eng. Lab. . . . .	2-3
10:26	Industrial Chemical Lab. . . . .	5-1	10:15 Thesis Reports . . . . .	2-2
10:29	Chemical Engineering . . . . .	3-6	10:32 Chemical Engineering . . . . .	5-4
10:31	Chemical Engineering . . . . .	5-4	Prof. Electives and Thesis	22
M41	Differential Equations . . . . .	3-6	General Study . . . . .	2-2
	Thesis . . . . .	3	Units of exercise and preparation: 50	
Units of exercise and preparation: 50				

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

**X-B. CHEMICAL ENGINEERING PRACTICE**

Students desiring to take the work of the School of Chemical Engineering Practice as undergraduates may apply for admission during the first term of the fourth year of Course X. If accepted, they will substitute for the fourth year second term the program shown below.

**FOURTH YEAR****School Chemical Engineering Practice***Second Term*

10:30 Engineering Equipment . . .	4 - 1
10:32 Chemical Engineering . . . .	5 - 4
*Field Station . . . . .	12
*Field Station . . . . .	12
Thesis . . . . .	12
	50

\* Students will take two of the Following Stations:

10:84 Bangor . . . . .	12
10:85 Boston . . . . .	12
10:86 Buffalo . . . . .	12

## XI. SANITARY ENGINEERING

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

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

Opportunities are offered to fourth year and graduate students for group inspection of nearby water and sewage works, and arrangements may be made which permit fourth year and graduate students to receive several days' training in the operation of both the water treatment plant of the City of Providence and the sewage treatment plant of the City of Worcester.

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

Graduates of this course are prepared for service with private or public engineering organizations engaged in the design and supervision of construction of water and sewage works; for employment with contractors or manufacturers engaged in the building of water and sewage plants or equipment therefor; and for entrance into the broader fields of city, state, or national public health work.

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

## XI. SANITARY ENGINEERING

FIRST YEAR. See page 75

### SECOND YEAR

<i>First Term</i>		<i>Second Term</i>			
5-11	Qualitative Analysis . . . . .	7-2	1-18	Map Read. and Top. Draw. . . . .	2-0
7-01	Biology . . . . .	5-2	2-15	Applied Mechanics . . . . .	3-5
8-03	Physics . . . . .	5-5	5-12	Quantitative Analysis . . . . .	7-2
E21	English and History . . . . .	3-5	8-04	Physics . . . . .	6-4
M21	Calculus . . . . .	3-6	E22	English and History . . . . .	3-5
MS21	Military Science . . . . .	3-0	M22	Differential Equations . . . . .	3-6
	General Study . . . . .	2-2	MS22	Military Science . . . . .	3-0
Units of exercise and preparation: 28-22		Units of exercise and preparation: 27-22			

#### Required during Summer 1933. At Camp Technology

1-041	Surveying . . . . .	12-1
1-60	Hydrographic Surveying . . . . .	5-0
7-34	Limnological Fieldwork . . . . .	5-0

### THIRD YEAR

<i>First Term</i>		<i>Second Term</i>			
1-21	Railway and High. Curves . . . . .	2-2	1-25	Eng. Construction . . . . .	4-4
1-43	Materials . . . . .	1-2	1-40	Structures . . . . .	3-5
2-20	Applied Mechanics . . . . .	3-6	1-62	Hydraulics . . . . .	3-5
5-41	Organic Chemistry . . . . .	4-3	2-36	Testing Materials Lab . . . . .	2-1
5-684	Physical Chemistry . . . . .	3-3	5-23	Sanitary Chemistry . . . . .	7-1
6-40	Electrical Eng. Elem. . . . .	4-6	7-29	Bacteriology . . . . .	5-2
Ec31	Political Economy . . . . .	3-3	Ec32	Political Economy . . . . .	3-3
	General Study . . . . .	2-2	Units of exercise and preparation: 27-21		
Units of exercise and preparation: 22-27					

### FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>			
1-41	Structures . . . . .	4-8	1-421	Structures . . . . .	2-4
1-48	Foundations . . . . .	3-4	1-52	Structural Design . . . . .	6-0
1-75	Hyd. and Sanitary Eng. . . . .	4-6	1-65	Hydraulic Machinery . . . . .	2-2
1-801	Sanitary Design . . . . .	3-0	1-78	Sanitary Engineering . . . . .	3-4
2-46	Heat Engineering . . . . .	4-7	1-802	Sanitary Design . . . . .	6-0
12-321	Geology . . . . .	2-1	2-47	Heat Engineering . . . . .	2-3
	General Study . . . . .	2-2	2-63	Eng. and Hydraulic Lab. . . . .	2-2
Units of exercise and preparation: 22-28		Thesis . . . . .		7	
		General Study . . . . .		2-2	
		Units of exercise and preparation: 49			

## XII. GEOLOGY

The course in geology is planned for students who wish to make geology, in its theoretical or practical aspects, their principal line of work. It, therefore, provides for a thorough and exact foundation of physics, chemistry, and mathematics followed by courses in all important branches of geology, such as mineralogy, general geology, field geology, stratigraphy, paleontology, petrography, the various branches of economic geology and geophysics. A broad general knowledge is emphasized but provision is also made for a certain amount of specialization in the fourth year.

A number of electives are included which may be chosen from either engineering subjects closely related to geology, or from more advanced geological subjects. The course is thus given considerable flexibility and can be adapted to the needs of the student who may already know which of the various branches he will elect for his speciality. However, a broad foundation of geological knowledge is the main feature of the course.

The growth of economic geology is a comparatively recent development. The geologist and the geological engineer have won for themselves a prominent place in many technical enterprises related to ore and coal mining, petroleum production, civil engineering and water supply.

There exists now a definite demand for men who have an education in engineering subjects along with their geological training, and this is provided for in this course. Among the graduates of this Department are many of the most prominent practical geologists of the present day.

Courses in various branches of geology are offered to students of other departments, either as part of the particular curriculum or as electives.

**Geophysics.** For those students who plan to pursue graduate studies in the geological aspects of geophysics, this Department, in coöperation with the Physics Department, offers in the third and fourth years a broad program of study in the sciences fundamental to geophysics. The program involves basic studies in geology and classical physics, with a continuing emphasis on the underlying mathematical technique. In geology, crystallography, petrography, economic geology, structural geology, and other subjects are required. In physics, the schedule includes studies in dynamics, electromagnetic theory, optics, thermodynamics, and elasticity. The program affords a preparation sufficiently broad and fundamental so that the student may subsequently build upon it, should he so desire, a career in either the more purely geological or the physical aspects of geophysics.

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

## XII. GEOLOGY

FIRST YEAR. See page 75

## SECOND YEAR

5:11 Qualitative Analysis.....	7-2	<i>Second Term</i>	
8:03 Physics.....	5-5	5:12 Quantitative Analysis....	7-2
12:01 Mineralogy.....	8-2	8:04 Physics.....	6-4
E21 English and History.....	3-5	12:02 Mineralogy.....	5-1
M21 Calculus.....	3-6	12:30 Geology.....	4-2
MS21 Military Science.....	3-0	E22 English and History.....	3-5
Units of exercise and preparation:	29-20	M22 Differential Equations....	3-6
		MS22 Military Science.....	3-0
		Units of exercise and preparation:	31-20

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>	
3:05 (a) Mining, Elements of..	2-2	3:23 (a) Ore Dressing.....	3-2
5:13 Quantitative Analysis....	7-2	7:10 (b) Zoology.....	4-2
7:01 (b) General Biology.....	5-2	12:15 Petrography.....	8-2
12:211 Opt. Crystallography....	4-1	12:40 Geology, Economic.....	4-3
12:31 Geology.....	5-3	12:50 Historical Geology.....	3-2
12:511 Paleontology.....	3-2	12:512 Paleontology.....	1-1
Ec31 Political Economy.....	3-3	Ec32 Political Economy.....	3-3
(a) Professional Elective..	4-0	G64 Organic Evolution.....	2-2
Language.....	3-5	Language.....	3-5
Units of exercise and preparation	(a) 31-18 (b) 30-18	Units of exercise and preparation	(a) 27-20 (b) 28-20

Required during Summer 1933. At Summer Mining Camp

1:10 Surveying.....	23-1
12:36 Field Geology.....	8

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>	
5:611 (b) Phys. Chem. Elem....	4-4	3:46 Met. of Common Metals .	3-3
8:801 (a) Electrochemistry, Prin.	3-6	8:802 (a) Electrochem., Prin....	3-6
12:33 Field Geology.....	3-2	12:42 App. Economic Geology..	2-1
12:38 Physiography.....	3-1	12:61 Diastro. and Vulcanology.	2-3
12:41 Economic Geology Lab. . .	6-2	12:80 Geol. Coal and Petroleum	4-3
12:46 Ec. Geol. Non-Met. Dep. .	3-3	Thesis.....	13
12:48 Eng. Geol. and Hyd.....	3-2	(a) Professional Elective..	7
12:60 Structural Geology.....	2-3	(b) Language.....	3-5
(a) General Study.....	2-2	(b) General Study.....	2-2
(b) Language.....	3-5	(b) Professional Elective..	4
Units of exercise and preparation	(a) 25-21 (b) 27-22	Units of exercise and preparation:	50

Professional Electives may be chosen from suitable advanced courses in the Department of Geology, or from certain courses in other departments.

### XIII. NAVAL ARCHITECTURE AND MARINE ENGINEERING

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

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

Lectures are given on theoretical naval architecture and marine engineering, treating of displacement and stability, launching, theory of waves, rolling of ships, strength of ships, propulsion of ships, steering and maneuvering, and also of power, 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 given also on the organization and management of shipyards, including buildings, plant personnel, wages, trades unions, etc.

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

### XIII. NAVAL ARCHITECTURE AND MARINE ENGINEERING

FIRST YEAR. See page 75

#### SECOND YEAR

<i>First Term</i>		<i>Second Term</i>	
2'00 Applied Kinematics.....	5-3	2'15 Applied Mechanics.....	3-5
2'901 Forging.....	2-0	2'91 Foundry.....	3-0
8'03 Physics.....	5-5	8'04 Physics.....	6-4
13'31 Ship Construction.....	2-2	13'32 Ship Construction.....	2-2
13'50 Marine Engineering.....	2-1	13'41 Ship Drawing.....	5-0
E21 English and History.....	3-5	E22 English and History.....	3-5
M21 Calculus.....	3-6	M22 Differential Equations....	3-6
MS21 Military Science.....	3-0	MS22 Military Science.....	3-0
Units of exercise and preparation:	25-22	Units of exercise and preparation:	28-22

#### THIRD YEAR

<i>First Term</i>		<i>Second Term</i>	
1'63 Hydraulics.....	2-3	2'21 Applied Mechanics.....	3-5
2'20 Applied Mechanics.....	3-6	2'42 Eng. Thermodynamics....	4-5
2'40 Eng. Thermodynamics....	4-5	2'611 Engineering Laboratory..	2-1
2'951 Machine Tool Laboratory	6-0	2'952 Machine Tool Laboratory.	4-0
13'01 Naval Architecture.....	2-2	13'02 Naval Architecture.....	2-2
13'33 Ship Construction.....	2-2	13'43 Ship Design.....	6-0
13'42 Ship Design.....	3-0	13'51 Marine Engineering.....	2-3
Ec31 Political Economy.....	3-3	Ec32 Political Economy.....	3-3
General Study.....	2-2	General Study.....	2-2
Units of exercise and preparation:	27-23	Units of exercise and preparation:	28-21

#### FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>	
2'30 Materials of Engineering .	2-2	2'36 Testing Materials Lab. ..	2-1
2'612 Engineering Laboratory ..	2-2	2'615 Engineering Laboratory ..	2-2
6'40 Electrical Eng. Elem.....	4-6	5'35 Applied Chemistry.....	1-2
6'89 Electrical Eng. Lab. ....	2-2	13'38 Shipyard Organization. .	2-1
13'03 Naval Architecture.....	3-3	13'62 Marine Engine Design...	5-0
13'45 Ship Design.....	8-0	13'70 Steam Turbines.....	2-3
13'54 Marine Engineering.....	2-3	13'72 Marine Diesel Engines...	2-2
13'61 Marine Engine Design...	5-0	Ec50 Accounting.....	4-2
General Study.....	2-2	Thesis.....	8
Units of exercise and preparation:	30-20	General Study.....	2-2
		Units of exercise and preparation:	45

### XIII-C. SHIP OPERATION

The course in Ship Operation is intended for students who wish to enter the fields of shipping administration and ship management or to engage in other maritime pursuits such as port administration, 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 course in Business and 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 shipowning 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 shipowner 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 economic and business administration subjects.

The course leads to the degree of Bachelor of Science in Ship Operation.

## XIII-C. SHIP OPERATION

FIRST YEAR. See page 75

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>		
2.00	Applied Kinematics.....	5-3	2:15 Applied Mechanics.....	3-5
8:03	Physics.....	5-5	2:901 Forging.....	2-0
13:50	Marine Engineering.....	2-1	8:04 Physics.....	6-4
E21	English and History.....	3-5	13:32 Ship Constructio.....	2-2
Ec31	Political Economy.....	3-3	E22 English and Histo.....	3-5
M21	Calculus.....	3-8	Ec32 Political Economy.....	3-3
MS21	Military Science.....	3-0	Ec37 Banking.....	3-3
Units of exercise and preparation:		24-23	MS22 Military Science.....	3-0
			Units of exercise and preparation:	25-22

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>		
2:20	Applied Mechanics.....	3-6	2:30 Materials of Engineering.	2-2
2:40	Eng. Thermodynamics...	4-5	2:42 Eng. Thermodynamics...	4-5
13:01	Naval Architecture.....	2-2	6:40 Electrical Eng., Elem....	4-6
13:33	Ship Construction.....	2-2	13:021 Naval Architecture.....	2-2
13:42	Ship Design.....	3-0	13:51 Marine Engineering.....	2-3
13:83	Terminal Facilities.....	3-3	13:72 Marine Diesel Engines...	2-2
E33	Report Writing.....	2-2	Ec62 Business Law.....	3-2
Ec61	Business Law.....	3-3	Ec80 Ocean Shipping Admin....	2-4
Ec65	Statistics.....	2-3	Units of exercise and preparation:	21-26
Units of exercise and preparation:		24-26		

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>		
2:612	Engineering Laboratory..	2-2	2:961 Machine Tool Laboratory.	2-0
6:40	Electrical Eng., Elem....	4-6	5:35 Applied Chemistry.....	1-2
6:89	Electrical Eng. Lab.....	2-2	13:472 Ship Design.....	6-0
13:471	Ship Design.....	6-0	13:66 Marine Engineering Des..	3-0
13:56	Marine Engineering.....	3-3	13:82 Ship Operation.....	3-4
13:81	Ship Operation.....	2-3	Ec46 Industrial Relations.....	3-5
Ec51	Industrial Accounting....	4-4	Ec62 Business Law.....	3-3
Ec61	Business Law.....	3-3	G63 Economic Geography....	2-2
Units of exercise and preparation:		26-23	Thesis.....	8
			Units of exercise and preparation:	47

#### XIV. ELECTROCHEMICAL ENGINEERING

Electrochemical Engineering is a composite course in which most of the fundamental work of Course VI, Electrical Engineering, is combined with basic courses in Chemistry as preparation for the more specialized work in electrochemistry and the related field of electrothermics. The course aims primarily to prepare students to enter the various electrochemical, electrothermic and electrometallurgical industries. The instruction given in this course is, however, of so broad a character that students completing it should be well prepared to enter various lines of purely electrical or chemical as well as electrochemical work, or to engage in research. The course also offers a satisfactory foundation in the physical sciences for the subsequent study of patent law.

The electrical work begins in the second term of the second year and continues throughout the third year and first half of the fourth year. The theory of direct and alternating currents and of direct and alternating current machinery is treated at length and the student becomes familiar in the laboratory with such electrical machinery as he is likely to meet in the practice of his profession. Courses dealing with the new and important subjects of electronics and electrical discharges in vacuo are also included. The instruction in chemistry includes the full course in qualitative analysis taken in the summer, followed by courses in analytical and organic chemistry.

Throughout the third year the principles of electrochemical and chemical phenomena are discussed both from the kinetic and thermodynamic points of view. The application of these principles to electrochemical processes is continued in the first term of the fourth year, the classroom work being accompanied by extended laboratory practice in electrochemical measurements. In the second term this work is concluded by a course in applied electrochemistry including electrodeposition, accumulators, electric furnaces and their products, electrolytic processes and electrometallurgy, and by work in the electric furnace laboratory. Related to the work in electrometallurgy are courses in the examination of metals and alloys by the methods of metallography and x-ray analysis. 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.

In the fourth year a wide range of elective studies is allowed in the field of physics, chemistry, mathematics, metallurgy, electrical engineering, etc., to meet the needs of those who desire to specialize along particular lines of work.

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

## XIV. ELECTROCHEMICAL ENGINEERING

FIRST YEAR. See page 75

Required during Summer 1933 (Following First Year)

5:10 Qualitative Analysis . . . . . 14-4

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>		
2:96	Machine Tool Laboratory. . . . .	3-0	5:31 Gas Analysis . . . . .	1-1
5:12	Quantitative Analysis . . . . .	7-2	6:00 Electrical Eng., Prin . . . . .	4-4
8:03	Physics . . . . .	5-5	8:04 Physics . . . . .	6-4
E21	English and History . . . . .	3-5	E22 English and History . . . . .	3-5
M21	Calculus . . . . .	3-6	M22 Differential Equations . . . . .	3-6
MS21	Military Science . . . . .	3-0	MS22 Military Science . . . . .	3-0
	Language . . . . .	3-5	Language . . . . .	3-5
Units of exercise and preparation: 27-23		Units of exercise and preparation: 23-25		

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>		
5:41	Organic Chemistry . . . . .	4-3	6:02 Electrical Eng., Prin . . . . .	5-6
5:418	Organic Chemical Lab . . . . .	6-0	6:39 Engineering Electronics . . . . .	5-4
6:01	Electrical Eng., Prin . . . . .	3-4	6:71 Electrical Eng. Lab . . . . .	5-5
6:81	Electrical Eng. Lab . . . . .	3-2	8:802 Electrochemistry . . . . .	3-6
8:12	Heat Measurements . . . . .	3-1	Ec32 Political Economy . . . . .	3-3
8:801	Electrochemistry, Prin . . . . .	3-6	General Study . . . . .	2-2
Ec31	Political Economy . . . . .	3-3	Units of exercise and preparation: 23-26	
	General Study . . . . .	2-2		
Units of exercise and preparation: 27-21				

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>		
3:611	Metallography . . . . .	4-1	3:656 X-Ray Metallography . . . . .	3-3
6:09	Electrical Eng., Prin . . . . .	3-6	8:85 App. Electrochemistry . . . . .	3-6
8:07	Precision of Measurements . . . . .	1-1	8:87 Electric Furnace Lab . . . . .	2-2
8:82	Electrochemistry . . . . .	3-6	8:93 Electrochem. Colloquium . . . . .	1-1
8:86	Electrochemical Laboratory . . . . .	9-3	Elective and Thesis . . . . .	23
	Elective and Thesis . . . . .	8	General Study . . . . .	2-2
	General Study . . . . .	2-2	Units of exercise and preparation: 48	
Units of exercise and preparation: 49				

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

## XV

## BUSINESS AND ENGINEERING ADMINISTRATION

The course in Business and Engineering Administration provides training for men who expect ultimately to undertake the management of such manufacturing, commercial or financial enterprises as demand a knowledge of scientific and engineering principles. Consideration of economic theory and business functions and their relationship in industry, is combined with instruction in general engineering. Problem courses in production, marketing, finance, accounting, economics, statistics, labor relations, business law, and industrial policy, are used to develop the breadth of outlook essential to the successful administrator. These subjects follow preliminary training in the fundamental sciences of physics, chemistry and mathematics which serves to establish habits of precise thinking and accurate observation. In addition, the student elects a field of engineering in which he gains understanding of technical principles and processes. Further requirements in language, literature, English composition, report writing and cultural electives serve to develop the student's powers of expression and appreciation.

The objectives of the course may best be illustrated by a brief description of certain of the more important subjects. Executive problems of Production and Marketing are presented by the case method, classroom exercises being in the nature of business conferences. In the field of Finance, banking is considered from the standpoint of the business executive who as a customer makes use of banking facilities. The study of the financial organization of the corporation and its operating responsibilities relating to income, surplus and expansion emphasizes the problems of the individual establishment, while the treatment of securities and investments brings to the classroom the tested experience of coöperating lecturers from investment houses and banks. The instruction in Accounting is designed to provide future executives with an analytical instrument of control, rather than to train bookkeepers or professional accountants. In like manner, instruction in Business Law marks those areas of business relationships in which the executive may employ preventive rather than curative legal service. The study of Industrial Relations affords a broad grasp of trends in the fields of labor. In the study of the technique of executive control consideration is given to typical executive difficulties in the management of men.

The student in this course is offered a choice of engineering studies, classified under two options: (1) Engineering  
(2) Chemistry.

In Option 1 (Engineering) basic courses in applied mechanics, heat engineering, electricity and hydraulics, are complemented by further elective subjects grouped in three fields of concentration.\*

(a) The Civil Engineering program meets the needs of students preparing for administrative positions in the transportation or construction industries.

(b) The Mechanical and Electrical Engineering program qualifies students to deal with technical aspects of executive problems characteristic of mechanical or electrical industries. Such establishments comprise a major cross-section of American industry.

(c) The Industrial Practice program differs chiefly from the Mechanical and Electrical program by the requirement that the student enter supervised employment in industry for ten weeks during the Junior-Senior summer, and by the opportunity to elect most of the engineering subjects of the fourth year. In this way the student gains background in industrial methods valuable in his senior business subjects, and the privilege of adjusting his technical curriculum more precisely to fit personal interests which summer employment has clarified. The number of students in Industrial Practice must of necessity be limited, and in the event of an excess of applicants the selection of candidates will be made by the staff of the Department.

In Option 2 (Chemical Engineering) students receive instruction in the important branches of chemistry and chemical engineering. The primary purpose of the option is to train men for ultimate administrative positions rather than for technical research or process control. The option meets the needs of students planning to enter the paper, leather, rubber, fertilizer, or other chemical industries.

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

\* For men interested in shipping administration, ship management and other branches of marine transportation the Institute offers a course in Ship Operation (XIII-C) which closely parallels the course in Business and Engineering Administration. A description of this course together with the schedule of studies will be found on pages 123-124.

**XV**  
**BUSINESS AND ENGINEERING ADMINISTRATION**

**Option 1. Engineering**

**FIRST YEAR. See page 75**

**SECOND YEAR**

<i>First Term</i>		<i>Second Term</i>	
2 00 Applied Kinematics.....	5 -3	2 15 Applied Mechanics.....	3 -5
8 03 Physics.....	5 -5	8 04 Physics.....	6 -4
Ec31 Political Economy.....	3 -3	Ec37 Banking.....	3 -3
Ec65 Statistics.....	2 -3	Ec32 Political Economy.....	3 -3
E21 English and History.....	3 -5	E22 English and History.....	3 -5
M21 Calculus.....	3 -6	M22 Differential Equations....	3 -6
MS21 Military Science.....	3 -0	MS22 Military Science.....	3 -0
Units of exercise and preparation: 24 -25		Units of exercise and preparation: 24 -26	

**Required during Summer, 1933**

**Group (a) Civil Engineering. At Camp Technology**

1 041 Surveying.....	12 -1
1 20 Rail. & High. Fieldwork...	5 -0
1 60 Hydrographic Surveying ..	5 -0

**Group (c) Industrial Practice. At M. I. T.**

1 02 Surveying.....	3 -1
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## XV. BUSINESS AND ENGINEERING ADMINISTRATION — *Continued*

### THIRD YEAR

#### Option 1. Engineering†

<i>First Term</i>		<i>Second Term</i>	
2:20 Applied Mechanics . . . . .	3-6	2:30 Materials of Engineering . . . . .	2-2
2:46 Heat Engineering . . . . .	4-7	2:47 Heat Engineering . . . . .	2-3
Ec61 Business Law . . . . .	3-3	Ec62 Business Law . . . . .	3-2
Ec81 Marketing . . . . .	3-3	Ec70T Production . . . . .	3-3
E33 Report Writing . . . . .	2-2	Ec82 Marketing . . . . .	3-3
Group Subjects* . . . . .		Group Subjects* . . . . .	

#### \*Group (a) Civil Engineering

1:21T Railway and High. Curves . . . . .	2-2	1:25 Eng. Construction . . . . .	4-4
6:40 Electrical Eng. Elem. . . . .	4-6	1:40 Structures . . . . .	3-5
		6:89 Electrical Eng. Lab. . . . .	2-2

#### \*Group (b) Mechanical and Electrical Engineering

1:02 Surveying . . . . .	3-1	2:36 Testing Materials Lab. . . . .	2-1
2:91 Foundry . . . . .	3-0	2:972 Machine Tool Laboratory . . . . .	3-0
2:971 Machine Tool Laboratory . . . . .	3-0	6:40 Electrical Eng. Elem. . . . .	4-6
General Study . . . . .	2-2		

#### \*Group (c) Industrial Practice

2:91 Foundry . . . . .	3-0	1:63 Hydraulics . . . . .	2-3
6:40 Electrical Eng. Elem. . . . .	4-6	2:951 Machine Tool Laboratory . . . . .	6-0
		2:36 Testing Materials Lab. . . . .	2-1
		Elective . . . . .	2-2

#### Required during Summer 1933 (Group 1c only)

Employment in Industry for not less than ten weeks. In order to satisfy this requirement the character of the work must be acceptable to the Department.

† Beginning in 1934-35 Ec50, Accounting, previously given in the second year, will be offered in the third year.

Ec56, Corporations, and Ec57, Corporate Finance and Investments, previously given in the third year, will henceforth be offered in the fourth year.

## XV. BUSINESS AND ENGINEERING ADMINISTRATION — *Continued*

### FOURTH YEAR

#### Option 1. Engineering

<i>First Term</i>	<i>Second Term</i>
Ec51 Industrial Accounting.... 4-4	Ec46 Industrial Relations..... 3-5
Ec61 Business Law†..... 3-3	Ec62 Business Law†..... 3-3
Ec71 Business Management... 4-6	Ec72 Business Management... 4-6
Ec98 Ind. Research Methods... 1-1	Thesis..... 6
Group Subjects*.....	Group Subjects*.....

#### \*Group (a) Civil Engineering

1'41 Structures..... 4-8	1'421 Structures..... 2-4
1'48 Foundations..... 3-4	1'54 Structural Design..... 4-0
General Study..... 2-2	1'63 Hydraulics..... 2-3
	General Study..... 2-2

#### \*Group (b) Mechanical and Electrical Engineering

1'63 Hydraulics..... 2-3	2'615 Engineering Laboratory... 2-2
2'36 Testing Materials Lab... 2-1	6'43 Gen. & Dis. of Elec. Energy 4-6
2'614 Engineering Laboratory... 4-3	Professional Elective..... 2-2
2'721 Machine Design..... 4-0	
Professional Elective..... 2-2	

#### Professional Electives

<i>First Term</i>	<i>Second Term</i>
1'64 Hydraulics..... 3-6	2'58 Power Plant Design..... 4-0
3'61 Metallography..... 4-1	2'722 Machine Design..... 4-0
3'712 Eng. Heat Treatment... 2-0	2'851 Fire Protection Eng. .... 2-2
5'58 Lubricating & Fuel Oil Test 3-1	2'854 Mech. Equip. of Bldgs. ... 2-2
5'683 Physical Chemistry..... 2-2	2'858 Inspection Methods..... 2-2
16'76 Aeronautics..... 3-1	5'843 Engineering Chemistry .. 2-2

#### \*Group (c) Industrial Practice

2'62 Engineering Laboratory . 4-2	Ec99 Industrial Problems..... 2-4
Approved Subjects†..... 16	Approved Subjects†..... 10

† The engineering subjects must form a coordinated program and be approved by the registration officer. They may be selected from such fields as:

Automotive  
Textile

Metal Working  
Refrigeration

or other branches of engineering suitable to the student's intended vocation.

‡ Ec61 and Ec62, Business Law, will after 1933-34 appear only in the third year.

## XV. BUSINESS AND ENGINEERING ADMINISTRATION — *Continued*

### Option 2. Chemical Engineering

**FIRST YEAR.** See page 75

Required during Summer 1933 (Following First Year)

5·10 Qualitative Analysis. . . . . 14-4

### SECOND YEAR

<i>First Term</i>		<i>Second Term</i>			
5·12	Quantitative Analysis. . . . .	7-2	5·13	Quantitative Analysis. . . . .	7-2
8·03	Physics. . . . .	5-5	8·04	Physics. . . . .	6-4
Ec31	Political Economy. . . . .	3-3	Ec32	Political Economy. . . . .	3-3
Ec65	Statistics. . . . .	2-3	Ec37	Banking. . . . .	3-3
E21	English and History. . . . .	3-5	E22	English and History. . . . .	3-5
M21	Calculus. . . . .	3-6	MS22	Military Science. . . . .	3-0
MS21	Military Science. . . . .	3-0		General Study. . . . .	2-2
Units of exercise and preparation: 26-24			Units of exercise and preparation: 29-19		

### THIRD YEAR

<i>First Term</i>		<i>Second Term</i>			
2·40	Eng. Thermodynamics. . . . .	4-5	2·42	Eng. Thermodynamics. . . . .	4-5
5·41	Organic Chemistry. . . . .	4-3	6·40	Electrical Eng. Elem. . . . .	4-6
5·416	Organic Chemical Lab. . . . .	9-0	10·201	Industrial Chemistry. . . . .	4-4
5·611	Physical Chemistry Elem. . . . .	4-4	Ec62	Business Law. . . . .	3-2
Ec61	Business Law. . . . .	3-3	Ec82	Marketing. . . . .	3-3
Ec81	Marketing. . . . .	3-3	Ec70T	Business Management. . . . .	4-4
E33	Report Writing. . . . .	2-2		General Study. . . . .	2-2
Units of exercise and preparation: 29-20			Units of exercise and preparation: 24-26		

### FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>			
10·21	Industrial Chemistry. . . . .	2-2	2·62	Engineering Laboratory. . . . .	4-2
10·26	Industrial Chemical Lab. . . . .	5-1	10·32	Chemical Engineering. . . . .	5-4
10·31	Chemical Engineering. . . . .	5-4	Ec46	Industrial Relations. . . . .	3-5
Ec51	Industrial Accounting. . . . .	4-4	Ec62	Business Law†. . . . .	3-3
Ec61	Business Law†. . . . .	3-3	Ec72	Business Management. . . . .	4-6
Ec71	Business Management. . . . .	4-6		Thesis. . . . .	6
Ec98	Industrial Res. Methods. . . . .	1-1		General Study. . . . .	2-2
	General Study. . . . .	2-2	Units of exercise and preparation: 49		
Units of exercise and preparation: 26-23					

Beginning in 1934-35, Ec50, Accounting, previously given in the second year, will be offered in the third year. Ec56, Corporations, and Ec57, Corporate Finance and Investments, previously given in the third year, will be offered in the fourth year.

† Ec61 and Ec62, Business Law, will appear only in the third year.

## XVI. AERONAUTICAL ENGINEERING

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

In general, the professional subjects are directed particularly toward airplane design, but in order that the student may gain some knowledge of other branches of aeronautical activity, he is allowed to elect in the fourth year certain subjects in some related professional field. In this connection attention is invited to the work preparatory to graduate specialization in Meteorology, offered by the Department of Physics.

Owing to the fact that the number of applicants for Course XVI often greatly exceeds the facilities available for instruction, the Course in Aeronautical Engineering reserves the right to limit the number of students in each class. Applications will be received during the second term of the first year, and notifications of admission or refusal will be issued shortly after the spring examinations. Toward the end of the second year, a limited number of additional applications will be considered. Students whose work has been unsatisfactory may be required to withdraw from the course at any time in favor of better qualified men. Students not enrolled in the course are admitted to aeronautical subjects only when facilities permit and if their records are good.

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

The professional work of the fourth year presupposes preparation in theoretical and applied aerodynamics and structures (M43, M44, 16-00 and 1-401). *These are offered during the summer session for transferring students who are otherwise prepared for fourth year work.*

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

## XVI. AERONAUTICAL ENGINEERING

FIRST YEAR. See page 75

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>			
2:00	Applied Kinematics.....	5-3	2:102 Mech. Eng. Drawing.....	4-0	
2:12	Machine Drawing.....	6-0	2:15 Applied Mechanics.....	3-5	
8:03	Physics.....	5-5	8:04 Physics.....	6-4	
E21	English and History.....	3-5	E22 English and History.....	3-5	
M21	Calculus.....	3-6	M22 Differential Equations....	3-6	
MS21	Military Science.....	3-0	MS22 Military Science.....	3-0	
	Language.....	2-4	Language.....	2-4	
Units of exercise and preparation:		27-23	Units of exercise and preparation:		24-24

## Required during Summer 1933

16:52	Airplane Shopwork.....	8-2
16:53	Aircraft Prod. Methods...	7-2

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>			
2:20	Applied Mechanics.....	3-6	1:401 Structures.....	3-5	
2:30	Materials of Eng.....	2-2	2:35 Testing Materials Lab....	4-2	
2:40	Eng. Thermodynamics... ..	4-5	2:42 Eng. Thermodynamics... ..	4-5	
5:683	Physical Chemistry.....	2-2	2:611 Engineering Laboratory..	2-1	
M43	Theoretical Aeronautics..	6-4	16:00 Aerodyn. of Airplane Des.	3-3	
	General Study.....	2-2	M44 Theoretical Aeronautics..	6-4	
	Language.....	3-5	Language.....	3-5	
Units of exercise and preparation:		22-26	Units of exercise and preparation:		25-25

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>			
6:40	Electrical Eng. Elem.....	4-6	2:251 (a) Dynamics of Machines	2-4	
16:01	Aerodyn. of Airplane Des.	4-4	6:85 Electrical Eng. Lab. ....	2-3	
16:02	Aircraft Structures.....	2-2	16:05 (b) Airplane Structures... ..	3-3	
16:13	Airplane Design Prac. ...	8-0	16:55 Airplane Design.....	7-2	
16:62	Aeronautical Laboratory..	4-3	Ec32 Political Economy.....	3-3	
Ec31	Political Economy.....	3-3	General Study.....	2-2	
	Electives.....	4	Electives.....	9	
Units of exercise and preparation:		47	Units of exercise and preparation:		48
<i>Electives</i>					
3:61	Metallography.....	4-1			
16:82	Internal Comb. Engines..	4-3			
16:901	Meteorology, Introductory	2-2			
Ec50	Accounting.....	4-2			
Ec65	Statistics.....	2-2			
	General Study.....	2-2			
<i>Electives</i>					
			16:08 Airplane Design Problems	6-6	
			16:63 Aero. Lab. & Res. Meth..	4-2	
			16:84 Internal Comb. Engines..	4-5	
			16:902 Meteorology, Aeronautical	2-2	

Other subjects may be selected with approval of Registration Officer.

**XVII. BUILDING ENGINEERING AND CONSTRUCTION**

This course is planned to supply trained men to the building industry and its allied industries, who may be expected to contribute to the solution of the many problems that confront these industries, in reducing wastes, introducing new economies and new methods and in setting up a better system of building economics. The course may be described as the interpretation of the science of materials to the art of building.

It provides the usual fundamentals associated with a sound engineering training, in addition to which it lays particular emphasis upon materials and the manner in which they are assembled, according to what is known as the best practice in buildings of wood, timber, reinforced concrete and steel.

Courses are also given in building finance, building management, accounting, quantity surveying and appraisement, superintendence, business and industrial relations, and the history of construction.

The course provides the basic training for graduate work in materials; the economics of building and real property; management and maintenance of buildings; and in general building and associated industries.

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

## XVII. BUILDING ENGINEERING AND CONSTRUCTION

FIRST YEAR. See page 75

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>	
2:00 Applied Kinematics.....	5-3	2:15 Applied Mechanics.....	3-5
5:844 Engineering Chemistry...	5-1	8:04 Physics.....	6-4
8:03 Physics.....	5-5	17:20 History of Construction..	3-0
17:21 Building Construction....	5-1	17:22 Building Construction....	5-1
E21 English and History.....	3-5	17:73 Materials.....	2-1
M21 Calculus.....	3-6	E22 English and History.....	3-5
MS21 Military Science.....	3-0	M22 Differential Equations....	3-6
Units of exercise and preparation:	29-21	MS22 Military Science.....	3-0
		Units of exercise and preparation:	28-22

## Required during Summer 1933. At Camp Technology

1:042 Surveying.....	11-1
17:65 Quantity Surveying and Estimating...	11-0

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>	
2:20 Applied Mechanics.....	3-6	1:40 Structures.....	3-5
2:46 Heat Engineering.....	4-7	1:63 Hydraulics.....	2-3
6:40 Electrical Eng., Elem.....	4-6	2:47 Heat Engineering.....	2-3
17:31 Building Construction....	5-1	6:48 Elec. Equip. of Bldgs....	1-2
17:51 Structural Analysis.....	4-2	6:89 Electrical Eng. Lab.....	2-2
Ec31 Political Economy.....	3-3	12:49 Geology of Materials.....	2-2
Units of exercise and preparation:	23-25	17:32 Building Construction....	5-1
		17:52 Structural Analysis.....	4-2
		17:74 Materials.....	2-1
		General Study.....	2-2
		Units of exercise and preparation:	25-23

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>	
1:41 Structures.....	4-8	1:422 Structures.....	2-4
1:48 Foundations.....	3-4	2:59 Mech. Equip. of Bldgs....	4-3
2:36 Testing Materials Lab....	2-1	17:42 Building Construction....	3-1
2:363 Test. Mat. Lab. (Con.)...	2-0	17:50 Job Management.....	1-1
17:41 Building Construction....	8-2	17:54 Structural Analysis.....	3-2
17:53 Structural Analysis.....	3-1	17:75 Materials.....	2-1
17:81 Seminar.....	1-1	17:82 Seminar.....	1-1
Ec74 Contract. Management....	2-4	Ec53 Building Finance.....	3-5
General Study.....	2-2	Thesis.....	7
Units of exercise and preparation:	27-23	General Study.....	2-2
		Units of exercise and preparation:	48

### XVIII. MATHEMATICS

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

The course outlined is for men who desire to study more mathematics than is contained in the professional courses. It is well adapted to serve as a preparation for specialization in pure mathematics, in mathematical physics, or along lines of engineering requiring proficiency in mathematics.

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

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

## XVIII. MATHEMATICS

FIRST YEAR. See page 75

## SECOND YEAR

<i>First Term</i>		<i>Second Term</i>			
8:03	Physics . . . . .	5-5	8:04	Physics . . . . .	6-4
E21	English and History . . . . .	3-5	E22	English and History . . . . .	3-5
M21	Calculus . . . . .	3-6	M22	Differential Equations . . . . .	3-6
M23	Algebra and Geometry . . . . .	3-6	M24	Algebra and Geometry . . . . .	3-6
MS21	Military Science . . . . .	3-0	MS22	Military Science . . . . .	3-0
	Language . . . . .	3-5		Language . . . . .	3-5
Units of exercise and preparation: 20-27		Units of exercise and preparation: 21-26			

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>			
Ec31	Political Economy . . . . .	3-3	Ec32	Political Economy . . . . .	3-3
M62	Modern Algebra . . . . .	3-6	M54	Mathematical Laboratory . . . . .	3-6
M731	Mechanics . . . . .	3-6	M732	Mechanics . . . . .	3-6
M831	Analysis . . . . .	3-6	M832	Analysis . . . . .	3-6
	Language . . . . .	3-5		Language . . . . .	3-5
	General Study . . . . .	2-2		General Study . . . . .	2-2
Units of exercise and preparation: 17-28		Units of exercise and preparation: 17-28			

## FOURTH YEAR (For 1933-34)

<i>First Term</i>		<i>Second Term</i>			
M26	Least Squares and Prob . . . . .	2-2	M54	Mathematical Lab. . . . .	3-9
	Elective and Thesis . . . . .	40		Elective and Thesis . . . . .	36
	General Study . . . . .	2-2			
Units of exercise and preparation: 48		Units of exercise and preparation: 48			

## FOURTH YEAR (In effect 1934-35)

<i>First Term</i>		<i>Second Term</i>			
S'461	Int. to Theoret. Physics . . . . .	4-8	S'462	Int. to Theoret. Physics . . . . .	4-8
M441	Geometry . . . . .	3-6	M442	Geometry . . . . .	3-6
M841	Analysis . . . . .	3-6	M842	Analysis . . . . .	3-6
	Elective and Thesis . . . . .	18		Elective and Thesis . . . . .	18
Units of exercise and preparation: 48		Units of exercise and preparation: 48			

## MILITARY ENGINEERING

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

Graduates of the United States Military Academy or the United States Naval Academy will be admitted on their credentials; Army Officers or Navy Officers of the United States, 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.

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

Changes in this schedule may be made to suit the special needs of officers when such changes have been approved by the Faculty.

## Required during Summer 1933 Preceding the Academic Year

1:40 Structures.....	3-5
2:20 Applied Mechanics.....	3-6
2:21 Applied Mechanics.....	3-5
2:46 Heat Engineering.....	4-7
2:47 Heat Engineering.....	2-3
Units of exercise and preparation:	<u>15-26</u>

## FOURTH YEAR

<i>First Term</i>		<i>Second Term</i>	
1:41 Structures.....	4-8	1:25 Eng. Construction.....	4-4
1:581 Reinf. Concrete Design....	6-2	1:42 Structures.....	4-8
2:30 Materials of Engineering...	2-2	2:395 Con. Bldg., Des. and Spec.	2-4
2:36 Testing Materials Lab.....	2-1	3:71 Heat Treatment.....	4-2
2:363 Testing Mat. Lab. (Con.)..	2-0	6:21 Ind. App. Elec. Power....	3-6
2:221 Engineering Laboratory...	3-2	6:85 Electrical Eng. Lab.....	2-3
5:683 Physical Chemistry, Elem..	2-2	7:57 Municipal Sanitation.....	4-4
6:40 Electrical Eng., Elem.....	4-6	Thesis.....	<u>6</u>
7:31 Bacteriology.....	2-2	Units of exercise and preparation:	60
Thesis.....	3		
Units of exercise and preparation:	<u>55</u>		

### UNDERGRADUATE SCHEDULES FOR RESERVE OFFICERS' TRAINING CORPS

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

#### BASIC COURSE

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

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

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

<b>First Year</b>			
<i>First Term</i>		<i>Second Term</i>	
MS11.	Infantry drill and rifle marksmanship . . . . .	MS12.	Infantry drill and elementary military subjects . . .
	3 - 0		3 - 0
<b>Second Year</b>			
MS21.	Military map reading, field engineering and basic military subjects . . . . .	MS221.	Coast Artillery Unit: Elements of heavy artillery.
	3 - 0	MS222.	Engineer Unit: Elements of engineer training . . . . .
		MS223.	Signal Unit: Tactics and signal communications . .
		MS224.	Ordnance Unit: Ordnance materiel . . . . .
		MS226.	Chemical Warfare Unit: Elements of chemical warfare training . . . . .
			3 - 0

### ADVANCED COURSE

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

The course is open to students who have satisfactorily completed two years in the basic course at this Institute or elsewhere, who are acceptable to the Professor of Military Science and Tactics, and who have received the approval of the professor in charge of the course in which they are registered. A student enrolled in the advanced course receives commutation of uniform at the rate of twenty-five dollars for the first year and ten dollars for the second year and commutation of subsistence at the rate of twenty-five cents per day from date of enrollment until the end of the second Institute year thereafter, including one summer vacation, except for the period of the R. O. T. C. camp, when he will be subsisted by the Government. To enroll, he must execute a contract to continue the course of instruction for two years, should he remain that length of time at the Institute, and the fulfillment of this contract then becomes a prerequisite for graduation. The contract includes the obligation to attend a six weeks' R. O. T. C. camp, normally during June and July following the first year of the advanced course, at which all expenses, including transportation, are paid by the Government. In very exceptional cases, attendance at camp may be postponed until after the senior year.

*Students in the advanced course are required to elect G3, International Law and American Foreign Policy, and G98, Military History and Policy of the United States, as two of their General Studies. (Students in Courses VI-A, XIII-A, XIII-C, XV and XVII are excused from the requirement in G3.) Students in the advanced course are also required to register for MS31, MS32, MS41 and MS42 at one of the hours prescribed for MS11 or MS12.*

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

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

### COAST ARTILLERY UNIT

Open to students in all courses. Students whose Institute courses do not include surveying and who are unable to demonstrate proficiency in this subject will be required to take one of the Institute Surveying subjects. Omissions and other approved changes in course schedules are noted below under the number of the course.

Third Year					
<i>First Term</i>		<i>Second Term</i>			
MS31.	Drill and command . . . .	1-0	MS32. Drill and command . . . .	1-0	
MS311.	Fire control and gunnery for heavy artillery . . . . .	3-2	MS321.	Fire control and gunnery for anti-aircraft artillery . . . . .	3-2
Fourth Year					
<i>First Term</i>		<i>Second Term</i>			
MS41.	Drill and command . . . .	1-0	MS42.	Drill and command . . . .	1-0
MS411.	Artillery materiel; organ- ization, administration, and duties of the Coast Artillery Corps . . . . .	2-1	MS421.	Tactical employment of antiaircraft and heavy artillery . . . . .	2-1

### ENGINEER UNIT

Open only to students in Courses I, II, III, IV, IV-A, VI, VI-A, VII, IX-B, XI, XII, XIII-C, XV, XVI, XVII, and XVIII. Except in MS41 and MS42, instruction in the fourth year is given by Institute personnel. Approved changes in course schedules are noted below under the number of the course.

Third Year					
<i>First Term</i>		<i>Second Term</i>			
MS31.	Drill and command . . . .	1-0	MS32.	Drill and command . . . .	1-0
MS312.	Organization, administra- tion, and duties of the Corps of Engineers . . . . .	3-3	MS322.	Fortifications; military roads and bridges; engi- neer combat principles; military law . . . . .	3-3
Fourth Year					
<i>First Term</i>		<i>Second Term</i>			
MS41.	Drill and command . . . .	1-0	MS42.	Drill and command . . . .	1-0

### SIGNAL UNIT

Open only to students in Courses VI, VI-A, VI-C, VIII, IX-B, XIV, and XV.b. Except in MS41 and MS42, instruction in the fourth year is given by Institute personnel. Approved changes in course schedules are noted below under the number of the course.

Third Year					
<i>First Term</i>		<i>Second Term</i>			
MS31.	Drill and command . . . .	1-0	MS32.	Drill and command . . . .	1-0
MS313.	Signal Corps tactics; codes and ciphers; organ- ization and equipment; military law . . . . .	3-3	MS323.	Military telegraphy and telephony; radio sets . . . .	3-3
Fourth Year					
<i>First Term</i>		<i>Second Term</i>			
MS41.	Drill and command . . . .	1-0	MS42.	Drill and command . . . .	1-0

## ORDNANCE UNIT

Open only to students in Courses II, III, III<sub>1</sub>, V, VIII, IX-A, X, X-B, XIV<sub>1</sub>, XV<sub>1b</sub>, XV<sub>3</sub>, and XVIII. Except in MS41 and MS42, instruction in the fourth year is given by Institute personnel. Approved changes in course schedules are noted below under the number of the course.

		Third Year			
		<i>First Term</i>		<i>Second Term</i>	
MS31.	Drill and command . . . .	1-0	MS32.	Drill and command . . . .	1-0
MS314.	Organization and duties of the Ordnance Department . . . . .	1-1	MS324.	Organization and duties of the Ordnance Department . . . . .	1-1
		Fourth Year			
		<i>First Term</i>		<i>Second Term</i>	
MS41.	Drill and command . . . .	1-0	MS42.	Drill and command . . . .	1-0

## AIR CORPS UNIT

Open only to students in Course XVI who were members of an Air Corps Unit on May 5, 1932. Except in MS31 and MS42, instruction in first term of third year and second term of fourth year is given by Institute personnel. Approved changes in course schedules are noted below under the number of the course.

		Third Year			
		<i>First Term</i>		<i>Second Term</i>	
MS31.	Drill and command . . . .	1-0	MS32.	Drill and command . . . .	1-0
			MS325.	Air Corps Tactics . . . . .	3-3
		Fourth Year			
		<i>First Term</i>		<i>Second Term</i>	
MS41.	Drill and command . . . .	1-0	MS42.	Drill and command . . . .	1-0
MS415.	Pursuit, attack, observation, and bombardment operations; administration and supply . . . . .	3-3			

## CHEMICAL WARFARE UNIT

Open only to students in Courses V, X, X-B, XIV and XV<sub>2</sub>. Except in the subjects indicated below, instruction is given by Institute personnel. Approved changes in course schedules are noted below under the number of the course.

		Third Year			
		<i>First Term</i>		<i>Second Term</i>	
MS31.	Drill and command . . . .	1-0	MS32.	Drill and command . . . .	1-0
MS316.	Combat Principles of Infantry and Chemical Troops . . . . .	2-2	MS326.	Tactics and technique of the Chemical Warfare Service . . . . .	2-2
		Fourth Year			
		<i>First Term</i>		<i>Second Term</i>	
MS41.	Drill and command . . . .	1-0	MS42.	Drill and command . . . .	1-0
MS416.	Tactical Employment of the Chemical Platoon . . . . .	2-2			

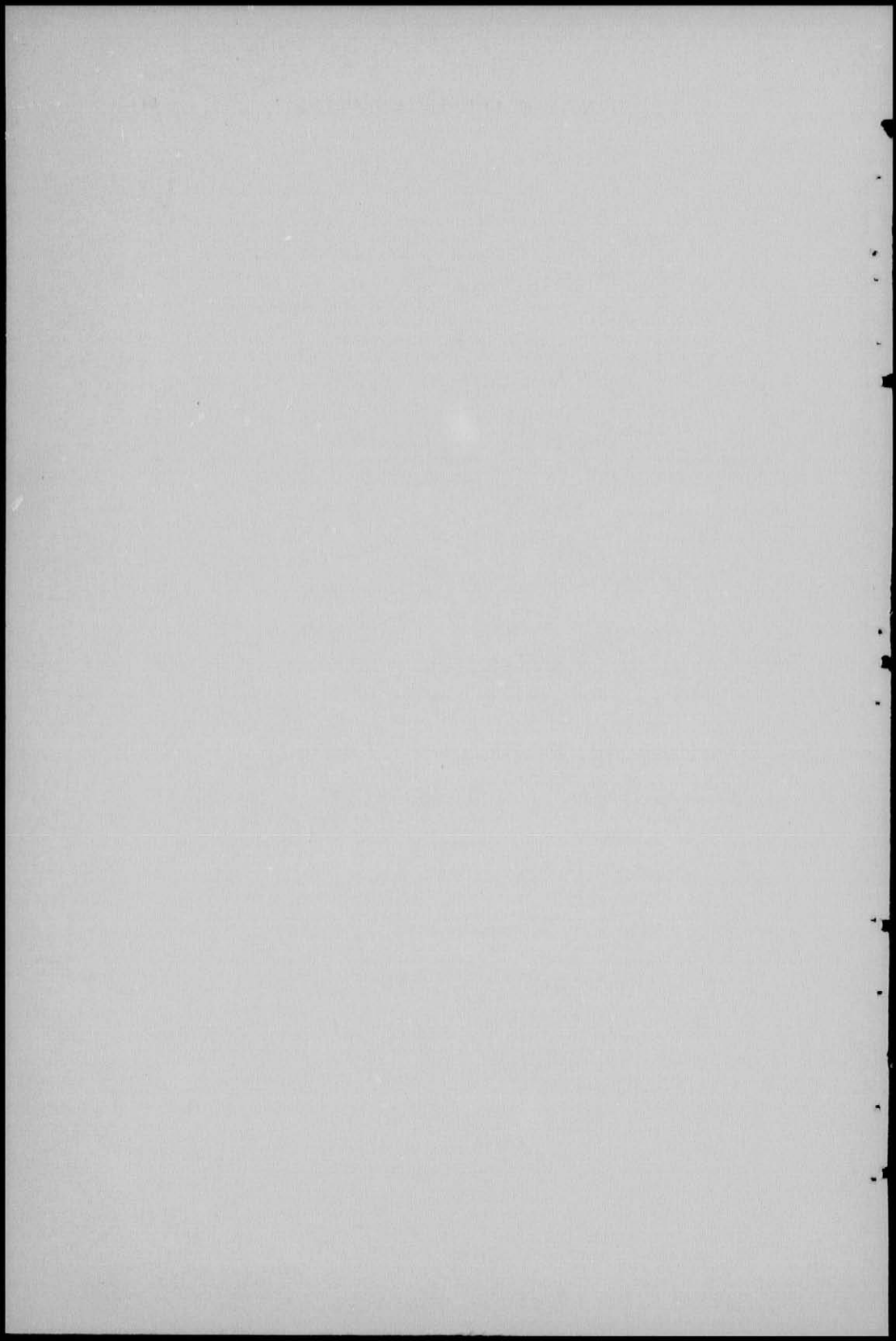
## CHANGES IN COURSE SCHEDULES

The following table shows approved changes in Course Schedules for the various units of the R. O. T. C. Changes shown in italics are required.

Course	Yr.	Tm.	Unit	Change	
II	3	1	C. A. C.; C. E.	Omit: General Study	2-2
			C. A. C.	Omit: Testing Materials Lab. 2'35	4-2
	4	2	C. A. C.	Add: Testing Materials Lab. 2'36	2-1
			O. D.	Omit: Professional Electives	4-0
				<i>Include Ordnance Engineering 2'88</i> <i>(5-3) or Gasoline Automobile 2'79</i> <i>(4-4) as a Professional Elective.</i>	
III <sub>1</sub>	3	2	C. A. C.; C. E.	Omit: General Study	2-2
			C. A. C.	Omit: General Study	2-2
III <sub>2</sub>	3	2	C. A. C.; C. E.	Omit: General Study	2-2
			C. A. C.	Omit: Elective	3
III <sub>3</sub>	3	2	C. A. C.; C. E.	Omit: General Study	2-2
			C. A. C.	Omit: Elective	4
III <sub>4</sub>	3	2	C. A. C.; C. E.	Omit: General Study	2-2
			V	Omit: Organic Chemical Lab. 5'424	13-0
VI	4	1	C. A. C.	Add: <i>Study of War Gases 5'33</i>	1-1
			C. A. C.; O. D.; C. W. S.	Organic Chemical Lab. 5'425	9-0
	4	2	C. A. C.	Omit: Elective	4
			O. D.; C. W. S.	Omit: Elective	4
	3	1	C. A. C.; C. E.; S. C.	Add: <i>Powder and Explosives 5'43</i>	2-2
			C. A. C.	Omit: Eng. Electronics 6'39T	5-4
			C. E.; S. C.	Add: General Study (G3)	2-2
			C. A. C.; C. E.; S. C.	Add: Storage Batteries 6'29	1-1
	4	1	C. A. C.	Omit: Political Economy Ec32	3-3
			C. A. C.; C. E.	Omit: General Study	2-2
4	2	C. A. C.; C. E.	Omit: Professional Elective	3-6	
		S. C.	Add: Eng. Electronics 6'39T	5-4	
		C. A. C.; C. E.; S. C.	Omit: Hydraulics 1'64	3-6	
		C. E.; S. C.	Add: Eng. Electronics 6'39T	5-4	
		C. A. C.; C. E.; S. C.	Omit: Professional Elective	3-6	
		C. E.; S. C.	Add: Political Economy Ec32	3-3	
VII <sub>1</sub>	3	1	C. A. C.; C. E.	Add: Elec. Equip. Bldgs. 6'48	1-2
			C. A. C.; C. E.	Omit: General Study	2-2
VII <sub>2</sub>	4	1	C. A. C.	Omit: General Study	2-2
			C. A. C.	Omit: Elective	5
VIII	3	1	C. A. C.; S. C.	Omit: General Study	2-2
			O. D.	Omit: General Study	2-2
	4	1	S. C.	Add: <i>Organic Chemistry 5'42</i>	3-2
			C. A. C.	<i>Include an elective that meets Signal Corps requirements</i>	3-6
IX-B	4	2	C. A. C.	Omit: General Study	2-2
			S. C.	<i>Include an elective that meets Signal Corps requirements</i>	3-6
	4	1	S. C.	Omit: Elective	4
			S. C.	Add: <i>Powder and Explosives 5'43</i>	2-2
X	4	2	C. A. C.; O. D.; C. W. S.	<i>Include Electrical Communications 6'301</i> <i>or other elective approved by the Signal Unit</i>	3-6
			O. D.; C. W. S.	<i>Include Electrical Communications 6'302</i> <i>or other elective approved by the Signal Unit</i>	3-6
X	4	2	C. A. C.; O. D.; C. W. S.	Omit: Professional Elective	4
			O. D.; C. W. S.	Add: <i>Powder and Explosives 5'43</i>	2-2

CHANGES IN COURSE SCHEDULES

Course	Yr.	Tm.	Units	Change	
XIII	3	1	C. A. C.	Omit: General Study . . . . .	2-2
	4	2	C. A. C.	Omit: General Study . . . . .	2-2
XIV	4	1	C. A. C.	Omit: Elective . . . . .	3
	4	2	C. A. C.	Omit: Elective . . . . .	2
			O. D.	Omit: Elective . . . . .	4
			C. W. S.	Add: <i>Powder and Explosives</i> 5'43 . . . . .	2-2
			Omit: Elective . . . . .	6	
			Add: <i>Study of War Gases</i> 5'33 . . . . .	1-1	
			<i>Powder and Explosives</i> 5'43 . . . . .	2-2	
XV <sub>ia</sub>	4	1	C. A. C.	Omit: General Study . . . . .	2-2
XV <sub>ib</sub>	3	1	C. A. C.; C. E.; S. C.	Omit: General Study . . . . .	2-2
	4	1	C. A. C.	Omit: Professional Elective . . . . .	2-2
XV <sub>ic</sub>	3	2	C. A. C.; C. E.	Omit: Professional Electives . . . . .	2-2
XV <sub>2</sub>	4	1	C. A. C.	Omit: General Study . . . . .	2-2
XVI	4	1	C. A. C.	Omit: Elective . . . . .	4
	4	2	C. A. C.	Omit: Elective . . . . .	4
XVII	3	2	C. A. C.; C. E.	Omit: General Study . . . . .	2-2
XVIII	4	1	C. A. C.	Omit: Elective . . . . .	4
	4	2	C. A. C.	Omit: Elective . . . . .	4



THE GRADUATE SCHOOL  
ARCHITECTURE, ENGINEERING, SCIENCE

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

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

## THE GRADUATE SCHOOL

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

In 1884 courses leading to the degrees of Master of Science and Doctor of Philosophy were announced. The former degree was first conferred in 1886 and the latter in 1907, both to students in the Department of Chemistry. The first degree of Doctor of Science was conferred in the Department of Electrical Engineering in 1911. The degree of Doctor of Public Health was established in 1924 in the Department of Biology and was first conferred in 1925. In 1921 the degree of Master of Science for students in the Department of Architecture was changed to Master in Architecture. The degree of Doctor of Engineering, established in 1902, was discontinued in 1919.

At the present time the Institute awards the following higher degrees:

To students in all Departments of Science and Engineering, the degree of Master of Science, with designation of the field of study, or without such designation, depending upon the character of the course pursued; in the Department of Architecture, the degree of Master in Architecture; in the Departments of Science, namely, Biology, Chemistry, Geology, Mathematics, and Physics, the degrees of Doctor of Philosophy and Doctor of Science; in the Departments of Engineering, namely, Aeronautical Engineering, Chemical Engineering, Civil and Sanitary Engineering, Electrical Engineering, Electrochemical Engineering, Mechanical Engineering, Mining and Metallurgy, and Naval Architecture, the degree of Doctor of Science;

in the Department of Biology, and Public Health, the degree of Doctor of Public Health.

The registration in the Graduate School for 1932-1933 was between five and six hundred students, approximately one-fifth of the total registration of the Institute. Of these, one hundred fifty-seven were pursuing courses leading to the Doctorate, three hundred thirteen to the degree of Master of Science, eleven to the degree of Master in Architecture, and forty-two were taking special work without reference to a degree.

The cosmopolitan character of the School is indicated by the fact that the students were graduates from one hundred fifty-four universities, technical schools, or institutions of higher learning, distributed among all but four states of the Union and thirty foreign countries.

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

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

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

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

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

Applications for admission to the Graduate School are to be made in duplicate on blanks obtainable from the Secretary of the Graduate School, except those of Naval Constructors appointed by the United States Government. Applications should, if possible be filed with the Secretary not later than May 1, in order that applicants may be advised regarding their standing before the beginning of the Summer Session. Frequently it is very desirable that deficiencies in undergraduate work be made up during the summer; in any case applications and credentials should be submitted *not less than three weeks before the opening of the term* in which the student expects to register. Applications from students who have not previously been in residence at the Institute must be accompanied by a certified transcript of their college records and letters from three or more professors acquainted with their work. As soon as applications for admission have been acted upon students will be notified. All new students other than Institute graduates should plan to reach Cambridge several days before the opening of the term and, upon their arrival at the Institute, *should consult the Dean of the Graduate School before filing their registration cards.* The Dean is

the general consulting officer for graduate students on all matters pertaining to graduate work. Institute graduates should consult the chairman of the Committee on Graduate Students of the Department in which they elect their major work before registering.

**Tuition and Expenses.** See pages 34 and 40.

Information regarding Graduate Scholarships and the Technology Loan Fund will be found on pages 50 to 55.

**Coöperation with Harvard University.** Graduate students are given the opportunity of taking at Harvard University a limited number of courses under a coöperative agreement between Harvard University and the Massachusetts Institute of Technology, which provides that "Advanced courses other than courses prescribed in undergraduate programs or courses in research, may, with the consent of the Instructor and the Dean or the Head of the Department in which the student wishes to work, be taken in either institution by students of the other without payment of fees."

A graduate student at the Institute desiring to take advantage of this privilege must present to the Dean of the Graduate School, from the chairman of his department committee, a request for admission to the desired Course, stating the catalogue number and title, together with the name of the instructor giving it. The Dean will then give the student a letter of recommendation, to be presented in person, to the Dean of the Harvard Graduate School.

#### THE MASTER'S DEGREE

The degree of Master of Science is awarded upon the satisfactory completion of a course of advanced study and research approved by the Faculty and extending over not less than one year. The degree of Master in Architecture is awarded to students completing the requirements for this degree in the Course in Architecture. See page 177 under Department of Architecture.

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

College students intending to enter the Institute for a course of study leading to the Master's degree will find it advantageous to

make their selection of college electives correspond as nearly as possible to the undergraduate work of the Institute. If in doubt in regard to any courses of study, they should write to the Dean of the Graduate School or to the chairman of the Committee on Graduate Students of the department they wish to enter.

Members of the instructing staff of the Institute may meet the requirements for the Master's degree by taking approved programs of work as described on page 156.

### Requirements for the Degree of Master of Science

#### *Undergraduate Prerequisites*

To be accepted as a candidate for the Master's degree, except in Architecture,\* an applicant must have completed requirements in the following undergraduate subjects common to all courses.

**Language.** The equivalent of the entrance requirement of the Institute. In place of such requirements, the applicant may satisfy the Department in which he wishes to take advanced work that he has a good reading knowledge of scientific French or German.†

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

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

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

**Cultural Subjects and Economics.** It is expected that the applicant shall have a knowledge of English, History, Economics and General Studies, similar to those included in the undergraduate curricula at the Institute. In the case the applicant is unusually deficient in meeting this requirement, he may be required to take courses in these subjects.

**Professional Subjects.** The applicant must, in addition, have completed such professional subjects as may be required by the Department in which he desires to take his Master's degree. Such

\* For requirements in Architecture see page 177.

† Both languages are required in certain departments as indicated below under the respective departments.

subjects will be found listed below under each Department respectively. Deficiencies in required undergraduate courses must be removed before proceeding with dependent graduate work.

### *Graduate Requirements*

The degree of Master of Science is awarded upon the satisfactory completion of a course of 96 units\* of advanced study and research, three-quarters of which, or 72 units including thesis, are chosen from "A" subjects primarily for graduates, and the remaining 24 units are chosen from "A" subjects, or from "B" subjects open to graduates and undergraduates. The number of units credited to thesis shall not be less than 20 or more than 40. If 64 units of the required "A" subjects, including thesis, are chosen from subjects in a single field of science or engineering, the degree will be recommended with specification of the field in which the student has thus specialized, otherwise the degree will be awarded without specification of field.

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

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

*"A" Subjects primarily for Graduates.* These are more advanced in character than those required for the degree of Bachelor of Science. They are intended for mature students and are presented with this class of students in view.

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

A description of all "A" and "B" subjects will be found under the Description of Subjects on pages 223-318. The units assigned to each subject, the instructor in charge of the subject, and the required preparatory subjects will be found under the Tabulation of Subjects' pages 319-361.

\* For definition of "Unit" see page 41.

Students in doubt as to their preparation for any graduate course should correspond with the professor in charge. Many of the subjects which are prerequisites are offered in the Summer Session. Subjects taken as preparation for graduate studies will not be considered as counting towards a higher degree. Subjects listed under "B" in one department shall not be counted as "A" subjects in another department.

The number of units allotted to each subject of instruction is shown in the schedules; for instance, on page 165 under the subject of 1·14 Geodesy, 2 units are devoted to classroom work and 4 units are assigned for outside preparation. The subject would therefore count for 6 units in making up the 96 units required for the degree. Where no division of time between exercise and preparation is indicated, the total number of units devoted to the subject is given.

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

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

**Candidacy for the Degree.** After the student has been in residence not less than one term, he may, upon recommendation of the committee in charge of his course of study, be placed on the list of accepted candidates for the degree. The candidacy will be for the Master's degree with specification of field of study or without designation of field, as the committee may then determine.

**Recommendation for the Degree.** To be recommended for the Master's degree, a student must not only have completed the program of graduate study and research approved by his Department Committee, *but his scholastic standing must be of a distinctly high grade.*

His academic rating will be based on records received in all "A" and "B" subjects taken while registered as a graduate student, or credited to him by the committee in charge of his course.

**Prescribed Curricula Leading to the Degree of Master of Science.** In addition to the elective graduate courses leading to the

degree of Master of Science the Institute awards the degree for the satisfactory completion of prescribed curricula in the following fields:

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

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

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

A five-year coöperative course in Electrical Engineering (VI-A) leading to the degrees of Bachelor of Science and Master of Science in Electrical Engineering.

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

**Program of Studies for Instructors and Assistants.** Members of the teaching staff may work towards a Master's or a Doctor's degree by following a program of study and research approved by the Committee on Graduate Students of their respective departments. The length of time needed for completing the requirements will depend upon the amount of work undertaken. Members of the instructing staff may apply for scholarship aid to meet tuition fees on the same basis as other graduate students. (See page 50.)

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

The study and research leading to the Doctor's degree are especially valuable to those who wish to engage in original investigation or to teach at higher institutions of learning. Moreover, the increasing demand in the industries for men who have had extended scientific training and have also the attitude of mind impelling them to attack new problems, opens special advantages to those who have obtained a Doctor's degree.

The degree of Doctor of Science or Doctor of Philosophy certifies to the creditable completion of a program of advanced studies, and

\* The specific requirements for the degree of Doctor of Public Health are given on page 200.

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

**Admission.** The general requirements for admission of all graduate students will be found on page 151. In addition, an applicant for admission to a course of graduate study leading to the Doctor's degree must include on his application blank a general statement of his proposed course of study and research, and indicate the choice of major and minor fields in which he desires to specialize. If not a graduate of the Institute of Technology, his application must contain a full statement of his preparation for undertaking work leading to the doctorate.

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

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

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

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

### Requirements

Students proceeding towards the doctorate will be under the general supervision of the Committee on Graduate Students of the Department in which they elect their "major" work.

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

In addition to the "major," a "minor" must be taken in at least one other branch of science or engineering or in mathematics. In general only one "minor" is required, consisting of at least twenty-five units of work, more advanced in character than required in the undergraduate curriculum of the department in which the student is majoring. The program for the minor requirement must be submitted to and approved by the Committee on Graduate Students of the department in which the minor is taken, soon after the student has registered for the Doctorate. In approving a schedule of studies for a "minor" in a given field of science or engineering, a department committee may include subjects offered in other departments provided these subjects lie within the field of the "minor" and form, with other subjects, a logical program.

The student's grasp of subjects included in the field of his major and minor is tested by examinations, which may be written or oral or both, at the discretion of the department concerned. Satisfactory records in subjects taken in regular course may be accepted by a Departmental Committee as meeting the requirements in a "minor." "Minor" requirements must be completed at least seven months be-

fore the candidate intends to present himself for his degree except by special vote of the Committee on the Graduate School. A comprehensive examination on the field of science or engineering constituting the "major" must be passed not less than seven months before the time at which it is expected that the degree may be conferred.

**Language.** All candidates for the Doctor's degree must possess a good reading knowledge of scientific French and scientific German as shown by a reading test *to be taken not less than seven months before the award of the degree.* Exception, however, may be made in the case of a student working for the degree of Doctor of Science in the field of engineering, and only one of these languages required if approved by the Departmental Committee on Graduate Students in charge of the student's work.

**Candidacy for the Doctorate.** When a student has completed the requirements in his "minor" and in modern languages, has passed his general "major" examination, and has given evidence of his ability to carry on research work of a high grade, his Departmental Committee will recommend to the Committee on the Graduate School that he be placed on the list of accepted candidates for the Doctor's degree. This recommendation, when approved by this committee, will be presented to the Faculty. When the student has been placed on the list of candidates he will be so notified by the secretary of the Faculty. He will then be free to devote himself for a period of at least seven months exclusively to his research and to the preparation for his final examination, which will, in general be limited to the special field of his research. Students who expect to complete the work for the doctorate and receive their degrees at Commencement (in June) must meet all of the above requirements and be placed on the list of accepted candidates not later than November of the preceding year.

Each candidate for the degree of Doctor of Science, Doctor of Philosophy, or Doctor of Public Health must deposit with the secretary of the Committee on the Graduate School two typewritten copies of his thesis and one typewritten copy of an abstract of his thesis, not exceeding one thousand words in length, suitable in form and substance for publication. These must be received at least two weeks before the first annual examination if the candidate expects to receive his degree at Commencement. He must also submit to his department committee such other abstracts as the committee may require.

When the thesis has been accepted and the final examination

passed, the candidate, upon the recommendation of his Departmental Committee and of the Committee on the Graduate School, will be recommended to the Faculty for the degree.

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

**DEPARTMENT OF CIVIL AND SANITARY ENGINEERING**

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

In Structural Engineering a considerable number of advanced subjects are offered in which modern methods of investigating stresses in complicated structures, both of steel and reinforced concrete, are presented at length and applied to structures of various types, such as arches, suspension bridges, continuous bridges, frameworks of high buildings and high masonry arched dams. Experimental researches have been carried on in the past, and are now being conducted with the object of verifying mathematical investigations and formulas pertaining to such structures, and further research may be profitably made in this field by interested students. Other research work consists of the design and investigation of the economy and suitability of various types of construction for particular structures and investigations of properties of soils which may be of interest in engineering construction. The number of separate graduate courses offered in Structural Engineering is considerable, and the student wishing to specialize in this subject has a wide field open to him. Students seeking admission to these graduate courses should have a thorough training in the fundamental principles of structures equivalent to that covered by the Theory of Structures 1.40, 1.41, 1.42.

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

In Water Power Engineering, students investigate existing water power plants and make detailed studies and designs for a water power project. Studies are also made of the comparative economy and the valuation of various water power developments. Experimental investigations may be carried on in the Hydraulic Laboratory, and the cordial relations between water power companies in New England and the Institute have made it possible for students to conduct certain investigations at existing commercial plants. The graduate courses in this subject are dependent upon the undergraduate courses in Water Power Engineering (1.70, 1.71) and students wishing to enter the graduate subjects should have had the full equivalent of these undergraduate courses, which latter have been found to represent advanced work for most graduate students entering the Institute from other institutions, as well as for those who have graduated from other departments of the Institute.

In the field of Theoretical Hydraulics, work of an advanced nature is given, in which the whole subject of hydraulic flow is reviewed and the relation between fundamental formulas and experimental results discussed. Subject matter, not ordinarily

included in elementary courses in hydraulics, includes a discussion of open channel flow with special reference to the alternate and critical stages and to the occurrence of the hydraulic jump and its utilization as an absorber of energy; the flow of water at velocities below the critical and the determination of the value of the critical velocity; recent developments in the art of measuring the flow of water in closed conduits; and the dynamic action of streams upon immersed surfaces and solids.

Training in the River Hydraulic Laboratory is given by lecture courses and by experimental work. Researches have been conducted in recent years to determine the permeability of a proposed dike along the Connecticut River near Hartford, Connecticut; to develop a method for reducing or preventing silting under a floating dry dock in New York Harbor; and to determine a method for controlling the erosion of the banks of the Connecticut River near Northampton, Massachusetts. Other subjects investigated include the effect of locks on a sea level canal subject to tidal currents, and the character of aprons best fitted to resist erosion for certain projected dams.

Advanced courses in Railway and Highway Transportation such as experimental work in the Highway Testing Laboratory, investigations of highway traffic control, design and operation studies for improvements of existing railway terminals and other special problems have in the past been done as advanced work, and the department is prepared to offer similar opportunities in the future if sufficient demand exists. The undergraduate courses in these subjects, however, cover the general subject of transportation, including the interrelation of railway, highway and water transportation, and it has been found that the fourth year courses constitute advanced work for most graduate students attending the Institute as well as for those who have graduated from other options of the Civil Engineering course.

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

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

Arrangements have been made for graduate students in Sanitary Engineering to spend several days at the Providence water treatment plant, during which time they are instructed in the principles of coagulation, the chemical treatment of water and the operation of modern rapid sand filters; also a similar period at the Worcester sewage treatment plant, where they are instructed in the operation of racks, grit chambers, Imhoff tanks, dosing tanks, trickling filters,

secondary settling tanks and sludge drying beds. Both of these short courses include practice in routine laboratory tests.

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

Research in the hydraulic, chemical and biological processes relating to Sanitary Engineering may be carried on in the Hydraulic, Sanitary Engineering, Chemical and Bacteriological laboratories of the Institute; and opportunities are available in the Sanitary Engineering Laboratory for experimental investigations upon plumbing fixtures and connections.

### Professional Undergraduate Prerequisites for Civil Engineering

In addition to the general requirements for all graduate students stated on page 151, a student who desires to be a candidate for the degree of Master of Science in Civil Engineering must present evidence of training in certain professional studies considered essential for all Civil Engineers and corresponding approximately to the following Institute subjects:

Surveying	1'00, 1'01, 1'05, 1'06
Railway & Highway Eng.	1'20, 1'21
Applied Mechanics	2'20
Hydraulics	1'62
Geology	12'322
Structures	1'40, 1'41, 1'421
Bridge Design	1'501

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

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

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

**Professional Undergraduate Prerequisites  
for Sanitary Engineering**

In addition to the general requirements for all graduate students stated on page 151, students who desire to be candidates for the degree of Master of Science in Sanitary Engineering must present evidence of having had training in certain professional studies considered essential for all Sanitary Engineers, the field covered corresponding approximately to that covered by the following courses at the Institute:

Surveying	1'041
Biology and Bacteriology	7'29
Chemistry	5'23
Structures	1'40, (1'41), (1'421)
Hydraulics	1'62
Applied Mechanics	2'20
Sanitary Engineering	(1'75), (1'76), (1'79)

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

**GRADUATE SUBJECTS IN CIVIL AND SANITARY ENGINEERING****"A" Subjects. Primarily for Graduates.**

Available for graduates in either Civil or Sanitary Engineering.

<i>First Term</i>		<i>Second Term</i>			
1'301	Railway Trans. Adv. . . . .	2-4	1'136	Vibration Problems . . . . .	3-6
1'31	Railway Design, Adv. . . . .	Time arr.	1'14	Geodesy, Adv. . . . .	2-4
1'32	Design of Harbor Works	3-6	1'302	Railway Trans. Adv. . . . .	2-4
1'372	Highway Trans. Adv. . . . .	2-4	1'31	Railway Design, Adv. . . . .	Time arr.
1'491	Soil Mechanics. . . . .	3-6	1'373	Highway Trans. Adv. . . . .	2-4
1'551	Structural Design, Adv. . . . .	6-0	1'492	Soil Mechanics. . . . .	3-6
1'561	Structures Adv. . . . .	3-9	1'552	Structural Design, Adv. . . . .	6-0
1'581	Reinf. Concrete Design. . . . .	6-2	1'562	Structures, Adv. . . . .	3-9
1'68	Th. of Hydraulic Models	1-3	1'57	Secondary Stresses. . . . .	2-4
1'691	River Hydraulic Lab. . . . .	9-0	1'582	Reinf. Concrete Design. . . . .	2-4
1'731	Water Power Eng., Adv. . . . .	3-6	1'66	Hydraulics Advanced. . . . .	2-6
1'811	Sanitary Eng., Adv. . . . .	3-6	1'67	Des. of Masonry Dams. . . . .	5-2
1'851	Water Power Design, Adv. . . . .	8-0	1'692	River Engineering. . . . .	2-4
1'881	Sanitary Design, Adv. . . . .	6-0	1'732	Water Power Design, Adv. . . . .	3-6
			1'812	Sanitary Eng., Adv. . . . .	3-6
			1'852	Water Power Design, Adv. . . . .	8-0
			1'882	Sanitary Design, Adv. . . . .	6-0

**"B" Subjects. Open to Graduates and Undergraduates.**

<i>First Term</i>		<i>Second Term</i>			
1'131	Geodesy. . . . .	2-4	1'132	Geod. Astron. & Nav. . . . .	3-6
1'135	Seismometry & Vibra. Meas. . . . .	3-2	1'133	Geodetic Laboratory. . . . .	2-0
1'271	Transportation Eng. . . . .	5-5	1'134	Adjust. of Observations. . . . .	3-6
1'41	Structures. . . . .	4-8	1'138	Seismological Lab. . . . .	4-0
1'48	Foundations. . . . .	3-4	1'16	Aerial Surveying. . . . .	2-2
1'501	Bridge Design. . . . .	7-0	1'25	Eng. Construction. . . . .	4-4
1'511	Bridge Design. . . . .	4-0	1'26	Railway Signaling. . . . .	2-3
1'70	Water Power Eng. . . . .	6-3	1'272	Transportation Eng. . . . .	3-3
1'75	Hydraulic & San. Eng. . . . .	4-6	1'28	Railway Design. . . . .	5-0
1'801	Sanitary Design. . . . .	3-0	1'36	Phys. & Chem. of Test.	
5'37	Chem. of Road Materials. . . . .	4-0		High. Mat. . . . .	5-1
			1'38	Highway Design. . . . .	5-0
			1'42	Structures. . . . .	4-8
			1'502	Bridge Design. . . . .	5-0
			1'512	Bridge Design. . . . .	6-0
			1'71	Water Power Engineering. . . . .	6-3
			1'76	Sanitary Engineering. . . . .	2-3
			1'78	Sanitary Engineering. . . . .	3-4
			1'79	Hydraulic & San. Design. . . . .	2-0
			1'802	Sanitary Design. . . . .	6-0
			G10	Develop. of Transportation	2-2

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1'25	Engineering Construction (B) . . . . .	4-4
1'371	Pavements and Highway Transportation (B) . . . . .	3-6
1'41	Structures (B) . . . . .	4-8
1'68	Th. of Hydraulic Models (A) . . . . .	1-3
1'691	River Hydraulic Lab. (A) . . . . .	9-0

### DEPARTMENT OF MECHANICAL ENGINEERING

The Department of Mechanical Engineering offers advanced work, including theoretical courses and opportunities for research leading to the degrees of Master of Science and Doctor of Science in several different divisions of the field of Mechanical Engineering. Graduate work may be pursued in one or more of the following groups of study: mathematics; advanced mechanics, including the theory of elasticity, dynamics and stress analyses by photo-elastic methods; plasticity and semi-elastic materials; applied hydrodynamics; advanced machine design and the design of automatic machinery; advanced heat engineering, including thermodynamics at low temperatures, the study of ice formation, heat flow under fluctuating temperature conditions, steam power plant design, and the design of reciprocating engines of either steam or internal combustion types; automotive engineering, including the design, methods of manufacture, operation, and testing of various types of motor vehicles and the study of their fuel characteristics; physical metallurgy, including study of the influence of heat treatment and various mechanical processes upon the physical properties of engineering materials and X-ray examinations of materials; textile engineering and textile machinery design, metrology and engineering standards. In addition to the work in these fields of Mechanical Engineering a student with the requisite preparation may elect as a part of his course some work in other lines, such as business administration and management.

The Engineering Laboratories with their varied and extensive equipment, offer excellent facilities for experimental research along all of the foregoing lines. The Laboratories, which may be classified as Steam, Hydraulic, Compressed Air, Refrigeration, Air Conditioning, Gas and Gasoline, Automotive, Power Measurements, Textile, Testing Materials, cover a floor space of over 70,000 square feet. In addition to these the Laboratories of the Department of Physics are available for research involving Heat Measurements and the use of the X-ray; and the Laboratories of the Department of Mining and Metallurgy are available for research in Physical Metallurgy, Metallography and Heat Treatment.

The Steam Laboratory has fourteen engines, three turbines, seven condensers, together with miscellaneous and auxiliary equipment.

The Hydraulic Laboratory has a plant for testing water wheels up to 175 h. p. under heads up to 38 feet; numerous measuring tanks, high pressure pumps and auxiliary apparatus.

The Compressed Air Laboratory contains five air compressors of from 10 to 25 h.p. input capacities, working with delivery pressures up to 2,500 pounds per square inch.

The Power Measurement Laboratory contains equipment for testing fans, transmission of power by belts, critical speed, torsion dynamometers, gear testing machine, dynamic balancing machines, also Sprague dynamometer outfit for determining transmission losses.

The Testing Materials Laboratory contains an Amsler vertical machine of 1,000,000 pounds capacity, a 400,000-pound Richlé machine, a Southwark-Emery machine with a capacity of 300,000 pounds, four machines of 100,000, one of 70,000, three of 60,000, one of 50,000, one of 20,000 and one of 10,000 pounds capacity; also two beam machines and three torsion machines. It also contains Charpy and Izod impact machines, and a full equipment of modern testing apparatus for measuring the hardness of different materials. The equipment also includes a complete laboratory for mixing and testing cement, all the apparatus required for proportioning, mixing and testing concrete, with a 200,000 pound Southwark-Emery machine for making compression tests, and a complete equipment for testing road materials. A photo-elastic laboratory containing the equipment necessary for stress analysis by the use of polarized light also forms a part of the laboratory for testing materials.

The Textile Laboratory embraces a full equipment of testing machines, with capacities ranging from 500 grams to 2,000 pounds, the machines being equipped with numerous types of jaws and arranged to be run at varying rates of load application. The machines are all equipped with autographic apparatus for recording the stretch of the fabric under test. In addition there are numerous special machines for measuring wear, textile resilience and moisture effects. The laboratory is under full moisture control, with automatic apparatus for both humidification and dehumidification. In addition to the equipment for physical tests of textiles, there is provided a separate room newly equipped with optical apparatus for the microscopic study of fibers. This includes microscopes of high and low magnification, a full complement of autographic and projection instruments, together with the most modern means for the production and mounting of microscopic specimens. This room is double curtained for darkness, is mechanically ventilated and is conveniently arranged for advanced research upon textile fibers. In addition to the physical and optical laboratory equipment, there is a full set of cotton-working machinery, from card to the loom inclusive. This is used for the demonstration of manufacturing processes and supplements the work of the testing laboratories.

The Gas and Gasoline Laboratory contains about 2,200 h. p. of engines of different types, two Diesel engines, an equipment for testing airplane engines up to 600 h. p., Sprague dynamometers being attached to many of the engines. In addition the laboratory contains oil engines, a gas producer and a gas producer engine. Two optical indicators and a complete two-element oscillograph of the latest type built by the Westinghouse Electric and Manufacturing Company are available for research work in the Laboratory.

The Refrigerating Laboratory contains a 5-ton absorption refrigerating machine, a 1-ton ammonia machine used for cooling brine, a half-ton commercial sulfurous anhydride machine for general testing, 2 one-quarter ton ammonia machines for ice freezing,

seven different types of domestic refrigerating machines, including both absorption and compression ammonia machines, as well as units using sulfurous anhydride and methyl chloride. There are also cut-away models of a commercial machine and of two different types of domestic units. The laboratory is supplied with the necessary equipment of auxiliary apparatus and measuring instruments. A study of humidity problems is made possible by the presence of two Carrier air conditioning units of industrial and domestic sizes. A constant temperature room is available for testing purposes.

### Requirements

A student proposing to follow a course of study leading to a degree of Master of Science or Doctor of Science in the Field of Mechanical Engineering must have satisfactorily completed a course of study essentially equivalent to the four-year curriculum leading to the degree of Bachelor of Science in Mechanical Engineering at the Massachusetts Institute of Technology.

The following exceptions to this requirement may be made:

(a) Satisfactory records in other studies outside of this curriculum will be accepted as full equivalent of the following courses in the Mechanical Engineering schedule:

1'03	Surveying	2'92	Pattern Making
2'04	Mechanical Engineering Equipment	2'98	Production Methods
2'90	Forging		Fourth Year elective studies

(b) Students who have not had the equivalent of the following subjects in their undergraduate curricula but can present satisfactory records in other engineering work of substantially the same time allotment may make up such deficiencies by electing one or more of these studies as "B" subjects in their graduate course schedules.

2'251	Dynamic of Machines	2'58	Power Plant Design
2'26	Mechanics of Engineering	2'71	Machine Design
2'43	Refrigeration	2'781	Industrial Plants

## GRADUATE SUBJECTS IN MECHANICAL ENGINEERING

## "A" Subjects. Primarily for Graduates

<i>First Term</i>		<i>Second Term</i>			
2'254	Dynamics of Engines . . . . .	2-4	2'09	Des. of Automatic Mach. . . . .	12-0
2'281	Adv. Mech. & Th. of Elast. . . . .	3-9	2'282	Adv. Mech. & Th. of Elas. . . . .	3-9
2'295	App. Hydrodynamics . . . . .	4-8	2'285	Photoelasticity . . . . .	4-2
2'393	Reinf. Con. Des. Adv. . . . .	Time arr.	2'296	Gen. Th. Hyd. Turb. & Pumps . . . . .	4-8
2'394	Concrete Research . . . . .	Time arr.	2'332	Eng. Metal Problems . . . . .	8-4
2'501	Refrigeration, Adv. . . . .	3-9	2'393	Reinf. Conc. Des. Adv. . . . .	Time arr.
2'505	Storage & Trans. of Food-stuffs . . . . .	3-6	2'394	Concrete Res. . . . .	Time arr.
2'581	Power Plants, Adv. . . . .	3-6	2'502	Heat Transmission, Adv. . . . .	3-9
2'591	Heat & Ventilation, Adv. . . . .	3-6	2'504	Refrigeration Eng. . . . .	3-3
2'593	Air Conditioning . . . . .	2-4	2'506	Des. of Refrig. Plant . . . . .	2-4
2'741	Machine Des., Adv. . . . .	8-2	2'592	Heat. & Vent. Design . . . . .	4-4
2'801	Automotive Eng. . . . .	3-6	2'594	Refrig. & Air. Cond. Lab. . . . .	4-2
2'811	Automotive Design . . . . .	8-0	2'672	Motor Veh. Test. . . . .	5-3
2'981	Manufacturing Proc. . . . .	3-3	2'742	Machine Des. Adv. . . . .	8-2
2'99	Met. & Dimens. Eng. Stand. Research	3-6	2'802	Automotive Eng. . . . .	3-6
			2'812	Automotive Design . . . . .	10-0
				Research	

The following subjects in Group A given in other departments may be taken for credit in the field of Mechanical Engineering.

3'651	Physical Metallurgy . . . . .	10-2	3'654	Physical Metallurgy . . . . .	10-6
M36	Calculus . . . . .	3-6	M37	Calculus . . . . .	3-6
			1'136	Vibration Problems . . . . .	3-6

## "B" Subjects. Open to Graduates and Undergraduates

2'251	Dynamics of Engines . . . . .	2-4	2'26	Mechanics of Eng. . . . .	3-6
2'35	Testing Materials Lab. . . . .	4-2	2'331	Eng. Metals . . . . .	2-2
2'391	Reinf. Conc. Design . . . . .	7-0	2'392	Reinf. Con. Des. . . . .	6-0
2'43	Refrigeration . . . . .	2-4	2'49	Refrigeration . . . . .	3-5
2'661	Maint. & Oper. of Auto. Equip. . . . .	2-2	2'58	Power Plant Design . . . . .	4-0
2'671	Engine Testing . . . . .	4-2	2'602	Engineering Lab. . . . .	3-3
2'681	Automotive Engine Lab. . . . .	4-4	2'64	Refrigeration Lab. . . . .	2-2
2'71	Machine Design . . . . .	5-0	2'66	Automobile Lab. . . . .	2-2
2'877	Textile Microscopy . . . . .	5-2	2'77	Engine Design . . . . .	6-2
			2'781	Industrial Plants . . . . .	3-3
			2'782	Industrial Plants . . . . .	4-0
			2'79	Gasoline Automobile . . . . .	4-4
			2'850	Automatic Mach. . . . .	2-2
			2'851	Fire Protection Eng. . . . .	2-2
			2'853	Locomotive Eng. . . . .	2-2
			2'854	Mech. Equip. of Bldgs. . . . .	2-2
			2'855	Steam Turbine Eng. . . . .	2-2
			2'858	Inspection Methods . . . . .	2-2
			2'87	Textile Engineering . . . . .	6-2
			2'877	Textile Microscopy . . . . .	5-2
			2'953	Welding Eng. and Practice . . . . .	3-1
			2'982	Prep. for Manufacturing . . . . .	3-3
			2'983	Production Design . . . . .	2-2

**AUTOMOTIVE ENGINEERING**

Students desiring to specialize in Automotive Engineering for a year of graduate study, leading to the degree of Master of Science in Mechanical Engineering, should register for Subjects 2'801, 2'802, 2'811, 2'812, 2'254, 2'671, 2'672, 2'661, 2'981, 3'741, 10'79 and such other subjects as may be approved by the Committee on Graduate Students in the Department.

**HEATING AND VENTILATING ENGINEERING**

Students desiring to specialize in Heating and Ventilation and Air Conditioning for a year of graduate study leading to the degree of Master of Science in Mechanical Engineering, should register for Subjects 2'591, 2'592, 2'593, 2'594, 7'53, 8'14 and such other subjects as may be approved by the Committee on Graduate Students of the Department.

**REFRIGERATION ENGINEERING**

Students desiring to specialize in Refrigeration Engineering for a year of graduate study leading to the degree of Master of Science in Mechanical Engineering, should register for Subjects 2'501, 2'502, 2'504, 2'505, 2'506, 2'593, 2'594, and such other subjects as may be approved by the Committee on Graduate Students in the Department.

**TORPEDO DESIGN**

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

**TORPEDO DESIGN, UNITED STATES NAVY**

<i>First Term</i>		<i>Second Term</i>	
2'06	Mechanism of Machines . . . 2-2	2'08	Automatic Machinery . . . . 4-4
2'07	Automatic Machinery . . . . 3-3	2'256	Dynamics of Rotation . . . . 1-2
2'251	Dynamics of Machines . . . . 2-4	2'32	App. of Photoelasticity . . . . 3-1
2'301	Materials of Engineering . . . 1-2	2'42	Eng. Thermodynamics . . . . 4-5
2'40	Eng. Thermodynamics . . . . 4-5	2'51	Torpedoes . . . . . 2-4
2'761	Machine Design . . . . . 6-2	2'691	Automotive Engine Lab. . . . 2-0
3'615	Metallography . . . . . 3-2	2'762	Machine Design . . . . . 6-2
3'713	Heat Treatment . . . . . 3-2	3'732	Physical Metallurgy . . . . . 8-2
3'731	Physical Metallurgy . . . . . 1-2	5'75	Thermodynamics . . . . . 2-2
5'683	Physical Chemistry . . . . . 2-2	Hours of exercise and preparation	32-22
Hours of exercise and preparation	27-26		54
	53		

## TEXTILE ENGINEERING

In response to numerous requests for opportunities to study textile questions of advanced character the Institute has fully equipped a Textile Laboratory where the physical study of textile fibers, yarns and fabrics is carried out in extreme detail. This laboratory consists of a process room equipped with cotton working machinery from the gin to the loom, a testing laboratory with testing machines and moisture control, and a microscope room darkened and fully equipped with textile optical apparatus. For graduates of textile schools of approved character, and for graduates of the Institute as well, a course of study has been outlined leading to the degree of Master of Science in Mechanical Engineering. This is awarded at the end of one or two years of study, depending upon the candidate's preparation and aptitude. The schedule of studies for the graduate year follows:

<i>First Term</i>		<i>Second Term</i>	
2'872	Design of Cotton Mach. . . . . 3-6	2'09	Design of Automatic Mach. . 12-0
2'874	Dyn. of Textile Machinery . . . 2-2	2'873	Des. of Wool Work. Mach. . . 3-6
2'875	Textile Technical Analysis . . . 2-3	8'191	Micro. Th. & Photomicrog. . 3-2
2'876	Prin. of Fabric Structure . . . . 2-4	2'877	Textile Microscopy . . . . . 5-2
3'651	Physical Metallurgy . . . . . 10-2		23-10
	19-17		33
	36	Textile Research . . . . .	17
Textile Research . . . . .	14	Total . . . . .	50
Total . . . . .	50		

**DEPARTMENT OF MINING AND METALLURGY****Including Petroleum Production**

Advanced work in the Department of Mining and Metallurgy may be pursued to advantage in the fields of mining engineering, metallurgy and petroleum engineering.

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

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

Opportunity is offered for graduate study and research in Ceramics, leading to the degree of Master or Doctor of Science. The purpose is to give the student broad training in the fundamentals of this subject that he may be fitted to take a responsible position in the industry. Students intending to take advanced work in Ceramics should take 3'94, Optical Ceramics, and 3'93, Ceramics, in the fourth year.

**Mining Engineering**

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

**"A" Subjects. Primarily for Graduates.**

<i>First Term</i>		<i>Second Term</i>	
3'061	Mining Eng., Adv. . . . . Time arr.	3'062	Mining Eng., Adv. . . . . Time arr.
3'101	Mine Valuation . . . . . 3-8	3'102	Mine Valuation . . . . . 3-8
3'241	Ore Dressing, Adv. . . . . Time arr.	3'12	Econ. of Mining, Adv. . . . Time arr.
3'251	Th. & Prac. of Flot. . . . Time arr.	3'242	Ore Dressing, Adv. . . . . Time arr.
3'26	Ore Dressing Econ. . . . . Time arr.	3'252	Th. & Prac. of Flot. . . . Time arr.
3'271	Ore Dressing Des. . . . . Time arr.	3'26	Ore Dressing Econ. . . . . Time arr.
3'331	Fire Assay., Adv. . . . . Time arr.	3'272	Ore Dressing Des. . . . . Time arr.
	Research	3'332	Fire Assay., Adv. . . . . Time arr.
			Research

**"B" Subjects. Open to Graduates and Undergraduates**

<i>First Term</i>		<i>Second Term</i>	
3'03	Economics of Mining . . . . . 4-4	3'04	Prin. of Mining . . . . . 3-4
3'13	Geophys. Prospect. Elem. . . 4-0	3'21	Ore Dressing . . . . . 3-2
3'412	Met: Copper & Lead . . . . . 5-3	3'22	Ore Dressing Lab. . . . . 5-2
		3'421	Met: Gold & Silver . . . . . 3-1

**Petroleum Production**

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

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

**"A" Subjects. Primarily for Graduates.**

<i>First Term</i>		<i>Second Term</i>	
3'901	Oil & Gas Land Val. . . . . 3-8	3'902	Oil & Gas Land Val. . . . . 3-8
3'911	Petroleum Eng. Adv. . . . . Time arr.	3'912	Petroleum Eng., Adv. . . . Time arr.
3'921	Oil & Gas Law . . . . . 2-4	3'922	Oil & Gas Law . . . . . 2-4
	Research		Research

**"B" Subjects. Open to Graduates and Undergraduates.**

<i>First Term</i>		<i>Second Term</i>	
3'031	Economics of Mining . . . . . 2-2	3'86	Petroleum Prod. . . . . 3-2
3'85	Petroleum Prod. . . . . 4-2		

### Metallurgy

Graduate work leading to the degrees of Master of Science and Doctor of Science in the field of Metallurgy may be carried out along a number of lines. The broad divisions are Ferrous Metallurgy, covering the various phases of the metallurgy of iron and steel, and Non-Ferrous Metallurgy, with its numerous subdivisions covering the metallurgy of gold, silver, copper, lead, zinc, aluminum, nickel, etc. In the case of all these metals there are numerous fields of investigation regarding the methods and processes of metal production, the production of alloys and investigation of their properties, the effects of impurities on the metals and methods for their removal, and the effects of heat treatment and mechanical work on structures and properties.

In the metallurgical laboratories facilities are provided for the preparation of metals and alloys, the roasting and special treatment of ores, the extraction of metals from their ores by both smelting and wet extraction or leaching methods, also for advanced work in the theory and practice of fire assaying, the heat treatment of metals and alloys, and for advanced metallographic work.

#### "A" Subjects. Primarily for Graduates.

<i>First Term</i>	<i>Second Term</i>
3'331 Fire Assaying, Adv. . . . . Time arr.	3'332 Fire Assaying, Adv. . . . . Time arr.
3'501 Met. Iron & Steel, Adv. . . . . Time arr.	3'502 Met. Iron & Steel, Adv. . . . . Time arr.
3'511 Metal. Plant Design . . . . . 13-0	3'512 Metal. Plant Design . . . . . 13-0
3'53 Non-Fer. Metal., Adv. . . . . Time arr.	3'52 Metallurgy, Gen. Adv. . . . . Time arr.
3'54 Gold & Silver Met., Adv. . . . . Time arr.	3'55 Metal. Calc., Adv. . . . . 2-6
3'651 Phys. Metallurgy, Adv. . . . . Time arr.	3'652 Phys. Metallurgy, Adv. . . . . Time arr.
3'66 App. of Metallography. . . . . 5-0 Research	3'66 App. of Metallography. . . . . 5-0 3'74 Th. of Metal Hardening. . . . . 2-4 Research

#### "B" Subjects. Open to Graduates and Undergraduates.

##### Summer

3'60 Metallurgical Plant Visits. . . . . 3-1

<i>First Term</i>	<i>Second Term</i>
Metallurgy	3'42 Metal. Gold & Silver . . . . . 5-2
3'411 Copper & Lead . . . . . 6-3	3'44 Met. Gen. Zinc & Minor Metals 4-3
3'43 Iron & Steel . . . . . 7-3	3'45 Heat Treat. of Steel . . . . . 2-1
or	3'56 Metallurgical Plants . . . . . 3-3
3'41 Copper & Lead . . . . . 10-3	
3'431 Iron & Steel . . . . . 3-3	

### Physical Metallurgy

In recent years the field of Metallurgy has come to be divided into the closely related branches of Production Metallurgy (described on page 174) and Physical Metallurgy. The first division deals chiefly with the production of metals from their ores and their refining. Physical Metallurgy is concerned with the properties and uses of the finished metals and their alloys. This branch of Metallurgy is less than forty years old and only in the last few years has it developed to an extent that would justify its consideration as a distinct field of study. Its value both to science and industry has been definitely established and its application to all processes in which metals are involved is rapidly increasing. It is being applied not only to the specific metal industries dealing with the manufacture of steel, brass, aluminum alloys and the like, but also in the fields of automotive and aircraft manufacture, oil production and refining, building construction and other major developments.

The laboratories are equipped with gas and electric furnaces for the making of alloys in small quantities and through coöperative arrangements alloys may be made on a commercial or semi-commercial scale. Equipment is available for detailed metallographic investigation, for heat treatment study and research, as well as for X-ray examination. The latter field is provided for by a lead room in which radiographic studies may be made and by facilities for research in the atomic arrangement in metals. Through coöperation with the Department of Mechanical Engineering, physical testing of all sorts is possible.

In addition to these possibilities for investigation in the general field of Physical Metallurgy, opportunity is given for study and research in more specialized subjects such as welding, heat and corrosion resisting alloys, the light alloys, nitriding and the properties of cast iron. Facilities are also available for the study of many of the fundamental physical properties of metallic systems such as electrical and thermal conductivities, magnetic properties and similar topics.

#### "A" Subjects. Primarily for Graduates.

<i>First Term</i>	<i>Second Term</i>
3'501 Met. of Iron & Steel, Adv. Time arr.	3'502 Met. of Iron & Steel, Adv. Time arr.
3'53 Non-Fer. Metal., Adv. . . . Time arr.	3'652 Phys. Metallurgy, Adv. . . . Time arr.
3'651 Phys. Metallurgy, Adv. . . . Time arr.	3'66 App. of Metallography. . . . 5-0
3'66 App. of Metallography. . . . 5-0	3'74 Th. of Metal Hardening. . . . 2-4
3'673 Phys. of Metals, Adv. . . . Time arr. Research	Research

**"B" Subjects. Open to Graduates and Undergraduates.****Summer**

3'60 Metallurgical Plant Visits.. 3-1

<i>First Term</i>		<i>Second Term</i>	
3'641	Phys. Metal. (Non-Fer.)... 5-2	3'422	Met. Gold & Silver..... 2-2
		3'642	Phys. Metal. (Ferrous)..... 5-2
		3'643	Light Alloys..... 2-4
		3'657	X-Ray Metal., Adv..... Time arr.
		3'67	Physics of Metals..... 2-4
		3'68	Metallog. of Welding..... 4-2
		3'69	Cor. & Heat Resisting Alloys. 2-4

**Ceramics**

The field of Ceramics covering as it does pottery, structural clay products, refractories, abrasives, glass and enamels, is a very broad one, but a sound training in the fundamentals of the subject gives a basis for later specialization. The laboratories are well equipped with testing apparatus as well as with machines and kilns for carrying out the regular plant processes.

**"A" Subjects. Primarily for Graduates.**

<i>First Term</i>		<i>Second Term</i>	
3'95	Fund. Ceramic Processes... 7-4 Research	3'96	Phys. Prop. of Ceramic Prod. 5-4 Research

**"B" Subjects. Open to Graduates and Undergraduates.**

<i>First Term</i>		<i>Second Term</i>	
3'031	Economics of Mining..... 2-2	3'04	Principles of Mining..... 3-4
3'94	Optical Ceramics..... 6-2	3'93	Ceramics..... 4-5

**DEPARTMENT OF ARCHITECTURE****Architecture**

The graduate work leading to a Master's degree is so arranged as to give the student who has mastered during the previous five years the multiple requirements of an undergraduate curriculum an uninterrupted opportunity to devote himself to the main essentials of his professional work. The time is divided between Design, Free-hand Drawing and History, so that the best possible opportunity is offered in long periods of consecutive hours for concentration on these fundamental subjects.

The advantage of a graduate year for the student who has taken his undergraduate work directly after leaving high school lies further in the fact that the intervening years have resulted in an appreciation of the significance and value of an architectural training of which he is only just becoming conscious on graduation, and for the application of which this added year provides a precious opportunity.

The graduate year is of particular value in offering to students of Architecture intending to become teachers the chance to acquire experience in problems of design of a far broader nature than can possibly characterize undergraduate instruction.

The Departmental Library is well equipped with books, photographs, plates and slides, and is a true research laboratory for the ambitious student.

Hereafter only those students will be accepted as applicants for the Master's degree in Architecture whose previous performance in the required work, whether at Technology or elsewhere, has been better than a passing grade, and shown evidence of unusual ability.

The degree of Master in Architecture is awarded upon the satisfactory completion of a programme of 96 units of advanced study approved by the Department of Architecture, followed by the preparation of a thesis of high grade. At the discretion of the Department of Architecture one or more students may be chosen annually from those completing graduate requirements to continue a year of study in Design without being required to pay tuition on the condition that they render at least two problems in the course of the academic year of a grade not below that of second medal.

Graduates from other colleges who desire to obtain the Master's degree in Architecture must present evidence that they have had the essential equivalent of the following undergraduate subjects as pre-requisites for graduate work.

Deficiencies in these subjects may be removed by taking the subjects at the Institute.

2'231 Structural Mechanics	4'331 Theory of Architecture
2'232 Structural Mechanics	4'332 Theory of Architecture
2'234 Structural Mechanics	4'411 Architectural History
4'06 Graphics	4'412 Architectural History
4'071 Modelling	4'421 Architectural History
4'072 Modelling	4'422 Architectural History
4'11 Shades and Shadows	4'811 Construction
4'12 Perspective	4'812 Construction
4'211 Office Practice	M111 Mathematics
4'212 Office Practice	

Foreign Language: The applicant should satisfy the Department that he has a good reading knowledge of architectural French or an equivalent acquaintance with some other of the Romance Languages.

Cultural Subjects and Economics: It is expected that the applicant shall have a knowledge of English, History, Economics and General Studies similar to that included in the undergraduate courses at the Institute. In case the applicant is unusually deficient in meeting this requirement, he may be required to take these subjects.

The following undergraduate courses in Architecture are also required, but as these are open to both graduate and undergraduate students they may be elected in part as "B" subjects leading to the Master's degree.

4'051 Freehand Drawing and Figure Composition
4'052 Freehand Drawing and Figure Composition
4'091 Color, Composition, Theory and Application
4'092 Color, Composition, Theory and Application
4'24 Professional Relations
4'481 European Civilization
4'482 European Civilization
4'53 Architectural Humanities
4'751 Design
4'752 Design

## GRADUATE SUBJECTS IN ARCHITECTURE

## "A" Subjects. Primarily for Graduates.

<i>First Term</i>		<i>Second Term</i>		
4'053	Freehand Drawing . . . . .	6-0	4'054 Freehand Drawing . . . . .	6-0
4'491	European Civilization . . . . .	2-4	4'492 European Civilization . . . . .	2-4
4'761	Design VI . . . . .	36-0	4'762 Design VI . . . . .	36-0

## "B" Subjects. Open to Graduates and Undergraduates.

<i>First Term</i>		<i>Second Term</i>		
4'051	Freehand Drawing . . . . .	6-0	4'052 Freehand Drawing . . . . .	6-0
4'091	Color. Comp., Th. & App. . . . .	1-4	4'092 Color. Comp., Th. & App. . . . .	1-4
4'481	European Civilization . . . . .	2-3	4'24 Professional Relations . . . . .	1-1
4'61	City Planning . . . . .	2-3	4'482 European Civilization . . . . .	2-3
4'641	Th. & Prac. City Planning . . . . .	3-6	4'642 Th. & Prac. City Planning . . . . .	3-6
4'651	Th. & Prac. City Planning . . . . .	3-6	4'652 Th. & Prac. City Planning . . . . .	3-6
4'671	City Planning Design . . . . .	20-0	4'672 City Planning Design . . . . .	20-0
4'681	City Planning Design . . . . .	28-0	4'682 City Planning Design . . . . .	16-0
4'751	Design V . . . . .	30-0	4'752 Design V . . . . .	12-0

Subject to the approval of the Departmental Committee on Graduate Students certain fourth-year subjects given in other departments, and optional subjects in Architecture and in exceptional instances third-year subjects which form with the advanced work a logical general program may be elected.

### Architectural Engineering

While no advanced work in Engineering is offered directly by the Department of Architecture, the graduates of IV-A can fulfil the requirements for a Master's degree in Architectural Engineering through a course selected from the following allied subjects offered by other Departments.

The minimum requirements in undergraduate professional subjects which a student must present as a prerequisite for acceptance as a candidate for the Master's degree in the field of Architectural Engineering are as follows:

1'02	Surveying	4'411	Architectural History
1'40	Structures	4'412	Architectural History
1'41	Structures	4'421	Architectural History
1'42	Structures	4'422	Architectural History
1'48	Foundations	4'461	European Civilization
1'63	Hydraulics	4'462	European Civilization
2'304	Materials of Engineering	4'78	Planning Principles
2'36	Testing Materials Laboratory	4'80	Building Construction
2'362	Testing Materials Laboratory	4'90	Structural Drawing
2'391	Reinforced Concrete Design	4'911	Structural Analysis
2'392	Reinforced Concrete Design	4'912	Structural Analysis
2'59	Mechanical Equipment of Buildings	4'921	Structural Design
4'22	Office Practice	4'922	Structural Design
4'25	Estimating		

#### "A" Subjects. Primarily for Graduates.

<i>First Term</i>		<i>Second Term</i>	
1'491	Soil Mechanics . . . . . 3-6	1'492	Soil Mechanics . . . . . 3-6
1'551	Structural Design, Adv. . . . . 6-0	1'552	Structural Design, Adv. . . . . 6-0
1'561	Structures, Adv. . . . . 3-9	1'652	Structures, Adv. . . . . 3-9
1'66	Hydraulics, Adv. . . . . 1-4	1'57	Secondary Stresses . . . . . 2-4
2'281	Adv. Mech. & Th. of Elas. . . . . 3-9	2'282	Adv. Mech. & Th. of Elas. . . . . 3-9
2'393	Reinf. Concrete, Adv. . . . . Time arr.	4'492	European Civilization . . . . . 2-4
2'394	Concrete Research . . . . . Time arr.		

#### "B" Subjects. Open to Graduates and Undergraduates.

<i>First Term</i>		<i>Second Term</i>	
4'471	European Civilization . . . . . 2-3	4'472	European Civilization . . . . . 2-3
4'481	European Civilization . . . . . 2-3	4'482	European Civilization . . . . . 2-3
4'53	Architectural Humanities . . . . . 1-1	M54	Mathematical Laboratory . . . . . 3-5
4'61	City Planning . . . . . 2-3		

For descriptions of "A" and "B" subjects, see under Departments of Architecture, Civil Engineering, Mechanical Engineering and Mathematics.

## DEPARTMENT OF CHEMISTRY

The recent rise of chemistry in the United States has made it almost necessary for one who looks forward to a life work in the study or application of the science to give more than four years to preparation. For those whose time is limited, a program of work has been arranged which leads to the degree of Master of Science. The requirements are designed to make it possible for the candidate to specialize in any field of particular interest. Graduates of textile schools who have received a Bachelor's degree in Textile Chemistry in a regular four-year course approved by the Massachusetts Institute of Technology may be admitted to a graduate course extending over at least two years and leading to the Master's degree. The program of studies may be chosen with the approval of the Department of Chemistry from the list of senior and graduate studies offered in the Department. About one-third of a year is devoted to research for the S.M. degree. The degree of Doctor of Philosophy, on the other hand, is awarded to the candidate having a broad scientific education in the fundamental branches of chemistry, and who has given evidence of the ability to carry on independent research by presenting a thesis which is a definite contribution to scientific knowledge.

### Requirements for the Degree of Doctor of Philosophy in the Department of Chemistry

The time necessary to complete the requirements for the degree of Doctor of Philosophy is ordinarily three years in the case of candidates who begin the work with a previous preparation in Chemistry, Physics, Mathematics, French and German equivalent to the work in these subjects required of candidates for the degree of Bachelor of Science at this Institute.

During the first two years the student is expected to attend lecture courses, conferences, seminars and complete the requirements for the minor subject as well as make a substantial beginning in the investigation which is to constitute the thesis. The student should make every effort to survey the subject of his thesis and to obtain preliminary experimental data which will insure the maximum conservation of effort during the final year. Candidates must pass written examinations in French and German and (I) pass oral or written examinations in (a) Inorganic and Analytical Chemistry, (b) Physical Chemistry and (c) Organic Chemistry; or (II) must complete with creditable records certain courses in these subjects, specified by the Committee on Graduate Students of the Department of Chemistry. The final year is devoted to research. The examination in the branch of chemistry in which the candidate is carrying out his research must be oral and is usually taken in October of the last academic year of residence. It is recommended that the other examinations be taken, if possible, by the end of the first year. The final examination is

devoted to the research and that part of the science which is closely related to the experimental work of the thesis.

It is possible to carry out research under direction in the summer months.

### Requirements for the Degree of Master of Science with Specification of Field

Candidates for the degree of Master of Science with or without specification in the Department of Chemistry must present approved equivalents for the subjects of the First and Second years, specified in the general requirements for graduate work. In addition they must present equivalents for the following subjects in Course V.

- (a) Complete language requirement
- (b) 5'10 Qualitative Analysis
- (c) 5'12 Quantitative Analysis
- 5'13 Quantitative Analysis
- (d) 5'41 Organic Chemistry
- 5'42 Organic Chemistry
- (e) 5'414 Organic Chemical Laboratory
- 5'424 Organic Chemical Laboratory
- (f) 5'61 Physical Chemistry I
- 5'62 Physical Chemistry II
- 5'63 Physical Chemistry III
- 5'64 Physical Chemistry IV

(Differential Equations M22 is not required of students specializing in Inorganic or Organic Chemistry.)

### Research Associates

The department maintains five research associates. These positions are open to candidates who have completed the requirements for the degree of Doctor of Philosophy. The appointments, which are made for one year or longer, offer an opportunity to a research associate to continue the research upon which his thesis for the degree was based and thus to advance the problem as the result of his specific knowledge and the technique acquired during the earlier investigation.

### The Research Laboratory of Physical Chemistry

A considerable portion of the more recent advance in science has been in fields lying between the divisions of science as they were originally established. One of the most important of these developments is physical chemistry, which has grown up as a result of investigations lying between the previously loosely defined borders of the sciences of physics and chemistry.

The first, and for a long time the only research laboratory in the United States devoted to this new development, was the Research Laboratory of Physical Chemistry of the Massachusetts Institute of Technology. This laboratory was founded in 1903 by A. A. Noyes and W. R. Whitney, then both professors in the Institute. The

activities of this laboratory have had a decided effect on the development of chemistry in this country, both in the encouragement of research along the lines for which it was founded, and in stimulating the use of physicochemical methods in related fields. It is interesting to note that a large number of the prominent physical chemists of this country have been connected with the laboratory either as members of its staff or as graduate students. From 1903 until 1920, Professor Noyes was director of the laboratory, with the exception that from 1907 to 1909, while he was acting president of the Institute, Professor G. N. Lewis served as acting director. In 1920, Professor Noyes became director of chemical research of the California Institute of Technology, and Professor F. G. Keyes was appointed director.

The publications of the laboratory, which have appeared to the greater extent in chemical journals, now number over three hundred separate papers. Some of the most important lines of research that have been carried on in past years in the laboratory are as follows:

The conductance of solutions of strong electrolytes throughout wide ranges of concentration, temperature and pressure.

The conductance and ionization of fused salts.

The transference numbers and hydrations of ions.

Liquid junction potentials.

The solubility of salts in the presence of other salts.

The electromotive force produced in solutions by centrifugal action.

The properties of solutions of electrolytes in liquid ammonia.

The potentials of concentration cells of electrolytes.

The potentials of the alkali metals.

A system of qualitative analysis including all the elements.

The free energy of chemical substances.

The thermodynamic properties of carbon dioxide, ammonia, methane and nitrogen.

The thermodynamic temperature scale.

Phase diagrams of gas-solid systems.

Equations of state for fluids.

Applications of the Debye-Hückel theory of strong electrolytes.

Physical interpretation of the constants in the equation of state.

A description of the researches in progress appears elsewhere in this publication.

### Professional Opportunities in Physical Chemistry

There is a demand for men of mature scientific education to serve as investigators and to direct investigational work in industry, in endowed research institutions, in government bureaus and in academic institutions. The numerous industries in particular have nearly all come to realize the desirability and even necessity of maintaining fundamental scientific investigations relative to their processes as a basis for future development. In consequence of the benefits already derived from systematic investigation, many industrial research laboratories have been and are being organized. It is universally agreed that graduate work is an essential preparation for positions in connection with these laboratories. Since the work in such laboratories is of a widely varying nature, a student considering the possibilities in this field of work should endeavor to pursue that sort of educational course

which will give him a broad foundation and a wide scientific perspective. In respect to the latter, physical chemistry with its outlook on two or more fundamental sciences is particularly useful.

It is coming to be recognized that for a large proportion of students, including those who intend eventually to undertake industrial work, the best possible training is research and study in pure science. There are several reasons for this conclusion. Pure science is always far in advance of its applications. The scientific discoveries of today are, to a large extent, the basis for the industrial advances of tomorrow. A student in pure science acquires a working knowledge of the more recent discoveries in his branch of science. This knowledge is, of course, a necessary foundation for his later research, either in the practical or theoretical aspects of his subject. Pure science research methods furnish him a model that can be safely followed for all types of investigation, and, in practice, lead him to correct habits of thought and procedure for research in any field of investigation.

### The Equipment of the Research Laboratory of Physical Chemistry

The work in progress in the laboratory can be roughly divided into four parts, including investigations (a) on the physical properties of pure substances and mixtures of pure substances under wide variations of temperature and pressure for the purpose of broadening the present thermodynamic interpretation of chemical reactions, (b) on chemical equilibria under pressure to obtain special data for extending the theoretical treatment of equilibria, and on heats of reaction in solution, (c) on solutions of electrolytes, and (d) on the ultra-violet absorption of gases and chemical reactivity as related to atomic structure. A brief description of the equipment for each type of work is given below.

#### (a) Measurement of Thermodynamic Properties of Substances.

The laboratory has several specially constructed installations for measuring the pressure-volume-temperature relations of substances, the pressure range covering several thousand atmospheres, and the temperature range from liquid air temperatures to 500°C.

The laboratory has recently installed special equipment for gas thermometry measurements. This consists of a two-meter invar scale calibrated to 0.2 millimeter, a two-meter comparator having an invar bar, and a two-meter double manometer encased in an air jacket in which the temperature can be accurately controlled. A special platinum thermometer bridge is included.

#### (b) Calorimetry and Chemical Equilibria.

One large room is devoted to work on heats of reaction, and to measurement of chemical equilibria, especially those involving gases. The general equipment includes apparatus for obtaining and measuring high vacua, and for accurate temperature and pressure measurements.

The laboratory has an equipment for measuring heats of vapor-

zation of liquids and specific heats of liquids, vapors, and compressed gases from the boiling point of liquid air to 100°C.

(c) Study of Solutions of Strong Electrolytes.

The laboratory is well equipped with facilities for measurements on the properties of strong electrolytes, including apparatus for determining potentials, conductances, etc., as well as an equipment for obtaining the potentials of galvanic cells under high pressures and for the accurate measurement of freezing points.

(d) Spectrochemical studies.

The correlation of absorption spectra, Raman effect, and photochemistry forms the basis of these studies. A laboratory is equipped with excellent facilities for the investigation of such studies in the ultra-violet and visible regions of the spectrum. The equipment includes spectrographs of high and low dispersion, light sources, photometric and radiometric apparatus and the necessary auxiliary equipment.

### Researches in Progress

A comprehensive study of the pressure-volume-temperature relations of substances, involving wide temperature and pressure ranges, is being carried out both for gaseous and liquid systems. The investigations are being conducted in the light of modern concepts regarding the kinetic theory and the electronic structure of atoms and molecules. Connected with these studies are investigations concerning the absolute temperature scale. Measurements are also being carried out on other thermodynamic properties of substances, such as latent and specific heats at low temperatures.

The need of a more extensive knowledge of the properties of steam has resulted in the initiation, under the auspices of the American Society of Mechanical Engineers, of an extensive research program. The investigations needed for a complete knowledge of the thermodynamic properties of steam will be carried out in part by the United States Bureau of Standards, by the Harvard Engineering School, and by this research laboratory. It is estimated that a number of years will be required to complete the investigations undertaken by this laboratory. Substantial financial assistance is being given by the American Society of Mechanical Engineers.

The establishing of the absolute scale of temperature below zero is a problem of the greatest importance. As standard temperatures, for references and calibration, the freezing points of certain pure organic compounds have been studied. A number of these substances will be studied by the Reichsanstalt, by the physical laboratory of the University of Leiden, and by this laboratory, and samples will be exchanged for the purpose of obtaining the true and reproducible freezing points.

Investigations are also in progress on the change of the pressure-volume product of gases, with pressure and temperature, at low pressures, for the purpose of obtaining a test of the validity of several

proposed equations of state, and for verifying for gases certain fundamental aspects of the relation of internal energy change with volume.

A study is being made of the coefficient of expansion of several gases at constant pressure by means of the thermometric method for the purpose of determining the ice-point on the absolute temperature scale by means of extrapolation to zero pressure. The improved facilities will also make possible a very exact comparison of the platinum thermometer scale from 0°C. to the sulphur boiling point with the hydrogen and helium gas thermometers, and also from zero degrees to the boiling point of liquid air.

An apparatus has been constructed and is now in use for measuring the chemical potential or the so-called fugacity of water in mixture of gases. The experiment is intended to furnish a direct attack on the nature of the mass action law for gaseous systems under high pressures. It is intended to attack this general problem from all possible angles.

Researches on the properties of solutions of strong electrolytes, which have been carried on since the founding of the laboratory, consist, at present, of investigations of the potentials of concentration cells, the potentials at the junctions of salt solutions, and the freezing points of electrolyte solutions.

The ultraviolet absorption spectra of gases at pressures up to 400 atmospheres have been obtained; from these inferences may be drawn regarding the existence of molecular aggregates. Similar absorption studies are being continued. A comprehensive study is being made of the photochemical activity of a number of systems whose absorption spectra are known.

### **The Doctor's Degree with Major in Physical Chemistry**

Candidates for the Doctor's Degree with Major in Physical Chemistry will take courses 5·76, 5·77, 5·741, 5·742, 5·79, 5·931, 5·932 and 5·941, 5·942 (the last two throughout their residence at the Institute), and will take their Minor in Mathematics or in Physics. A suggested arrangement of these courses is shown below.

In addition to the courses here scheduled, as much as possible of the required 25 units of minor should be taken and the oral examinations in modern languages, inorganic and organic chemistry should be passed during the first year. The minor should be completed and optional courses taken during the second year in order that the third year may be left free as possible for research.

## FIRST YEAR

<i>First Term</i>		<i>Second Term</i>		
5'76	Thermodyn. & Chemistry* . . . . .	3-6	5'77 Thermodyn. & Chemistry . . . . .	2-4
5'931	Jour. Meet. in Phys. Chem. . . . .	1-1	5'932 Jour. Meet. in Phys. Chem. . . . .	1-1
5'941	Res. Conf. in Inorg., Organic or Physical Chem. . . . .	1-1	5'942 Res. Conf. in Inorg., Organic or Physical Chemistry . . . . .	1-1
5'98	Research‡		5'98 Research	

## SECOND YEAR†

<i>First Term</i>		<i>Second Term</i>		
5'741	Kinetic Th. of Matter I . . . . .	2-4	5'742 Kinetic Th. of Matter II . . . . .	2-4
5'931	Jour. Meet. in Phys. Chem. . . . .	1-1	5'932 Jour. Meet. in Phys. Chem. . . . .	1-1
5'941	Res. Conf. in Inorg., Organic or Physical Chemistry . . . . .	1-1	5'942 Res. Conf. in Inorg., Organic or Physical Chemistry . . . . .	1-1
5'98	Research		5'98 Research	

## THIRD YEAR

<i>First Term</i>		<i>Second Term</i>		
5'931	Jour. Meet. in Phys. Chem. . . . .	1-1	5'79 Theory of Solutions . . . . .	2-4
5'941	Res. Conf. in Inorg., Organic or Physical Chemistry . . . . .	1-1	5'932 Jour. Meet. in Phys. Chem. . . . .	1-1
5'98	Research		5'942 Res. Conf. in Inorg., Organic or Physical Chemistry . . . . .	1-1
			5'98 Research	

\*Students whose preparation in physical chemistry is not equivalent to courses 5'61, 5'62, 5'63 will take 5'71, 5'72 and postpone 5'76 and 5'77 until the second year.

†Courses 5'741, 5'742, and 5'79 will be given in alternate years. Therefore the schedule of these two years may be interchanged.

‡It is generally advisable to postpone the beginning of research until the oral examinations in modern languages and in organic chemistry and inorganic chemistry have been passed.

### The Research Laboratory of Organic Chemistry

A number of rooms are specially equipped for work in organic chemistry. The laboratories are open at all times. The division is well supplied with vacuum pumps, thermostats, electrical measuring instruments, mercury arcs, electrically heated closets and combustion furnaces, autoclaves, standardized thermometers, etc. A large variety of organic chemicals is available.

The offering of a number of advanced courses in organic chemistry makes it possible for the student to devote attention to those branches of the subject in which he is particularly interested.

### Researches in Organic Chemistry in Progress

Investigations in Organic Chemistry are directed by members of the instructing corps whose special interests lie in widely different fields. The chief investigations now in progress are as follows:

A comprehensive study is being made of the factors influencing the reactivity of atoms and groups in organic compounds. The problem is being investigated from the point of view of physical chemistry. Attention is being centered at present on the study of the reactivity

of the chlorine atom, the hydroxyl group, the hydrogen of the hydroxyl group, and the hydrogen atoms in hydrocarbons.

The mechanism of organic reactions is being studied. Work is well advanced on the mechanism of esterification.

The pyrolysis of organic compounds is being studied from the point of view of the rates of such reactions, influence of catalyzers and the relative lability of the bonds involved.

The correlation of the properties and reactions of organic compounds in the form of an analytic procedure has been studied for many years. The results already published have proved invaluable to chemists concerned with the identification of organic substances. This work is being actively continued for the purpose of further developing the system and keeping it abreast of the rapid advances in synthetic and analytical chemistry. Particular attention is now being given to the systematic separation and identification of the components of mixtures.

Urea, thiourea and guanidine and their derivatives are being actively investigated with the result that considerable new information has been gained about the reactions of the simpler organic compounds of nitrogen such as cyanic acid and cyanamide. It has been shown that many reactions consist in the direct combination and subsequent breaking apart of molecules, and physico-chemical methods are showing the factors which determine the ease and extent of such reactions. An understanding of the mechanism in these cases has made possible a number of new syntheses. Other researches are devoted to the factors which determine the possibility of tautomerism and to the effect of groups on the reactivity of quinones.

The following subjects, in addition to those noted above, are being investigated.

- Oxidation of meta-diphenols.
- Complex metal-pyridine compounds.
- The physical and chemical properties of tri-phenylmethyl.
- Action of ultra-violet radiation on organic reactions.
- The rates of absorption of gases by liquids where chemical reactions are involved.
- Methods of preparation and properties of mixed ethers.
- Halogenation by means of tertiary butyl hypochlorite.
- Absorption spectra of phthaleins and related compounds.
- Reactions of 3-nitrophthalic acid derivatives.
- Uses of anhydrous zinc chloride as a catalyst in transformations of ethers, acids and acid derivatives.
- The chemistry of diphenic acid and naphthalic acid and their derivatives.
- Catalysis in homogeneous systems.
- Preparation of derivatives for the identification of ethers and hydrocarbons
- Auto-oxidation reactions in organic chemistry.
- Mechanism of the Friedel-Crafts reaction.
- Raman and absorption spectra.
- The chemistry of fluorenone and its derivatives.
- Chemiluminescence.

### The Research Laboratory of Inorganic Chemistry

Opportunity for carrying on investigations in the field of Inorganic Chemistry was afforded by the establishment in 1928 of the Research Laboratory of Inorganic Chemistry, and with the opening of the new Eastman Research Laboratories improved quarters and facilities have been provided.

Although this branch of Chemistry was the first to obtain a high degree of development and a wealth of detail, it is nevertheless true that the field is very far from being exhausted; a practically unlimited opportunity for further investigation remains, not only in the chemistry of the less common and rare elements, but also in the elaboration of the chemistry of the commoner elements. Furthermore a great deal of the data accumulated in the past century is in need of revision; for example, in much of the earlier work the necessity for the rigid exclusion of air and moisture was often overlooked in the preparation of various substances, resulting in erroneous conclusions concerning their properties.

The program of the Laboratory since its establishment has been based on the premise that the primary function of the inorganic chemist lies in the preparation of inorganic substances in a state of purity and the study of their properties, individually and in reaction with other substances. Some of the subjects which have been investigated are as follows:

The preparation and properties of various fluorides and mixed fluo.ohalides especially of sulphur and silicon.

The action of fluorine with oxides and hydroxides.

The preparation and properties of various halides of boron and silicon.

The anhydrous lower valence halides of titanium and zirconium; and certain reactions of the anhydrous halides of thorium.

The preparation of new complex compounds (such as complex cyanides) of molybdenum and tungsten; as well as the study of new inner complex compounds.

The preparation of metal carbonyls at ordinary temperature and atmospheric pressure.

Chemical reactions induced by the electrodeless discharge in gases; especially the dissociation of ammonia and of carbon dioxide.

Relationships concerning the solubility of inorganic salts in the presence of other salts in non-aqueous media, such as anhydrous ethyl alcohol, acetic acid and ethylene dichloride.

New methods of preparation of pure compounds of rare earth metals.

The effect of added salts upon optical activity.

The thermal decomposition of thionyl chloride.

The analytical aspects of inorganic chemistry have been represented in the study of the selenious acid method for the determination of zirconium in ores and in steels; and the analysis and purification of gas mixtures containing helium.

The Laboratory is equipped to carry on a wide variety of inorganic research, including that requiring high vacuum technique, operations at high and low temperatures, and electrolytic oxidations and reductions.

## GRADUATE SUBJECTS

**"A" Subjects. Primarily for Graduates.**

<i>First Term</i>		<i>Second Term</i>			
5'07	Inorg. Chemistry, Adv. . . . .	2-3	5'08	Inorganic Lab., Adv. . . . .	6-0
5'08	Inorganic Lab., Adv. . . . .	6-0	5'52	Organic Chemistry II. . . . .	2-2
5'18	Qualitative Anal., Adv. . . . .	9-1	5'542	Organic Chemistry IV. . . . .	2-4
5'51	Organic Chemistry II. . . . .	2-2	5'56	Tech. Organic Chemistry. . . . .	2-2
5'53	Organic Chemistry III. . . . .	3-6	5'57	Chemistry of Dyes. . . . .	2-2
5'541	Organic Chemistry IV. . . . .	2-4	5'572	Stereochemistry. . . . .	2-4
5'55	Organic Qual. Anal. . . . .	10-0	5'574	Free Rad. & Org.-Met. Comp. . . . .	2-4
5'581	Organic Lab., Adv. . . . .	6-1	5'576	Sem. in Rec. Hist. of Org. Ch. . . . .	2-4
5'591	Rec. Adv. in Organic Chem. . . . .	1-1	5'582	Organic Lab., Adv. . . . .	5-1
5'71	Physical Chemistry. . . . .	4-6	5'584	Molec. St. of Org. Chem. Comp. . . . .	2-4
5'73	Free Energy. . . . .	2-4	5'592	Rec. Adv. in Organic Chem. . . . .	1-1
5'741	Kin. Th. of Matter I. . . . .	2-4	5'72	Physical Chemistry. . . . .	4-6
5'76	Thermodyn. and Chemistry . . . . .	3-6	5'742	Kin. Th. of Matter II. . . . .	2-4
5'90	Logic of Sci. Inquiry. . . . .	1-2	5'75	Thermodynamics. . . . .	2-2
5'911	Jour. Meet. in Inorg. Chem. . . . .	1-1	5'77	Thermodyn. and Chemistry . . . . .	2-4
5'921	Jour. Meet. in Org. Chem. . . . .	1-1	5'79	Theory of Solutions. . . . .	2-4
5'931	Jour. Meet. in Phys. Chem. . . . .	1-1	5'851	Meth. of Electrochem. Anal. . . . .	4-2
5'941	Research Conf. in Inorg., Org. or Phys. Chem. . . . .	1-1	5'855	Th. and App. of Catalysis. . . . .	2-2
5'98	Research. . . . .	Time arr.	5'912	Jour. Meet. in Inorg. Chem. . . . .	1-1
			5'922	Jour. Meet. in Org. Chem. . . . .	1-1
			5'932	Jour. Meet. in Phys. Chem. . . . .	1-1
			5'922	Research Conf. in Inorg., Org. or Phys. Chem. . . . .	1-1
			5'98	Research. . . . .	Time arr.

**"B" Subjects. Open to Graduates and Undergraduates.**

<i>First Term</i>		<i>Second Term</i>			
5'061	Inorg. Chemistry. . . . .	2-3	5'062	Inorg. Chemistry. . . . .	2-3
5'251	Chemistry of Foods. . . . .	3-1	5'251	Chemistry of Foods. . . . .	3-1
5'26	Food Analysis. . . . .	5-0	5'26	Food Analysis. . . . .	5-0
5'30	Proximate Analysis. . . . .	6-2	5'30	Proximate Analysis. . . . .	6-2
5'37	Chem. of Road Materials. . . . .	4-0	5'43	Powder and Explosives. . . . .	2-2
5'63	Physical Chemistry III. . . . .	4-4	5'64	Physical Chemistry IV. . . . .	3-4
5'842	Optical Methods. . . . .	2-1	5'83	History of Chemistry. . . . .	2-2

**DEPARTMENT OF ELECTRICAL ENGINEERING**

The Department of Electrical Engineering offers work of an advanced character leading to the degrees of Doctor of Science and Master of Science. The rules governing the granting of these degrees are set forth on pages 38-46. Students who are well prepared may obtain the Master's degree in one year, while usually three years are required for the Doctorate.

It is expected that only properly qualified students of more than average capacity will enter upon courses of advanced study. In order to be accepted for graduate study in the Department of Electrical Engineering a candidate must have completed the fundamental requirements common to all courses, and in addition must have covered the substantial equivalent of the undergraduate professional subjects in Electrical Engineering as offered in Course VI or the Communications Option Course VI-C. See pages 98 and 100.

It is expected that the student entering upon graduate work in Electrical Engineering will have taken professional courses in engineering other than Electrical Engineering to an extent substantially equivalent in total amount to that contemplated in the undergraduate curriculum of any of the options of Course VI. It is also expected that he will have taken non-technical study to a similar extent, and that he will have made such study in general economics as is substantially equivalent to a year's study of this subject at the ordinary rate. In case a student registers for graduate work while deficient in any one of these respects, the Department Committee on Graduate Study will ordinarily insist that he remove such deficiencies by special study while in residence.

It is expected that the candidate for the Master's degree in Electrical Engineering will, at the time that he is recommended for the degree, be able to read either technical French or technical German to an extent sufficient to enable him to consult freely, along the lines of his graduate work, the literature in the language concerned. An entering student who offers the equivalent of elementary and intermediate French or German will be considered to have satisfied this requirement, but in cases of doubt the Department will test proficiency in Modern Language by special examination. Proficiency in this regard may often be obtained while in residence, by special study and reading.

The Department is especially insistent that a student's preparation in mathematics and physics be excellent. He should have fully covered the equivalent of first-year and second-year mathematics as given in Course VI. In addition he should offer further work in mathematics substantially equivalent to that contemplated in subject M31. In the absence of such special preparation, he will be expected to cover this deficiency while in residence.

Entering students who are deficient in preparation, especially in mathematical and professional electrical-engineering subjects, are

urged to make up this deficiency before entrance by attendance at summer school. Graduate study in certain subjects, and also graduate research, may be carried on in the summer school. The Summer Session issue of the general catalogue should be consulted on this matter.

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

Simultaneously with the lecture courses the student carries on research work, thus beginning his training as an independent investigator. He selects his own research subject, which should be one in which he is vitally interested, and submits an outline of the proposed investigation to the Department Committee on Graduate Study. This outline is critically examined with a view to the scientific and educational value of the subject and the possibility of accomplishing the investigation in a reasonable time and with the facilities available. This outline must be approved before work is commenced.

In the laboratory graduate students are expected in the main to rely on their own resourcefulness, the professor in charge of the particular research exercising only a general supervision. It is usual for the student to construct any special apparatus needed for his research, but, in cases where it is likely to form a permanent addition to the laboratory equipment, he may be assisted by a laboratory mechanic.

All graduates in the Department who have not had equivalent experience are required to register for Seminar 6:501, 6:502. In the seminar meetings, papers on the historical aspects of electrical engineering are presented and discussed. Entering students should select seminar subjects early. Regulations concerning the seminar are available in the Department, and should be followed in making selections. The seminar and thesis subjects of a student should be so related that the former lays the foundation for the latter.

The entire work of each student is carefully scrutinized with a view to determining whether he is obtaining in full measure the advantages which should be derived from advanced study and research, and he is advised accordingly. Students should realize that the fulfillment in a merely routine manner of the requirements for the degree as stated in this catalogue is not considered by the department as a satisfactory realization of the advantages which should accrue from advanced study.

Students working for advanced degrees in electrical engineering are encouraged to acquire additional training in mathematics and physics. Those proceeding toward the doctorate may well elect one

of these subjects as a minor. The advanced mathematics subjects are listed on page 222, those in physics on page 206 of this catalogue. The Chairman of the Departmental Committee on Graduate Study should be consulted by the student when planning his work.

### Graduate Evening Work

One or more of the graduate subjects listed on page 197 may be given in the evening for properly qualified engineering graduates provided a sufficient demand exists. Those interested in such subjects should notify the Department preferably not later than May 15 and December 15, for work in the first and second terms, respectively, indicating the particular subject (or subjects) they would like to attend. It is not intended that such preliminary notice should definitely commit the applicant, but it will enable the Department to determine what subjects may be offered to advantage during a particular term.

### Facilities for Research

The Graduate Laboratory of Electrical Engineering was established in 1913 as an educational agency to stimulate the students and the staff by bringing them into contact with problems on the front line of their profession and to train the students in methods of research. Most of the graduate students and a number of undergraduates utilize the facilities of this laboratory. The direction of the research work is not confined to any particular group of professors, but many members of the instructing staff aid in the work and are actively interested in the laboratory as a whole and particularly in those researches which lie within their own special fields of endeavor. The laboratory equipment is of a comprehensive nature, permitting all of the ordinary, and many unusual, electrical measurements to be made with facility.

Though the Graduate Laboratory was established as a purely educational agency, noteworthy contributions to knowledge have been made and eighty-six bulletins describing the researches have been published.

Each year there are usually a limited number of appointments as research associates and assistants which are available for persons especially qualified by training and natural endowment for the work of investigation. These assistants may study toward an advanced degree, and may utilize the work covered by their research as a portion of their thesis.

The problems assigned to research assistants and also those elected by the students working for the doctorate are such as require for their solution a high degree of scientific skill and long-continued investigation. Frequently these problems are suggested by engineers in practice, thus bringing the department into additional touch with the advanced problems of the profession.

An idea of the scope of the research work carried on under the

general supervision of the Department may be gained by reference to the research bulletins previously mentioned. The following paragraphs describe a few of the major research problems which have received the attention of the laboratory and which in general have resulted in the design and construction of permanent laboratory equipment of great utility.

Much study has been given to the problem of constructing artificial transmission lines and cables with distributed constants, a method of design has been developed and several lines constructed, single-phase as well as three-phase. These lines have been used for extensive studies of direct- and alternating-current transients, and now comprise part of the equipment of a special laboratory used for both research and instruction purposes.

Extensive investigations were made to demonstrate the feasibility of representing entire power systems artificially. This has resulted in the construction of the M. I. T. Network Analyzer adequate for the single-phase representation on a 60-cycle, 200-volt, 0.5-ampere basis of systems embodying as many as twelve generating stations with their loads and interconnecting circuits. The network analyzer gives the Laboratory an exceptional facility for the study of steady-state problems such as voltage regulation, power interchange, power-factor regulation, and system expansion and interconnection; and the transient problems of symmetrical and unsymmetrical short circuits with the accompanying questions of system stability. In addition to its use in research and in connection with class instruction, the network analyzer has been made available for the solution of commercial power-system problems. The network analyzer has been built with the cooperation of the General Electric Company.

The transients, both electrical and mechanical, occurring in electrical machines as a result of short circuit, of sudden terminal voltage changes, or of sudden or periodic load changes, have been analyzed mathematically and the results checked experimentally. To facilitate such studies a special machine-transients laboratory has been established, equipped with motor-generator sets and necessary accessories such as static condensers, reactors, circuit breakers and instruments, including a nine-element oscillograph. In the alternating-current machines, provision is made for the use of solid cylindrical, squirrel-cage, slip-ring induction, and salient-pole rotors. An important outgrowth of the machine-transients laboratory is the development of stroboscopes of high light intensity by means of which the behavior of rapidly moving bodies can be observed and photographed.

An important problem, various phases of which have occupied the attention of the laboratory for a number of years, is the study of the fundamental properties of insulation.

Mechanical and electrical methods for the solution of differential and integral equations have been actively investigated in the laboratory. The complexity of many problems of engineering and

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physics is such that satisfactory progress in their solution is often dependent upon graphical methods. The Differential Analyzer, which has been developed here, is designed to perform mechanically the necessary operations required in the solution of differential equations. The coefficients of the equation may be constant or variable, and may be functions of any of the variables. By means of this machine and the product integrator which preceded it, the analysis of numerous problems has been successfully accomplished. These problems have included the determination of the transient behavior of transmission lines, power systems, and electrical machinery, the operating characteristics of non-linear circuits, the design of structures, and investigations of certain field distributions in acoustics, and functions of wave mechanics. In addition another machine, utilizing light radiation in its operation, has been developed for the solution of certain types of integral equations.

### The Vail Library

The need for a special library of electrical literature, which is a necessary adjunct to all research, whether it be of an experimental or non-experimental character, is satisfied by the Vail Collection. This collection comprising thirty-five thousand volumes, was presented to the Electrical Engineering Department in 1912 through the interest of the late Theodore N. Vail, and is one of the three great electrical libraries of the world. It is now merged with the other works on electrical subjects in the Central Library, but distinguished by a special binding stamp and a special bookplate. The total is now over 40,000 volumes and 20,000 pamphlets. Included in the collection are the works of all scientists and engineers who have made significant contributions to electrical science from the time of William Gilbert (1600) down to the present day. Among the rarities are the 1558 edition of Peregrinus, a large number of first editions including Gilbert's *De Magnete*, and a notable autographed collection of original papers. Of unique interest are two holograph letters of Ampère containing twelve pages of manuscript.

Modern authorities are even more fully represented. The leading electrical periodicals, in foreign languages as well as English, are kept on file, together with the publications of the principal electrical societies of all countries. These are provided for the most part in complete sets, and are supplemented by the standard periodical indexes. A selection of useful books for ready reference is made available in the main reading room, and all graduate students have free access to the library stacks.

In order that the resources of the collection may be well understood and fully utilized, a special reference librarian is provided for exclusive service to the Electrical Engineering Department. This librarian gives instruction in the use of the library by group talks and individually, and offers assistance in the gathering of references and the preparation of bibliographies. The collection is kept up to

date by the addition of all important publications in the field, and books not in the Institute Library are obtained elsewhere when needed through the Interlibrary Loan Service.

### Colloquia and Special Lectures

Through the courtesy and coöperation of the industries associated with the electrical-engineering field, the Department has been able to arrange a series of colloquia conducted by men of distinguished accomplishment in the practice of electrical engineering. The purpose of the colloquia is to secure the injection into the curriculum of matters showing the relation of science to engineering practice, while the Institute instruction is itself chiefly concerned with basic scientific considerations. The colloquia also give graduate and senior students opportunity for meeting prominent engineers and discussing with each of them that branch of the electrical art in which he is a particular authority.

It is the policy of the Department to provide a number of such colloquia during each academic year, bearing on such subjects as communications, the design and production of electrical machinery, the design, construction and operation of power-transmission lines, and the operation of plant such as public-utility plant or manufacturing plant, including the economic aspects.

The colloquia of 1932-33 were:

"Transmission-Line Transients," by Mr. L. V. Bewley of the General Electric Company.

"The Design and Operation of Oil-Impregnated Paper Cables," by Mr. F. H. Buller of the General Electric Company.

"A New Theory and Method of Designing Electric Wave Filters," by Mr. L. A. Kelley of Burkholder and Kelley, formerly of International Communications Laboratories, Inc.

"The Development of the Synchronous Electric Clock and the Frequency Control for Power Systems," by Mr. H. E. Warren of the Warren Telechron Company.

"The Electrical Transmission Line and Recent Transmission Developments in Communication," by Messrs. O. B. Blackwell and H. A. Affel of the American Telephone and Telegraph Company.

"Radio-Frequency Transmission Lines and Terminations," by Dr. P. B. Taylor of Westinghouse Electric and Manufacturing Company.

"Electric Furnaces," by Mr. N. R. Stansel of the General Electric Company.

"The Problems of Rectification and Smoothing of Alternating Currents," by Dr. F. S. Dellenbaugh of the Delta Manufacturing Company.

## GRADUATE SUBJECTS IN ELECTRICAL ENGINEERING

## "A" Subjects. Primarily for Graduates.

<i>First Term</i>		<i>Second Term</i>	
6'501	Elec. Eng. Seminar . . . . . 8	6'502	Elec. Eng. Seminar . . . . . 8
6'511	Electric Circuits. . . . . 3-7	6'512	Electric Circuits. . . . . 3-7
6'512	Electric Circuits . . . . . 3-7	6'513	Electric Circuits. . . . . 3-7
6'521	Alt. Cur. Machinery . . . . . 5-5	6'522	Alt. Cur. Machinery . . . . . 5-5
6'531	Org. & Adm. Pub. Ser. Cos. . 3-7	6'532	Org. & Adm. Pub. Ser. Cos. . 3-7
6'541	Power Gen. Stations. . . . . 3-6	6'542	Power Gen. Stations. . . . . 3-6
6'551	Railroad Elec. Traction . . . . 3-6	6'552	Railroad Elec. Traction . . . . 3-6
6'561	Adv. Network Theory . . . . . 5-5	6'562	Adv. Network Theory . . . . . 2-5
6'571	Illumination . . . . . 5-4	6'572	Illumination . . . . . 5-4
6'58	Oper. Circuit Anal. . . . . 3-7	6'58	*Oper. Circuit Anal. . . . . 3-7
6'59	Communications Lab. . . Time arr.	6'59	Communications Lab. . . Time arr.
6'651	Elec. Power Dist. . . . . 3-6	6'62	Elec. Com., Prin. . . . . 5-5
6'661	Elec. Machine Dev. Prin. . . 4-6	6'652	Elec. Power Dist. . . . . 3-6
6'68**	Transmission-Line Transients 3-7	6'662	Elec. Machine Dev. Prin. . . 4-6
6'73	Elec. Meas. Lab., Adv. . Time arr.	6'68**	Transmission-Line Trans. . . 3-7
6'74	Elec. Eng. Lab., Adv. . Time arr.	6'69	Sound in Elec. Com. . . . . 5-5
	Research	6'73	Elec. Meas. Lab., Adv. Time arr.
		6'74	Elec. Eng. Lab., Adv. . Time arr.
			Research

## "B" Subjects. Open to Graduates and Undergraduates

<i>First Term</i>		<i>Second Term</i>	
6'221	Central Stations . . . . . 3-6	6'04	†Electrical Eng. Prin. . . . . 6-9
6'241	Electric Railways . . . . . 3-6	6'20	Power Trans. Equip. . . . . 3-6
6'251	Elec. Mach. Design . . . . . 3-6	6'21	Ind. App. of Elec. Power . . . 3-6
6'26	Elec. Ins. & Its Behavior . . . 5-4	6'222	Central Stations . . . . . 3-6
6'27	Illumination . . . . . 5-4	6'242	Electric Railways . . . . . 3-6
6'281	Prin. Wire Com. . . . . 3-6	6'252	Elec. Mach. Design . . . . . 3-6
6'311	Electrical Com., Prin. . . . . 3-5	6'282	Prin. Radio Com. . . . . 3-6
6'80	Electrical Eng. Lab. . . . . Time arr.	6'312	Electrical Com., Prin. . . . . 3-5
		6'80	Electrical Eng. Lab. . . . . Time arr.

## Summer

A number of the above "A" and "B" subjects are offered each year in the Summer Session. Definite information in this regard may be obtained from the Summer Session Bulletin.

\* Usually repeated in second term.

\*\* Given first or second term (or both) as announced by the Department.

† Only for students specializing in Communications.

**DEPARTMENT OF BIOLOGY AND PUBLIC HEALTH**

Graduate work in this Department may be selected in one of the fields listed below:

**Fields of Study**

Bacteriology	Industrial Biology
Basic Biological Science	Industrial Hygiene
Biochemistry	Public Health Administration
Biophysics	Public Health Engineering
Food Technology	Public Health Practice
Health Education	Sanitary Biology

**Degrees Awarded**

Master of Science	Doctor of Philosophy
Doctor of Science	Doctor of Public Health

A Certificate in Public Health is also awarded.

**Minimum Requirements for Admission to Graduate Work**

All graduate degrees: In addition to the general requirements the following professional prerequisites, or their equivalents, as judged by the Department Committee on Graduate Students, are necessary for admission to graduate work.

**Option 1. Biology or Biology and Public Health (S.M., Ph.D., Sc.D., Dr. P.H.)**

5'12 Quantitative Analysis	7'12 Anatomy and Histology
5'41 Organic Chemistry	7'20 Physiology
5'428 Organic Chemistry Lab.	7'22 Personal Hygiene & Nutrition
7'01 General Biology	7'301 Bacteriology
7'06 Botany	*7'302 Bacteriology
7'10 Zoology	*7'50 Infection and Immunity
7'11 Anatomy and Histology	*7'57 Municipal Sanitation
	*7'80 Biochemistry

\* May be counted as "B" subject for S.M. in this option by permission

**Option 2. Industrial Biology. (S.M., Ph.D., Sc.D.)**

5'12 Quantitative Analysis	7'15 Essentials of Anatomy
5'20 Chem. of Water & Sewage	7'20 Physiology
5'25 Chemistry of Foods	7'301 Bacteriology
5'41 Organic Chemistry	*7'302 Bacteriology
5'428 Organic Chemistry Lab.	7'361 Industrial Microbiology
5'684 Physical Chemistry, Elem.	*7'362 Industrial Microbiology
7'01 General Biology	7'80 Biochemistry
7'07 Mycology	

\* May be counted as "B" subject for S.M. in this option by permission.

## Option 3. Public Health Engineering. (S.M., Sc.D.)

1'041	Surveying	1'802	Sanitary Design
1'40	Structures	5'20	Chemistry of Water & Sewage
1'411	Structures	7'301	Bacteriology
1'60	Hydrographic Surveying	7'34	Limnological Field Work
1'62	Hydraulics	*7'50	Infection and Immunity
1'75	Hydraulic and Sanitary Eng.		
1'78	Sanitary Engineering		
1'801	Sanitary Design		

\* May be counted as "B" subject for S.M. in this option by permission.

In certain cases where the applicant has had experience in a related professional field, or has other special qualifications, the "B" subjects, and those starred in the above lists, may be taken during the work toward the Master's degree and may be credited as "B" subjects in the requirement for that degree.

**Requirements for the Certificate in Public Health.** The Certificate in Public Health is not a degree, but the course prescribed is essentially equivalent to that for the degree of Master of Science.

A candidate for the Certificate in Public Health must hold (1) a bachelor's degree from a recognized institution or, (2) a medical degree from a Class A medical school or (3) have had professional training equivalent thereto. In addition, students who have not passed courses of satisfactory grade in Anatomy and Physiology or other prerequisite subjects will be required to take these subjects before receiving the Certificate.

The work scheduled for the Certificate in Public Health requires: (1) At least one full academic year in residence with the satisfactory completion of 96 units of "A" or "B" subjects, of which the following are minimum essentials:

	<i>Units</i>
7'22 Personal Hygiene and Nutrition.....	4
7'302 Bacteriology.....	9
7'50 Communicable Diseases.....	6
7'541 Public Health Administration.....	5
7'542 Public Health Administration.....	5
7'551 Public Health Lab. Methods.....	8
7'552 Public Health Lab. Methods.....	4
7'56 Public Health Surveys.....	5
7'57 Municipal Sanitation.....	8
7'58 Vital Statistics.....	5

(2) The completion of an approved survey, or a research of some phase of public health, of at least 10 units. (3) The creditable passing of an oral examination covering the general field.

Students taking the Certificate of Public Health in the field of Health Education may substitute for laboratory work in the field of sanitary and diagnostic bacteriology an equal number of units in the field of health education and school health. Courses in the Harvard Graduate School of Education and in the School of Education of Boston University are available as electives.

The Massachusetts Institute of Technology subjects available as electives include:

**"A" subjects.** Epidemiology, Advanced Bacteriology, Health Hazards in Special Industries, Advanced Parasitology, Pathology, Public Health Problems, Public Health Field Work, School Health Administration.

**"B" subjects.** Biochemistry, Food Chemistry, Industrial Hygiene, Theoretical Biology, Parasitology.

For other available electives refer to the Departments of Biology, Chemistry and Physics.

Graduates of Class A medical schools and graduates of the Public Health option of the Department may reasonably expect to secure the Certificate in one year.

**Requirements for the Degrees of Doctor of Science or Doctor of Philosophy in Biology, or in Biology and Public Health.** The general examinations are held in four divisions, covering approximately fifteen subjects, three divisions being common to all programs, and the fourth varying according to the field of specialization. Examinations in foreign languages are held within the department of Biology and Public Health.

**Requirements for the Degree of Doctor of Public Health.** For this degree the requirements are of the same standard as for the degree of Doctor of Philosophy or Doctor of Science, and will in general presuppose a period of three years of graduate work for those entering upon this course of study directly from college work. To students who have received a Bachelor's degree from an institution of recognized standing or who have received the M.D. degree from Class A medical schools with at least two years of college training before entering the medical school, this degree is open on the same basis as the Doctor of Science or Doctor of Philosophy.

To be accepted as a candidate for the degree the student must pass a general examination in all the subjects required for the degree, given in four groups, at least seven months before the degree is conferred. In view of the wide range of subjects in which the candidate must qualify in his general examination, a special *minor* requirement may be waived.

The time required in preparation for the general examination may be reduced in the case of those individuals who have had extensive public health experience involving knowledge of the subjects regarded as essential to this degree, but each case will be considered individually on its merits and no general classes of applicants can be established on the basis of experience.

For those who enter upon graduate work for the degree of Doctor of Public Health without actual practical experience it is recommended that a portion of the time in the period preceding the general examination be spent in practical health work, under the direction of the Faculty, in some health department which is willing to cooperate with the Institute in this respect by employing such men on a

part-time basis or by offering facilities for securing experience in special fields of public health administration or procedure.

Medical officers of the United States Army who are graduates of accepted medical schools and who have in addition had the basic course in public health at the Army Medical School, the special courses required for sanitary officers, and at least five years of practical public health administration in the army, are accepted as applicants for the degree on a one-year basis, but to be accepted as candidates they must pass a general examination in the field of Public Health not less than six months previous to the time it is expected the degree will be received. Their period of residence is devoted largely to research which must be of advanced professional character.

### **The Biological Laboratories**

The Biological Laboratories offer facilities for advanced work in bacteriology, biochemistry, zymology, industrial hygiene, municipal sanitation, and food conservation and control. Special opportunities for training for the profession of Public Health and for investigation of methods of public health education and administration are available.

## GRADUATE SUBJECTS IN BIOLOGY

## "A" Subjects. Primarily for Graduates.

<i>First Term</i>		<i>Second Term</i>	
7-14	History of Biology . . . . .	1-4	7-09 Parasitology, Adv. . . . .
7-18	Tech. Asp. of Entom. . . . .	2-3	7-132 Histology . . . . .
7-321	Bacteriology, Adv. . . . .	3-4	7-23 Applied Nutrition . . . . .
7-35	Planktonology . . . . .	2-3	7-322 Bacteriology, Adv. . . . .
7-371	Industrial Microbiol. . . . .	5-4	7-372 Indust. Microbiol. . . . .
7-601	Health Education . . . . .	2-4	7-56 Public Health Surveys . . . . .
7-66	Epidemiology . . . . .	2-6	7-602 Health Education . . . . .
7-931	Biological Seminar . . . . .	1-3	7-604 School Health Adm. . . . .
	Research		7-63 Pub. Health Field work . . . . .
			7-64 Pub. Health Problems . . . . .
			7-65 Health Haz. in Spec. Ind. . . . .
			7-67 Functional Pathology . . . . .
			7-68 Pathology . . . . .
			7-722 Food Technology, Adv. . . . .
			7-81 Enzyme Chemistry . . . . .
			7-932 Biological Seminar . . . . .
			Research

## "B" Subjects. Open to Graduates and Undergraduates.

## OPTION 1

<i>First Term</i>		<i>Second Term</i>	
7-131	Histology, Adv. . . . .	4-2	7-03 Theoretical Biology . . . . .
7-361	Indus. Microbiology . . . . .	5-2	7-302 Bacteriology . . . . .
7-50	Communicable Diseases . . . . .	3-3	7-362 Indus. Microbiology . . . . .
7-53	Air Examination . . . . .	4-1	7-52 Industrial Hygiene . . . . .
7-541	Pub. Health Adm. . . . .	3-1	7-542 Pub. Health Adm. . . . .
7-551	Public Health Lab. Meth. . . . .	8-3	7-552 Serological Methods . . . . .
7-58	Vital Statistics . . . . .	2-3	7-57 Municipal Sanitation . . . . .
7-59	Sanitation . . . . .	6-2	
7-80	Biochemistry . . . . .	8-5	

## OPTION 2

<i>First Term</i>		<i>Second Term</i>	
7-22	Personal Hyg. & Nutr. . . . .	2-2	7-03 Theoretical Biology . . . . .
7-441	Tech. of Fish. Products . . . . .	4-4	7-302 Bacteriology . . . . .
7-551	Public Health Lab. Meth. . . . .	8-3	7-362 Indust. Microbiology . . . . .
7-711	Tech. of Food Products . . . . .	4-4	7-442 Tech. of Fish. Products . . . . .
			7-52 Industrial Hygiene . . . . .
			7-552 Serological Methods . . . . .
			7-712 Tech. of Food Products . . . . .

## OPTION 3

<i>First Term</i>		<i>Second Term</i>	
7-50	Communicable Diseases . . . . .	3-3	7-302 Bacteriology . . . . .
7-53	Air Examination . . . . .	3-2	7-52 Industrial Hygiene . . . . .
7-541	Public Health Admin. . . . .	2-3	7-542 Public Health Admin. . . . .
7-551	Public Health Lab. Meth. . . . .	8-3	7-552 Serological Methods . . . . .
7-58	Vital Statistics . . . . .	2-3	7-57 Municipal Sanitation . . . . .
7-59	Sanitation . . . . .	4-4	
7-80	Biochemistry . . . . .	8-5	

**DEPARTMENT OF PHYSICS**  
**Including**  
**ELECTROCHEMICAL ENGINEERING**

The Department of Physics offers work for the degrees of Master of Science and either Doctor of Science, or Doctor of Philosophy in Physics, and for Master of Science and Doctor of Science in Electrochemical Engineering. The following special requirements must be met for the doctor's degree, in addition to the general requirements and a good reading knowledge of French and German:

*Physics.* Undergraduate subjects, which may be taken at the Institute or elsewhere, but may not be counted for an advanced degree:

8'161 Optics	8'311 Atomic Structure
8'201 Electricity and Electronics	8'50 Heat and Thermodynamics

Undergraduate subjects which may be counted as B subjects toward an advanced degree:

8'461, 8'462	Introduction to Theoretical Physics
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*Electrochemistry.* Undergraduate subjects, which may be taken at the Institute or elsewhere, but may not be counted for an advanced degree:

6'01, 6'02	Electrical Engineering Principles
6'81, 6'82	Electrical Engineering Laboratory
8'11	Heat Measurements
8'801, 8'802	Electrochemistry Principles

Undergraduate subjects which may be counted as B subjects toward an advanced degree:

8'82 Electrochemistry	8'86 Electrochemistry Laboratory
8'85 Applied Electrochemistry	8'87 Electric Furnace Laboratory

### THE GEORGE EASTMAN RESEARCH LABORATORIES

The advanced work and research in the department are correlated under four main heads: experimental physics, theoretical physics, applied and industrial physics, and electrochemistry. The theoretical and experimental physics are located largely in the new George Eastman Laboratories, shared jointly by physics and chemistry. This laboratory, consisting of four stories and a basement, one half devoted to physics and the other to chemistry, contains facilities for experimental research, offices for the staff, and in addition, various joint facilities of the two departments, as a lecture room, library, social room, and classrooms for graduate courses, located about the middle of the building.

### Experimental Physics

All the floors of the new building except the third are devoted to experimental physics, particularly along the line of modern physics. In the basement there are well-equipped shops, including machine shop, instrument maker's shop, pattern shop, and a staff shop. The remaining space on this floor is devoted to spectroscopy, and communicates with the Spectroscopy Laboratory, which is described later.

The first and second floors, in addition to lecture room, directors' offices, stock room, classrooms, and glass blowers' room, contain provision for research in gaseous discharges, thermionic and photoelectric emission, radiation measurements, and related phenomena. These subjects, which have already thrown so much light on the structure of atoms and of matter, seem destined in addition to become of increasing practical importance.

On the fourth floor provision has been made for several related fields of research on the structure of matter in bulk. One of these is X-rays, and in particular X-ray crystal structure. This field, which has been considerably developed at the Institute, and for which there is good equipment, is concerned now mostly with the more complicated substances, as for example silicates. Another field is that of the dielectric and magnetic properties of matter, leading to information about the polar nature of the molecule, and involving experimentation on such things as refraction, Kerr effect, and dielectric constant.

### Spectroscopy Laboratory

Communicating with the basement by a corridor, but entirely independent of the main building, and located in a court, is the Spectroscopy Laboratory. This has been designed particularly to provide constant temperature and freedom from vibration. Included in it are complete Paschen circles for both 35-foot and 21-foot gratings, entered from a common source room; several other grating mountings; and separate rooms for vacuum spectrographs and other pieces of apparatus. These include among other things a 21-foot vacuum spectrograph, microphotometers, and various interferometers for work requiring high resolving power.

### Theoretical Physics

The third floor of the physics end of the new laboratory is devoted to theoretical physics. There is a well-equipped research library of physics, chemistry, and mathematics, containing reading room, stack space to accommodate thirty thousand volumes, and cubicles for studying in the stacks; a seminary and social room; and a number of offices for members of the staff and research students in theoretical physics. The staff is particularly well equipped to undertake and direct research in theoretical work, both in the topics in quantum theory and the structure of matter which are at present of such par-

ticular interest, and at the same time in the more classical branches of physics, as electromagnetism, hydrodynamics and mechanics.

### **The Rogers Laboratory of Physics**

In addition to the facilities of the George Eastman laboratory, a number of branches of teaching and research in classical and applied physics are located in Buildings 4 and 8, and collectively form the Rogers Laboratory of Physics. Among these are the optical and photographic laboratories, the heat measurement laboratory, the laboratory of industrial physics, and the electrochemical laboratories.

The optical and photographic laboratories are equipped primarily for instruction and research in the field of applied optics. In addition to the usual equipment, they are well provided for work in photomicrography, determinations of the optical properties of materials, and color measurements.

The heat measurements laboratory is equipped primarily for research in pyrometry, thermal conductivity, thermal expansion, specific heat, heat of combustion, and refractories. It is well provided with means for measuring high temperatures, and contains furnaces and kilns for use with refractories, a refrigerating unit connected to an insulated room that can be cooled to  $-40^{\circ}$  C., and much other equipment.

The electrochemical laboratories, consisting of two large laboratories and a number of smaller research laboratories, are equipped for work in both theoretical and applied electrochemistry. In the theoretical electrochemistry laboratory, facilities are provided for the investigation of problems relating to the properties of aqueous and fused electrolytes, electromotive force of voltaic cells, electrolytic oxidation and reduction, overvoltage, etc. The laboratory of applied electrochemistry is well provided for electric furnace and electro-metallurgical processes involving the use of heavy alternating and direct current.

### **Colloquia and Special Lectures**

In addition to the class work and research, the various colloquia, seminars, and special lectures contribute greatly both to the information of the student and to the stimulation of interest in many branches of physics. Cambridge is a center of scientific activity, and as a result there are each week many such colloquia and lectures which can be attended with profit, both at the Institute, at Harvard University, and at such institutions in Boston as the Lowell Institute.

**GRADUATE SUBJECTS IN  
PHYSICS AND ELECTROCHEMICAL ENGINEERING**

**"A" Subjects. Primarily for Graduates.**

<i>First Term</i>	<i>Second Term</i>
8:14 Heat Measurements II Time arr.	8:181 Optics Seminar . . . . . 2-2
*8:193 Geom. Optic, Adv. . . . . 2-4	*8:194 Physical Optics, Adv. . . . . 2-4
8:21 Electronic Phen. . . . . 2-4	8:212 Experimental Electronics . . . . . 4-3
8:212 Experimental Electronics . . . . . 4-3	8:214 Advanced Electronics . . . . . 3-9
8:213 Advanced Electronics . . . . . 3-9	*8:28 X-Ray Diffraction . . . . . 2-4
8:215 Spe. Prob. in Electronics Time arr.	8:29 Lattice Th., Solid State . . . . . 2-4
8:26 Polar Molecules . . . . . 4-3	8:30 Spe. Prob. in Crys. Phys. Time arr.
8:32 Line Spectra . . . . . 3-6	8:342 Spectroscopy Seminar . . . . . 1-1
8:341 Spectroscopy Seminar . . . . . 1-1	8:343 Spec. Prob. in Spectros. Time arr.
8:343 Spec. Prob. in Spectros. Time arr.	8:35 Excitation of Spectra . . . . . 5-4
8:361 Radia. Measure. Lab. . . . . 5-0	8:361 Radia. Measure. Lab. . . . . 5-0
8:481 Advanced Mechanics I . . . . . 3-9	8:463 Int. to Theor. Phys. III . . . . . 4-8
*8:521 Quantum Mechanics . . . . . 3-9	8:482 Advanced Mechanics II . . . . . 3-9
*8:56 Electromag. Wave Th. I . . . . . 3-9	*8:49 Elasticity & Fluid Dynam. . . . . 3-9
8:58 Theory of Relativity . . . . . 3-9	8:491 Bound. Value Pr. in Th. Phy. . . . . 3-9
8:591 Theoretical Seminar . . . . . 1-1	*8:512 Statistical Mechanics . . . . . 3-9
8:83 Electrochemistry, Adv. . . . . 3-6	*8:522 Theory of Spectra . . . . . 3-9
	*8:57 Electromag. Wave Th. II . . . . . 3-9
	8:592 Theoretical Seminar . . . . . 1-1

\* Omitted in 1933-34.

**"B" Subjects. Open to Graduates and Undergraduates.**

<i>First Term</i>	<i>Second Term</i>
8:171 Advanced Optics . . . . . 2-3	8:13 Heat Measurements . . . . . 5-1
*8:174 Motion Picture Photog. . . . . 1-3	8:173 Color Measurements . . . . . 3-2
8:27 X-Rays & Crystal Physics . . . . . 3-5	8:462 Int. to Theor. Phys. II . . . . . 4-8
8:36 Radiation Measurements . . . . . 5-4	8:472 Recent Dev. of Physics . . . . . 3-6
8:461 Int. to Theor. Phys. I . . . . . 4-8	8:542 Electromagnetic Wave Prop. . . . . 2-3
8:471 Hist. Dev. of Physics . . . . . 3-6	8:85 App. Electrochemistry . . . . . 3-6
8:541 Electromagnetic Theory . . . . . 2-2	8:87 Electric Furnace Lab. . . . . 2-2
8:82 Electrochemistry . . . . . 3-6	8:93 Electrochem. Colloq. . . . . 1-1
8:86 Electrochem. Lab. . . . . 9-3	

\* Omitted in 1933-34.

## DEPARTMENT OF CHEMICAL ENGINEERING

Because of the breadth of the field of Chemical Engineering the undergraduate course must be devoted to essentials and there is little opportunity for specialization. Therefore, in this field of engineering, postgraduate work is of peculiar importance and value.

The Department offers four types of opportunity for graduate study: first, subjects of instruction designed to broaden and deepen the knowledge and analytic power of the student without emphasis on any special field of application; second, the School of Chemical Engineering Practice, the purpose of which is to furnish the student practical experience in the solution of industrial problems under expert supervision and guidance; third, the Research Laboratory of Applied Chemistry, in which graduate students interested primarily in the chemical phases of industrial work may receive training in methods of industrial research; and, fourth, a group of subjects in Fuel Engineering designed to meet the needs of the engineer who wishes to specialize in that field.

### School of Chemical Engineering Practice

In addition to the regular postgraduate work, the Department of Chemical Engineering offers a special course leading to the degree of Master of Science in Chemical Engineering Practice.

In the School of Chemical Engineering Practice a carefully selected group of graduate students who have completed at least four years of undergraduate study at the Institute or elsewhere spend six months at three field stations located at Bangor, Me., Buffalo, N. Y., and Boston, Mass. At these stations six different concerns open their plants for the instruction of students who at each station are under the direct charge of a member of the Institute faculty and his assistants. The time being devoted wholly to their education, students receive no compensation, and their attention is directed chiefly to the application of theory to practice and to the quantitative measurement of the efficiency of the chemical engineering operations in use at these plants.

The field of chemical engineering has been divided into a series of unit operations which are studied quantitatively and in detail in the Practice School. Plant investigations are carried out by the students at each of the stations, these investigations covering two fields: first, investigation of some special phase of one of the unit operations; or second, investigation of some problem of industrial chemistry particularly important at the station in question.

Finally, the School of Chemical Engineering Practice offers exceptional opportunity for graduate engineering research, first by affording an opportunity for verifying laboratory data, formulae and conclusions with observations on larger apparatus operating under practical working conditions; and second, by extending, from laboratory scale at the Institute to commercial scale in the various plants, the range of investigations possible.

The following program will be taken by men graduating in Chemical Engineering from the Institute.

For twenty-four weeks, from July to December, students are at the field stations (10·81, 10·82 and 10·83). They then return to the Institute for an intensive study in Chemical Engineering Design (10·53) between the close of the Christmas vacation and the end of the examination period of the first term. The work of the second term, including thesis, is elective, though subject to the approval of the department registration officer of graduate students.

Students from other institutions will, in general, spend one scholastic year at the Institute before taking the field station work in order to meet the science and engineering requirements for graduate study in the department. The student's program is so dependent on previous training and experience that individuals interested in this field are requested to communicate directly with the department concerning details and arrangements.

#### **Research Laboratory of Applied Chemistry**

The primary function of this laboratory is to train young men for industrial research. To do this satisfactorily, however, it is necessary to have close contact with the research problems of the various chemical industries. To maintain such contact and to support a considerable amount of general research of scientific or industrial interest, the Research Laboratory of Applied Chemistry, for a suitable arrangement of fees, offers to industrial concerns and to trade associations, the facilities of its laboratories for the solution of the more fundamental types of problems. Except for a small permanent staff, the organization is made up of young men of unusual promise, who spend one, two or three years after graduation on full-time paid research and who then take industrial positions, generally in research or development work. Owing to the fact that the number of positions in the laboratory is limited, preference is usually given to properly qualified students who have attended the Institute for at least part of one year. Although the investigations for outside concerns are carried on only by the full-time members of the staff, graduate students frequently take advantage of the opportunity to undertake theses along similar lines leading to the degrees of Master of Science or Doctor of Science.

#### **Fuel Engineering**

The industries involving the processing and utilization of fuels constitute a large and important group. Since many phases of fuel engineering are distinctly chemical in nature, the training and viewpoint of the chemical engineer can be used to advantage.

Although some problems demand all the chemical knowledge and laboratory technique of the chemist and chemical engineer, many are not so exacting in the necessity for chemical training, and men who have majored in a non-chemical branch of engineering may prepare themselves adequately for fuel engineering practice by graduate study.

The Department of Chemical Engineering offers a group of subjects in fuel processing and utilization which forms the basis of a program of graduate study in fuel engineering, the balance of the program being made up of subjects in science, engineering or economics to meet individual needs and preferences. Since the program arranged will depend on undergraduate training and industrial experience, any one interested is requested to furnish the department with this information in order that his case may receive individual consideration.

### Requirements for Graduate Study

The requirements for graduate study in the Department of Chemical Engineering are dependent on the degree to which the student wishes to specialize. The broadest training is required in Chemical Engineering and in Chemical Engineering Practice as it is assumed that the student is preparing himself for any phase of chemical engineering. On the other hand students who plan definitely to major in Applied Chemistry or in Fuel Engineering will be expected to meet requirements in chemistry and in engineering to an extent justified by the field of specialization, and in each case emphasis will be placed on basic training in the sciences.

The preparation required above that common to all courses of the Institute is described broadly, for each type of graduate program previously outlined.

**Mathematics.** Differential Equations equivalent to the undergraduate subject M22 or M41.

**Chemistry.** (a) Chemical Engineering.\* A training approximately equivalent to that of the undergraduate course with particular emphasis on thoroughness of preparation in physical chemistry.

(b) Applied Chemistry. Similar to the requirement in Chemical Engineering but with more work in analytical and organic chemistry.

(c) Fuel Engineering. A minimum of general inorganic chemistry, with laboratory practice.

**Engineering.** (a) Chemical Engineering. A training which includes thorough preparation in thermodynamics, and, in general, in applied mechanics or elements of electrical engineering.

(b) Applied Chemistry. Thorough preparation in thermodynamics, and, in general, in materials of construction.

(c) Fuel Engineering. An engineering training equivalent to that given in an undergraduate course in mechanical or electrical engineering.

Graduate students will find it possible to meet many of these requirements at the Institute while studying for an advanced degree.

\* The requirements are the same for Chemical Engineering Practice.

## GRADUATE SUBJECTS IN CHEMICAL ENGINEERING

## "A" Subjects. Primarily for Graduates

<i>First Term</i>		<i>Second Term</i>			
10'25	Indust. Stoichiometry . . . . .	2-4	10'41	Distillation . . . . .	2-6
10'42	Drying . . . . .	2-4	10'46	Absorption and Extraction . . . . .	2-4
10'43	Evaporation . . . . .	2-4	10'50	Heat Transmission . . . . .	2-4
10'52	Chemical Engineering II . . . . .	2-4	10'55	Economic Balance . . . . .	3-6
10'53	Chem. Engineering Design . . . . .	3-9	10'62	App. Chem. Thermodyn. . . . .	3-6
10'54	Econ. Bal. in Chem. Indus. . . . .	5-7	10'63	App. Colloid Chemistry . . . . .	3-6
10'68	Corrosion . . . . .	2-4	10'65	High Pressure Processes . . . . .	2-4
10'70	Principles of Combustion . . . . .	4-6	10'71	Fuel Engineering . . . . .	3-6
10'72	Fuel Engineering Practice . . . . .	20	10'74	Furnace Design . . . . .	3-6
10'73	Fuel Engineering Design . . . . .	3-6	10'76	Seminar in Rad. Heat Trans. . . . .	2-4
10'79	Automotive Fuels . . . . .	2-4	10'912	Research Conferences . . . . .	1-2
Sch. Chem. Eng. Practice			10'942	Org. & Meth. of Ind. Res. . . . .	1-2
10'81	Bangor Station . . . . .	12	10'992	Seminar in Chem. Eng. . . . .	2-4
10'82	Boston Station . . . . .	12			
10'83	Buffalo Station . . . . .	12			
10'90	Exp. Research Prob. . . . .	Time arr.			
10'911	Research Conferences . . . . .	1-2			
10'941	Org. & Meth. of Ind. Res. . . . .	1-2			
10'991	Seminar in Chem. Eng. . . . .	2-4			

## "B" Subjects. Open to Graduates and Undergraduates

<i>First Term</i>		<i>Second Term</i>			
10'21	Indust. Chemistry . . . . .	2-2	10'32	Chemical Eng. . . . .	5-4
10'26	Indust. Chem. Lab. . . . .	5-1	10'78	Fuel Engineering Lab. . . . .	4-2
10'31	Chemical Eng. . . . .	5-4			

**COURSE LEADING TO THE DEGREE OF MASTER OF SCIENCE**  
**(For Chemical Warfare Officers)**

The work begins with the Summer Session in June. The summer work is normally devoted to the completion of any professional subjects necessary as preparation for the more advanced work of the Course, in which the student's preparation may be deficient.

**Required Work**

<i>First Term</i>		<i>Second Term</i>		
10'21	Indust. Chemistry . . . . .	2-2	5'43 Powder and Explosives . . .	2-2
10'25	Indust. Stoichiometry . . . . .	2-4	5'425 Organic Chem. Lab. . . . .	9-0
10'28	Chemical Engineering . . . . .	3-6	10'29 Chemical Engineering . . . . .	3-6
10'31	Chemical Engineering . . . . .	5-4	10'32 Chemical Eng. . . . .	5-4
10'941	Org. and Meth. of Ind. Res. . . . .	1-2	10'942 Org. and Meth. of Ind. Res. . . . .	1-2
M41	Differential Equations . . . . .	3-6	Thesis	30
	Sch. Chem. Eng. Practice . . . . .	36		

**Optional Subjects**

<i>First Term</i>		<i>Second Term</i>		
5'061	Inorganic Chemistry . . . . .	2-3	2'622 Engineering Lab. . . . .	3-3
5'51	Organic Chemistry II . . . . .	2-2	5'062 Inorganic Chemistry . . . . .	2-3
5'55	Organic Qual. Anal. . . . .	10-0	5'52 Organic Chemistry II . . . . .	2-2
10'54	Economic Balance . . . . .	5-7	10'63 App. Colloid Chemistry . . . . .	3-6
10'68	Corrosion . . . . .	2-4	10'65 High Pressure Proc. . . . .	2-4

The optional subjects listed are especially fitted to meet the need of the Chemical Warfare Officers. Subject to the approval of the Department, other subjects may be chosen from the lists available for credit for the Master's degree.

### DEPARTMENT OF GEOLOGY

In Geology many opportunities are given to pursue advanced work leading to the Master's and Doctor's degree. One line of work is in Economic Geology, and the student may specialize in mining geology, petroleum geology, hydrology, or geology applied to engineering or geophysics. Or again, he may elect to devote the greater part of his time to geology, mineralogy, petrography and paleontology in their more theoretical aspects as preparation for teaching and research.

**Requirements for the Degree of Master of Science.** The advanced work is facilitated by laboratories provided with modern appliances for work in economic geology, mineralogy, petrography and paleontology. The collections in economic geology are supplied with material from the mines of all parts of the world.

Candidates for the degree of Master of Science in Geology must present approved equivalents for the subjects of the first and second years as given on page 153 (except as noted below). In addition, they must present the equivalents for the following subjects:

5'12	Quantitative Analysis	12'38	Physiography
12'01	Mineralogy	12'40	Economic Geology
12'02	Mineralogy	12'511	Paleontology
12'15	Petrography	12'512	Paleontology
12'211	Optical Crystallography	D11	Drawing and Desc. Geometry
12'30	Geology	G64	Organic Evolution
12'31	Geology		Reading knowledge of French or German
12'33	Field Geology		

**Requirements for the Degree of Doctor of Philosophy, or Doctor of Science.** The preparation of the candidate for the Doctor's degree must be such as to satisfy the Committee on Graduate Courses that he is qualified to undertake the course of advanced study and research (pages 156-160).

Each candidate must show a knowledge of the entire field of geology by passing an oral, or written examination under the individual instructor in charge of each particular subject. These preliminary examinations precede the "major" examination which must be passed at least seven months before the degree is awarded. The "minor" requirement should likewise be passed before the major examination.

A reading knowledge of both French and German is required. It must be demonstrated at least a year before the degree is awarded, the test being the ability to review efficiently the foreign papers and books assigned in the regular graduate courses.

## GRADUATE SUBJECTS IN GEOLOGY

## "A" Subjects. Primarily for Graduates.

<i>First Term</i>		<i>Second Term</i>		
12'05	Mineralogy, Adv. . . . .	5-1	12'17 Petrographic Research . . . . .	8-2
12'351	Geol. Survey, Adv. . . . .	4-4	12'212 Optical Crystallography . . . . .	3-1
12'431	Economic Geol. Lab., Adv. . . . .	4-1	12'352 Geol. Survey, Adv. . . . .	4-4
12'433	Economic Geol. Sem., Adv. . . . .	2-2	12'432 Economic Geol. Lab., Adv. . . . .	4-1
12'521	Paleontology . . . . .	4-3	12'434 Economic Geol. Sem., Adv. . . . .	2-2
12'54	Micropaleontology . . . . .	3-2	12'522 Paleontology, Adv. . . . .	4-3
12'581	Stratigraphy, Adv. . . . .	2-4	12'53 Index Fossils . . . . .	6-1
12'631	Geol. Seminar, Adv. . . . .	2-5	12'55 Organic Evolution, Adv. . . . .	2-3
12'64	Geol. of North America . . . . .	2-4	12'582 Stratigraphy, Adv. . . . .	2-4
12'851	Theoret. Geophysics, Adv. . . . .	3-4	12'632 Geol. Seminar, Adv. . . . .	2-5
	Research		12'65 Geology of Europe . . . . .	2-4
			12'81 Geology of Petroleum, Adv. . . . .	3-2
			12'852 Theoret. Geophysics, Adv. . . . .	3-4
			Research	

Subject to the approval of the Departmental Committee on Graduate Students, other subjects for which a student has adequate preparation may be elected from the subjects primarily for graduates offered by the Mining Department, and by other related departments. A number of advanced subjects in geology and mineralogy, given at Harvard University, are also open to the student.

## "B" Subjects. Open to Graduates and Undergraduates.

<i>First Term</i>		<i>Second Term</i>		
12'211	Optical Crystallography . . . . .	4-1	12'42 App. Economic Geology . . . . .	2-1
12'25	Physical Crystallography . . . . .	3-2	12'44 Economic Geology of Fuels . . . . .	1-1
12'41	Economic Geology Lab. . . . .	6-2	12'61 Diastro. and Vulcan. . . . .	2-3
12'46	Economic Geol. of Non-Met. Dep. . . . .	3-3	12'80 Geol. Coal and Petroleum . . . . .	4-3
12'47	Micro. of Ores and Metals . . . . .	3-0	12'87 Intro. Geophy. Prospect. . . . .	2-2
12'48	Eng. Geol. and Hydrology . . . . .	3-2		
12'60	Structural Geology . . . . .	2-3		
12'86	Seismology, Elem. . . . .	2-2		

**XIII-A. NAVAL CONSTRUCTION****Course for Naval Constructors**

The Department of Naval Architecture and Marine Engineering offers to United States Naval Constructors a graduate course (XIII-A) of prescribed studies extending over three years, leading to the degree of Master of Science in Naval Construction. The complete curriculum is given below.

**Required during Summer 1933 (July 13 to September 6)**

M73 Review of Mathematics (Algebra, Plane and Solid Geometry, Trigonometry, Elementary Calculus, Differential Equations) . . . . . 20—0

**JUNIOR YEAR**

<i>First Term</i>		<i>Second Term</i>		
2'20	Applied Mechanics . . . . .	3—6	2'21 Applied Mechanics . . . . .	3—5
2'30	Materials of Engineering . . . . .	2—2	2.36 Testing Materials Lab. . . . .	2—1
13'01	Naval Architecture . . . . .	2—2	5'35 Applied Chemistry . . . . .	1—2
13'11	Theory of Warship Des. . . . .	4—13	8'07 Precision of Meas. . . . .	1—1
13'21	Warship Design . . . . .	5—0	13'02 Naval Architecture . . . . .	2—2
M36	Advanced Calculus . . . . .	3—6	13'12 Theory of Warship Des. . . . .	4—10
Units of exercise and preparation: 19—29		M37 Advanced Calculus . . . . .		3—6
		Units of exercise and preparation: 21—27		

**Required during Summer**

Work arranged by Postgraduate School

**SENIOR YEAR**

<i>First Term</i>		<i>Second Term</i>		
2'291	Theoretical Mechanics . . . . .	3—6	2'292 Theoretical Mechanics . . . . .	3—6
13'03	Naval Architecture . . . . .	3—3	3'432 Metallurgy . . . . .	2—1
13'13T	Theory of Warship Design . . . . .	3—6	13'14T Theory of Warship Design . . . . .	3—4
13'23T	Warship Design . . . . .	5—0	13'24T Warship Design . . . . .	5—0
13'58	Marine Engineering . . . . .	3—4	13'37 Merchant Shipbuilding . . . . .	2—2
Ec35	Political Economy . . . . .	3—5	13'48 Model Making . . . . .	1—0
	General Study . . . . .	2—2	13'64 Marine Engine Design . . . . .	4—0
Units of exercise and preparation: 22—26		Ec46 Industrial Relations . . . . .		3—5
		Memoirs . . . . .		0—3
		Units of exercise and preparation: 23—25		

**Required during Summer**

Work arranged by Postgraduate School

GRADUATE YEAR (For 1933-1934 only)

<i>First Term</i>		<i>Second Term</i>			
1'45	Structures . . . . .	3-6	1'46	Structural Design . . . . .	2-0
2'291	Theoret. Mechanics . . . . .	3-6	2'292	Theoret. Mechanics . . . . .	3-6
8'07	Precision of Measure . . . . .	1-1	13'14	Th. of Warship Des. . . . .	5-6
13'03	Naval Architecture . . . . .	3-3	13'24	Warship Design . . . . .	10-0
13'13	Th. of Warship Des. . . . .	6-9	16'78	Aeronautics . . . . .	3-5
13'23	Warship Design . . . . .	8-0		Thesis . . . . .	13
16'76	Aeronautics . . . . .	3-2		Units of exercise and preparation:	53
Units of exercise and preparation:		27-27			

GRADUATE YEAR (In effect 1934-1935)

<i>First Term</i>		<i>Second Term</i>			
1'451	Structures . . . . .	3-6	1'46	Structural Design . . . . .	2-0
2'031	Mechanism (special) . . . . .	5-0	1'452	Structures . . . . .	3-6
3'61	Metallography . . . . .	4-1	13'16	Theory of Warship Design	3-6
13'15	Theory of Warship Des. . . . .	3-6	13'26	Warship Design . . . . .	6-0
13'25	Warship Design . . . . .	6-0	L12	Elementary German . . . . .	3-5
16'76	Aeronautics . . . . .	3-1		Thesis . . . . .	13
Ec61	Business Law . . . . .	3-3		Units of exercise and preparation:	17-30
L11	Elementary German . . . . .	3-5			
Units of exercise and preparation:		30-22			

Note: (a) The General Study subject indicated in the second term will be a non-technical subject selected at a later date.

(b) Students who select the optional subject of Theory of Elasticity in first and second terms will omit memoirs and 3'612 Metallography in the first term and general study in the second term.

(c) Optional study of French may be substituted for L11 and L12 German.

(d) The subject of memoirs consists of the preparation of several technical articles, stress being laid on organization and form of article.

## DEPARTMENTS OF ECONOMICS, AND OF BUSINESS AND ENGINEERING ADMINISTRATION

The course leading to the Master's degree in Business and Engineering Administration is primarily designed for the engineering graduate who wishes to prepare himself for executive work in industry or trade. The graduate curriculum therefore requires some training in each of the major functions of business; production, marketing, finance, accounting, law, and labor relations. It also permits a certain latitude for more specialized work in one or more of these fields.

Instruction is carried on mainly through small group conferences, based on individual investigation and reading. Emphasis is placed on the development of analytical reasoning and sound business judgment.

Students who can satisfy prerequisites in undergraduate business and engineering subjects may obtain the Master's degree in one year. If only the engineering prerequisites are offered, the undergraduate business requirements usually may be met by attendance at the summer session preceding the graduate year.

Applications for advanced work in this field are expected only from students who in point of personality as well as intellect, show promise of success in administrative activities.

**Requirements for the degree of Master of Science.** In addition to the undergraduate requirements\* for the Master's degree common to all courses as stated on page 153, candidates should have taken a substantial amount of engineering subjects as prescribed in any one of the optional groups listed in the undergraduate course in Business and Engineering Administration. Candidates should also present evidence that they have had the equivalent of the following undergraduate subjects as prerequisites for graduate work:

Ec31, Ec33	Political Economy	Ec57	Corporate Finance and Investment
Ec37	Banking	Ec65	Statistics
Ec50	Accounting	Ec70	Business Management
Ec56	Corporations		

(Requirements in Ec56 and Ec57 are waived if the graduate student elects to take the "A" subjects, Financial Administration of Industry Ec581 and Ec582.)

Deficiencies in these subjects must be removed either in the preceding school year or in the summer school which precedes entrance upon graduate work.

\* M22 Differential Equations is not included as prerequisite for graduate work in this Department.

The following undergraduate subjects are also required, but as these are open to both graduate and undergraduate students, they may be elected in part as "B" subjects, in a program leading to a Master's degree:

Ec33 Current Econ. Problems	Ec62 Business Law
Ec46 Industrial Relations	Ec71 Business Management
Ec51 Industrial Accounting	Ec72 Business Management
Ec61 Business Law	Ec99 Industrial Problems

**GRADUATE SUBJECTS IN BUSINESS AND ENGINEERING ADMINISTRATION AND ECONOMICS**

**"A" Subjects. Primarily for Graduates.**

<i>First Term</i>		<i>Second Term</i>	
Ec39 International Finance . . . .	2-6	Ec472 Personnel Management . . .	3-5
Ec471 Personnel Management . . .	3-5	Ec522 Control through Bus. Rec. .	3-5
Ec521 Anal. of Bus. Statements . .	3-5	Ec582 Fin. Admin. of Industry . . .	3-5
Ec581 Fin. Admin. of Industry . . .	3-5	Ec592 Pub. Util. Reg. and Rates . .	2-4
Ec591 Pub. Util. Org. and Finance .	2-4	Ec662 Statistical Methods . . . . .	2-6
Ec661 Statistical Methods . . . . .	2-6	Ec682 Business Cycles . . . . .	3-5
Ec681 Business Cycles . . . . .	3-5	Ec762 Retail Marketing . . . . .	3-5
Ec751 Manufactur. Analysis . . . . .	3-5	Ec766 Advertising . . . . .	2-6
Ec761 Industrial Marketing . . . . .	3-5	Ec782 The Business Audit . . . . .	3-5
Ec781 Stand. Meas. in Indust. Man. .	3-5	Ec85 Govt. Control of Industry . . .	2-6
Ec90 Investment Analysis . . . . .	2-6	Ec91 Investment Analysis . . . . .	2-6
Ec95 Indust. Traffic Management . .	3-5		

**"B" Subjects. Open to Graduates and Undergraduates.**

<i>First Term</i>		<i>Second Term</i>	
Ec51 Industrial Accounting . . . . .	4-4	2982 Prep. for Manufacturing . . .	3-3
Ec61 Business Law . . . . .	3-3	Ec33 Current Economic Problems . .	2-4
Ec71 Business Management . . . . .	4-6	Ec46 Indust. Relations . . . . .	3-5
		Ec62 Business Law . . . . .	3-3
		Ec72 Business Management . . . . .	4-6
		Ec99 Industrial Problems . . . . .	2-4
		M54 Mathematical Laboratory . . .	3-5

## DEPARTMENT OF AERONAUTICAL ENGINEERING

Emphasis is laid upon individual study and research rather than upon formal classroom exercises. Each student must follow a consistent program of work directed toward some particular part of the aeronautical field such as aerodynamics, structures or power plants. Since most phases of the graduate work in Aeronautical Engineering rest heavily upon mathematics and mechanics, especial aptitude in these subjects is very desirable.

### Meteorology

A meteorological laboratory, including facilities for receiving weather reports and considerable equipment for observing and recording local weather conditions, is maintained as part of the Guggenheim Aeronautical Laboratory. Undergraduate preparation for this course is provided for in the Department of Physics. For students from other institutions, preparation in advanced physics and in German is a necessary prerequisite for graduate work. Details of these requirements will be furnished upon request.

### The Aeronautical Laboratory

All of the aeronautical equipment, except for the engine laboratory and the smallest of the three wind tunnels, is located in the Daniel Guggenheim Aeronautical Laboratory. This is a four-story building of ample proportions, housing not only laboratory and research facilities but also classrooms, conference rooms, and offices for the staff.

The principal aeronautical equipment consists of three wind tunnels, 4, 5 and  $7\frac{1}{2}$  feet in throat diameter respectively, each equipped with balances and the necessary auxiliary equipment for making tests of airplane models or any other objects which are to be submitted to a current of air moving at known speed. The large tunnel is capable of handling an airplane model 40 inches in span. The maximum wind speed attainable is 90 miles per hour in the  $7\frac{1}{2}$ -foot tunnel, 100 m. p. h. in the 5-foot tunnel, and 60 m. p. h. in the 4-foot tunnel.

In addition to the wind tunnels there is complete apparatus for testing various model forms in still air, by means of a carriage moving on inclined wires. A considerable amount of equipment for the preparation and testing of structural shapes is also available.

A laboratory for study and research in internal combustion engines is housed in a separate building containing the most up-to-date equipment for this purpose. Included in this equipment are a universal test engine of the N. A. C. A. type, a standard S. A. E. detonation rating engine and several single cylinder crank-cases capable of accommodating a wide variety of air-cooled and water-cooled cylinders. Considerable equipment for research in high-speed Diesel engines and a number of different types of high-speed engine indicators and superchargers are also available.

### Undergraduate Preparation

The preparation required for graduate work in Aeronautical Engineering is equivalent to that possessed by a graduate of the Massachusetts Institute of Technology in the undergraduate course in Aeronautical Engineering. With this preparation the candidate may reasonably expect to complete the requirements for the Master's degree in Aeronautical Engineering in one year. Graduates from other engineering courses at the Massachusetts Institute of Technology or from non-aeronautical courses in other accredited technical schools, may register as graduate students but will usually find it necessary to devote a considerable portion of their first year of residence to making up their deficiencies in undergraduate aeronautical subjects, with a second year of strictly graduate work.

Students who wish, primarily, formal instruction in Aeronautical Engineering subjects during a single year of residence are advised to register in the undergraduate course.

*Students entering either the graduate or undergraduate courses without previous training in Aeronautical Engineering are strongly advised to register in the summer session previous to their first term of residence, as by this means it is usually possible to reduce materially the total period of study required. It is particularly important that this summer program include subjects 1-401, 16-00, 16-02, M43 and M44 unless these already have been covered.*

In addition to the general requirements (see page 153), graduate students who desire to obtain the Master's degree in Aeronautical Engineering must offer the equivalent of the undergraduate courses which are listed below under Schedule I, if the degree with specification of field is undertaken, or under Schedule II, if the degree without specification is undertaken, or must take these courses during their first year of residence at the Institute. Exceptions or additions may be made in individual cases.

**SCHEDULE I****Not Counted as "B" Subjects.**

1'401 Structures (S)  
 2'12 Machine Drawing (S)  
 2'30 Materials of Engineering (S)  
 2'42 Engineering Thermodynamics (S)  
 16'00 Aerodynamics of Airplane Design (S)  
 16'52 Airplane Shopwork (S)  
 Intermediate French (S) or Spanish  
 Intermediate German (S)

**Counted as "B" Subjects.**

16'01 Airplane Design	16'62 Aeronautical Laboratory
16'02 Aircraft Structures (S)	M43 Theoretical Aeronautics (S)
16'13 Airplane Design Practice	M44 Theoretical Aeronautics (S)
16'55 Airplane Design	

**SCHEDULE II****Not Counted as "B" Subjects.**

1'401 Structures (S)  
 2'30 Materials of Engineering (S)  
 2'42 Engineering Thermodynamics (S)  
 16'00 Aerodynamics of Airplane Design (S)  
 Intermediate French or German (S) (Unless offered for Entrance)

**Counted as "B" Subjects**

16'01 Airplane Design  
 16'02 Aircraft Structures (S)  
 16'62 Aeronautical Laboratory

(Subjects marked (S) are usually offered during the Summer Session as well as during the regular academic year.)

## GRADUATE SUBJECTS

## "A" Subjects. Primarily for Graduates.

<i>First Term</i>		<i>Second Term</i>	
†2'255	Dyn. of Aircraft Engines.. 2-2	16'14	Airplane Des. Prac., Adv.. 6-0
16'06	Airplane Structures, Adv.. 3-6	16'22	Airship Structures..... 2-4
16'21	Airship Theory..... 2-3	16'26	Adv. Aeronautical Prob.Time arr.
16'26	Adv. Aeronautical Prob.Time arr.	16'30	Aircraft Propeller Design.. 4-4
16'35	Aircraft Instruments..... 3-3	16'69	Aeronautical Sem..... 2-2
16'73	Wing Theory, Adv..... 3-6	16'74	Wing Theory, Adv..... 3-6
16'921	Synoptic Meteorology.... 2-4	16'922	Synoptic Meteorology.... 2-4
16'931	*Dynamic Meteorology... 5-10	16'932	Dynamic Meteorology.... 5-10
16'941	*Meteorological Seminar.. 2-4	16'942	Meteorological Seminar... 2-4
			Thesis.... 20-40 hours per week

\* Required preparation not covered in Course XVI.

† For Naval Officers only.

## "B" Subjects. Open to Graduates and Undergraduates

<i>First Term</i>		<i>Second Term</i>	
16'01	Aerodyn. of Airplane Design 4-4	16'05	Airplane Structures..... 3-3
16'02	Aircraft Structures..... 2-2	16'08	Airplane Des. Prob..... 6-6
16'13	Airplane Des. Prac..... 8-0	16'55	Airplane Design..... 7-2
16'62	Aeronautical Lab..... 4-3	16'63	Aero. Lab. & Res. Methods 4-2
16'76	Aeronautics..... 3-1	16'76	Aeronautics..... 3-1
16'82	Int. Combustion Eng.... 4-3	16'78	Aeronautics..... 3-5
16'85	Airplane Eng. Des. Prac.. 8-0	16'84	Int. Combustion Eng.... 4-5
16'901	Introduct. Meteorology... 2-2	16'86	Airplane Eng. Des. Prac.. 8-0
16'921	‡Meteorological Lab..... 10	16'902	Aero. Meteorology..... 2-2
		16'922	‡Meteorological Lab..... 8
		16'95	Meteorological Inst. & Meth. of Observ..... 4-0

‡ Only 10 units in each term may be credited toward the Master's degree.

Students may also elect subjects, given in other departments, but bearing a useful relation to their program of aeronautical studies, Those specializing in aircraft design will, in general, be advised to take advanced work in materials and elasticity; those choosing aerodynamics as their field may advantageously take courses in advanced physics, while those chiefly interested in engines should supplement their aeronautical studies by work in physical chemistry and in dynamics. The selection of such courses is subject to approval of registration officer.

### DEPARTMENT OF MATHEMATICS

The Department of Mathematics offers courses leading to the degrees of Master of Science, Doctor of Philosophy and Doctor of Science.

The course of each student will be arranged in consultation with the Department from subjects mentioned below. A student who is interested in applied mathematics may also be allowed to select subjects offered in other departments. A candidate for the degree of Master of Science will be expected to offer the equivalents of M23, M24 Algebra and Geometry; M831, M832, M841, M842 Analysis; M441, M442 Geometry. Other work of advanced nature and equal time may be substituted for any of these courses.

To obtain the degree of Master of Science the student must elect in each term at least three courses of advanced mathematics or allied subjects, and fill the remainder of his time with other electives and thesis.

For the degree of Doctor of Philosophy the student must fill the requirements stated above for Master of Science with the exception of a master thesis and spend at least an additional year in research.

#### "A" Subjects. Primarily for Graduates.

<i>First Term</i>		<i>Second Term</i>	
M36	Calculus, Adv. . . . . 3-6	M37	Calculus, Adv. . . . . 3-6
M451	Four. Ser. & Int. Equations 3-9	M452	Four. Ser. & Int. Equations 3-9
M461	Theory of Numbers. . . . . 3-9	M462	Theory of Numbers. . . . . 3-9
*M551	Funct. of a Real Variable. . 3-9	*M552	Funct. of a Real Variable. . 3-9
M561	Funct. of a Complex Variable. . . . . 3-9	M562	Funct. of a Complex Variable. . . . . 3-9
M571	Differential Equations. . . . 3-9	M572	Differential Equations. . . . 3-9
M581	Continuous Groups. . . . . 3-9	M582	Continuous Groups. . . . . 3-9
*M631	Differential Geometry. . . . . 3-9	*M632	Differential Geometry. . . . . 3-9
M641	Differential Geometry, Adv. 3-9	M642	Differential Geometry, Adv. 3-9
*M651	Analytical Mechanics. . . . . 3-9	*M652	Analytical Mechanics. . . . . 3-9
M661	Algebra of Quant. Theory. . 3-9	M662	Algebra of Quant. Theory. . 3-9
*M671	Potential Theory. . . . . 3-9	*M672	Potential Theory. . . . . 3-9
*M681	Calculus of Variations. . . . 2-6	*M682	Calculus of Variations. . . . 2-6
M781	Geometry, Adv. . . . . 3-9	M76	Theory of Probability. . . . . 3-9
M791	Theor. and App. Elas. . . . . 2-6	M782	Geometry, Adv. . . . . 3-9
M90	Mathematical Reading. Time arr.	M792	Theor. and App. Elas. . . . . 2-6
	* Not offered 1933-34.	M90	Mathematical Reading. Time arr.

#### "B" Subjects. Open to Graduates and Undergraduates

<i>First Term</i>		<i>Second Term</i>	
M26	Least Squares. . . . . 2-2	M44	Theoret. Aeronautics. . . . . 6-4
M43	Theoret. Aeronautics. . . . . 6-4	M54	Mathematical Lab. . . . . 3-6
*M70	History of Science. . . . . 2-4		

\* Not offered 1933-34.

## DESCRIPTION OF SUBJECTS

### CIVIL AND SANITARY ENGINEERING

Subjects 1'00 to 1'99 (see page 74)

*The prerequisites for each subject will be found in the Tabulation.*

**1'00. Surveying.** An elementary course in the theory and practice of plane and topographical surveying. Textbook: *Breed and Hosmer's Principles and Practice of Surveying, Vol. I.*

**1'01. Surveying and Topographical Drawing.** A course in surveying consisting of fieldwork, computations and the making of scale drawings, profiles, contour maps, and conventional signs for topography, followed by a study of their application to the solution of engineering problems. Textbook: *Breed and Hosmer's Principles and Practice of Surveying, Vol. I.*

**1'02. Surveying.** A course in elementary surveying. Textbook: *Breed and Hosmer's Principles and Practice of Surveying, Vol. I.*

**1'04. Surveying.** At Camp Technology. The fieldwork consists of plane, topographic, hydrographic and elementary railway surveying. Plans and maps are made from notes taken in the field.

This subject satisfies the requirements in surveying for Courses II, III, IV-A, VI, VI-A, IX-B, XV<sup>ib,c</sup>. It will not be accepted in place of the work in surveying in Courses I, IV-B, VII, XI, XV<sup>1a</sup>, and XVII.

It will not be given unless eight or more students apply. Textbook: *Breed and Hosmer's Principles and Practice of Surveying, Vols. I and II.*

**1'041. Surveying.** At Camp Technology. The fieldwork consists of plane and topographic surveying, in which the transit, tape, level and plane table are used, the astronomical determination of the meridian, the adjustment of instruments and many important problems in surveying. Plans and maps are made from notes taken in the field (not accepted in place of 1'05 and 1'06 in Course I). Textbook: *Breed and Hosmer's Principles and Practice of Surveying, Vols. I and II.*

**1'042. Surveying.** At Camp Technology. Lectures, fieldwork and drafting. The theory and practice of plane and topographic surveying is taken up in the classroom and is supplemented by many problems. Field training is given in the use of surveying instruments. Specially designed for students in Course XVII. Textbook: *Breed and Hosmer's Principles and Practice of Surveying, Vol. I.*

**1'05. Plane Surveying.** At Camp Technology. 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. Textbooks: *Breed and Hosmer's Principles and Practice of Surveying, Vol. I; Hosmer's Practical Astronomy.*

**1'06. Geodetic and Topographic Surveying.** At Camp Technology. The fieldwork consists of the 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 and 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 (B).** At Camp Technology. Three weeks of field and office work. 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. (Elective for a limited number of students in Course I who have satisfactorily completed the third year.)

**1.10. Surveying.** At Summer Mining Camp, Dover, New Jersey. The fieldwork consists of plane, topographic, magnetic dip-needle, magnetometer and mine surveying. Plans and maps, both surface and underground, are made from the notes taken in the field. Discussions of surveying methods are 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. 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.*

**1.131. Geodesy (B).** An extended course in continuation of 1.13. The treatment of the mathematical theory of triangulation, geodetic instruments, the ellipsoid, the figure of the earth, gravitational methods, and leveling, is given in greater detail. Attention is given to the most recent practice in geodetic work in this country. Textbook: *Hosmer's Geodesy.*

**1.132. Geodetic Astronomy and Navigation (B).** Includes the theory and practice of astronomy as applied to the determination of astronomical positions and azimuths in a geodetic survey, and certain applications to celo-navigation. Textbooks: *Chauwenet's Spherical and Practical Astronomy; Hayford's Geodetic Astronomy.*

**1.133. Geodetic Laboratory (B).** Includes the comparison of standards of length, measurement of force of gravity with pendulums, determination of the magnetic elements, and the testing and calibration of various geodetic instruments.

**1.134. Adjustment of Observations (B).** Covers the principal methods of adjusting triangulation, leveling and astronomical observations by the method of least squares. Textbook: *Wright and Hayford's Adjustment of Observations.*

**1.135. Seismometry and Vibration Measurement (B).** Basic theory of free and forced vibrations with and without solid and fluid friction. Analytical treatment of behavior of various types of seismometers, accelerometers, frequency meters, etc., including methods of interpreting records of instruments. Attention is given to the fundamental principles of design of instruments and recording systems. Interpretation of earthquake records and effect of earthquakes on engineering structures.

**1.136. Vibration Problems (A).** Covers the available methods of solving the more complex problems in vibrations — step-by-step integration, the differential analyzer, model study, electrical network solution, Rayleigh and Rayleigh-Ritz methods, Lagrange's equations and Lagrange's general solution for  $n$ th order vibration equations. Non-harmonic vibrations are included. Analysis of structures under periodic forces and displacements. Particular attention is given to practical problems illustrating the application of the various methods and principles.

**1.138. Seismological Laboratory (B).** Includes the use and adjustment of seismometers and the determination of constants; also experiments on models and the interpretation of records.

**1.14. Advanced Geodesy (A).** Methods of developing the higher formulas for computing geodetic positions: the theories of potential and of the earth's fig-

ure; the application of least squares to geodetic surveys; and the theories of astronomical, magnetic and gravity observations. Textbook: *Jordan's Handbuch der Vermessungskunde* and *Clark's Geodesy*.

**1-15. Navigation.** Includes a study of the methods of using the compass, log, sextant and charts, the usual methods of navigating by dead reckoning (including Mercator and great-circle sailing), location of ships by astronomical observation for latitude and longitude, and by Sumner's method. Students will have practice in adjusting the compass, using the sextant and the charts.

**1-16. Aerial Surveying (B).** A study of the various methods of constructing maps from photographs for engineering purposes, and the methods of making topographic maps from vertical and from oblique photographs. A study is also made of the different methods of control of aerial surveys. The work covered is confined to the methods of producing the maps from the photographs, and does not take up the technical work of photography or of piloting.

**1-18. Map Reading and Topographical Drawing.** A study of the different conventional signs employed in making topographic maps. Each student is required to make a number of plates of conventional signs, and to solve problems relating to contour maps.

**1-181. Map Reading and Topographical Drawing at Camp Technology.** A study of map drawing and map interpretation. Includes the drawing of a topographical map from data taken in the field and the solution of problems illustrating the use of contour lines.

**1-20. Railway and Highway Fieldwork.** A complete survey including reconnaissance, preliminary and final location for a portion of a railway or highway; together with a systematic drill in laying out curves by different methods, setting slope stakes for earthwork and staking out masonry structures. A limited amount of class work is given to supplement the fieldwork. Textbooks: *Allen's Railroad Curves and Earthwork*; *Allen's Field and Office Tables*.

**1-21. Railway and Highway Curves.** A thorough study of the mathematics of curves with applications to location and property lines of railways, highways and waterways. Simple, compound, reversed, spiral and vertical (parabolic) curves are studied. Textbooks: *Allen's Railroad Curves and Earthwork*; *Allen's Field and Office Tables*.

**1-25. Engineering Construction (B).** Deals primarily with the construction of civil engineering works, such as railways, highways, water power, water supply and similar projects. The subjects covered are methods of computing earthwork and concrete volumes, quantity surveys, estimates and reports, contracts and specifications, methods of economic comparison, financing of engineering projects, engineering organization and duties, acquisition of land, and construction methods including clearing of the site, earth and rock handling, and construction of structures of concrete, steel and timber. Principles are illustrated by studies of typical projects.

**1-26. Railway Signaling (B).** Interlocking and block signals; and remote, centralized and automatic train control. Critical attention is given to the development of modern signaling practices with reference to the economics of train operation. The subject is illustrated by inspections of railway signal installations. Textbook: *Notes on Railway Signaling*.

**1-271, 1-272. Transportation Engineering (B).** Transportation by railway and highway with some attention to air and water transportation. Subjects treated include railway maintenance of way including turnouts and yards, highway location and pavement design and research, railway rolling stock and motor vehicles, economics of location illustrated by typical projects, traffic, and transportation surveys, highway traffic control, underlying principles of railway and highway operation, waterways, air transport, public relations and regulation including I. C. C. accounting, coordination of the different forms of transportation.

**1-28. Railway Design (B).** Problems in railway location, and the detailed design of a railroad yard including a locomotive terminal.

## DESCRIPTION OF SUBJECTS

**1'301, 1'302. Advanced Railway Transportation (A).** A continuation of the undergraduate courses in transportation engineering 1'271 and 1'272. It pertains to the design and operation of locomotive, freight and passenger terminals; use of motor transport; railway economics; public relations and control; and involves individual investigations and reports.

**1'31. Advanced Railway Design (A).** Design and analysis of railway terminals; elimination of grade crossings; and other problems adapted especially to students' requirements.

**1'32. Design of Harbor Works (A).** Includes the study of tides, currents, wave action, methods of shore protection, layout of channels and anchorage basins, size of ships; methods of making soundings, borings, pile driving, pile tests, wharf construction, dredging, land reclamation and other waterfront construction; design of wharves, bulkheads and similar structures; methods and equipment for cargo handling, study of preservative treatment of timber.

**1'35. Roads and Pavements (B).** 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. Physical and Chemical Testing of Highway Materials (B).** Tests of bituminous and non-bituminous highway materials with discussion of their relation to highway construction specifications. (The content of Chemistry of Road Materials 5'37 forms a portion of this subject.)

**1'371. Pavements and Highway Transportation (B).** Principles governing location, construction, and maintenance of roads and city pavements. A comprehensive study of state highways, highway financing, methods and analysis of transportation surveys, highway legislation, results of recent research, design of pavements, construction and organization methods, motor vehicle types and operating economics, snow removal, highway safety, city traffic problems.

**1'372, 1'373. Advanced Highway Transportation (A).** Study of research results and methods of design, construction, maintenance, operation and economics of highways.

**1'38. Highway Design (B).** A design for the improvement of an existing highway by substitution of improved alignment, grades and new pavement 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's 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. Theory of Structures.** A course covering outer forces, reactions, shears and bending moments, the use of influence lines, the three moment equation, torsion and bending on simple sections, the design of members subjected to flexure only, the analysis of trusses by algebraic and graphical methods and the design of simple columns. Textbook: *Niles and Newell's Airplane Structures*.

**1'41, 1'42. Theory of Structures (B).** 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. First term: roof and bridge trusses of various forms. Second term: 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 for students in Courses I, XI and XV<sub>a</sub>. 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 for students in Course IV-A. 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*.

**1'44. Stationary Structures.** 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, continuous beams, and the computation of deflection of beams and trusses. Textbook: *Spofford's Theory of Structures*.

**1'46. Structural Design.** Calculations and design drawings are made for a small steel truss highway bridge. Intended to illustrate and amplify the work of 1'45 by a practical design problem.

**1'48. Foundations (B).** A study of the methods of constructing foundations for bridges, buildings and other structures based on modern research in Soil Mechanics. Textbook: *Hool and Kinne's Foundations, Abutments and Footings*.

**1'491. Soil Mechanics (A).** A detailed study of those physical and mechanical properties of soil which govern its behaviour as an engineering material. Principles of soil classification; analyses of variations in structure and density; studies of the laws of permeability and capillarity; the quicksand phenomenon; compressibility, consolidation, intrinsic pressure, internal friction, cohesion, elasticity, plasticity; and correlation of these factors with problems in earth-work engineering. Textbook: *Mimeographed Notes*.

**1'492. Soil Mechanics (A).** Specific applications of modern soil research are considered on the basis of the physical studies of 1'491. Stability of slopes and retaining walls; bearing capacity and settlement of foundations; piles and pile groups; earth and masonry dams, with special reference to stability, seepage, and piping effect; highway subgrades; and special types of foundations. Textbook: *Mimeographed Notes*.

**1'501, 1'502. Bridge Design (B).** 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. Bridge Design (B).** Abridged from 1'501, 1'502 and especially adapted to the needs of students in I<sub>3</sub>.

**1'52. Structural Design.** Similar in character to 1'501, 1'502, giving only an outline of the subject.

**1'54. Structural Design.** Similar in character to 1'501, 1'502, giving only an outline of the subject.

**1'551, 1'552. Advanced Structural Design (A).** Supplements Advanced Structures and illustrates the applications of the principles there studied. The time is devoted to the design of statically indeterminate structures. The structures considered include tall buildings, arches of both the hinged and no-hinged type, continuous trusses and suspension bridges.

**1'561, 1'562. Advanced Structures (A).** An exhaustive treatment of the fundamental principles applying to the design of complicated structures of statically indeterminate types, such as suspension bridges, arches, continuous trusses, framed domes and frameworks of high buildings. The methods of least work,

slope deflection and deflections are all given thorough consideration. Several mechanical methods are also demonstrated. Textbooks: *Spofford's Theory of Structures*; *Mimeographed Notes prepared by Professor Spofford*; *Textbooks by various American and German authors*; *Monographs and Professional Papers*.

**1'57. Secondary Stresses (A).** The investigation of the various sources of secondary stress in trusses, the computation of the secondary stresses in a number of simple trusses and the study of methods of design which will eliminate excessive secondary stresses.

**1'581, 1'582. Reinforced Concrete Design (A).** Theoretical and practical principles involved in the design of structures of reinforced concrete. First term: 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. Second term: (a) an investigation of bending moments in reinforced concrete structures by exact methods, such as those of least work, slope deflections, etc.; (b) a discussion of professional papers concerning current developments in the design of concrete structures. Textbook: *Sutherland and Clifford's Reinforced Concrete Design*.

**1'60. Hydrographic Surveying.** At Camp Technology. (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. 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.** The elementary principles of Hydrostatics and Hydrodynamics, including the laws governing static and dynamic pressure, and the flow of water through orifices, tubes, nozzles, weirs, pipe lines and open channels. Special attention is given to the laws of hydraulic friction and accompanying losses; to the practice of water measurement in pipes and open channels; and to such important occurrences as back water in channels, the hydraulic jump and water hammer. 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 subjects of flow in open channels and the dynamics of streams are abbreviated. Textbook: *Russell's Hydraulics*.

**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 development. Textbooks: *Russell's Hydraulics and Daugherty's Turbines*.

**1'65. Hydraulic Machinery.** A consideration of the theoretical principles of hydraulic turbines and centrifugal pumps together with a consideration of the performance and practical selection of these machines.

**1'66. Advanced Hydraulics (A).** An elaboration of subjects fundamentally treated in 1'62 and, in addition, studies in the advanced field of theory and practice. Special treatment of pipe flow (including air, water and oil), the alternate stages of flow in open channels, design of transitions, the hydraulic jump, laws of hydraulic similitude and model experimentation are among the subjects included. Reference books: *Russell's Hydraulics*; *Gibson's Hydraulics*, and *Professional Papers*.

**1'67. Design of Masonry Dams (A).** Principles underlying the design of different types of masonry dams, with emphasis upon their structural analysis by the trial load method developed by the United States Reclamation Bureau to eliminate discrepancies between measured and computed data, particularly in larger structures, such as Hoover dam. Straight gravity dams, arched gravity dams, arched dams, and multiple arched dams are among the types considered.

**1'68. Theory of Hydraulic Models (A).** Presents the principles of dimensional analysis and the laws of hydraulic models, and considers various completed model studies.

**1'691. River Hydraulic Laboratory (A).** Instruction in the construction of models for river hydraulic experiments, in the method of making such experiments, and in the interpretation of the results thereof. Registration for the subject is limited in accordance with the number of models available in the laboratory.

**1'692. River Engineering (A).** A study of the hydraulic principles governing rivers, followed by a consideration of methods for their regulation.

**1'70. Water Power Engineering (B).** This subject and 1'71 treats of the problems involved in the location, design and construction of hydro-electric developments as a foundation for practice in this field, or for the advanced studies of the graduate year. The subjects include a thorough study of hydrology: precipitation, run-off, water losses and their relations; the analysis of stream flow data as a basis for estimates of water power, flood flow, storage and pondage problems, followed by the theory and practice of hydraulic turbines and general plant arrangement. Textbook: *Barrows' Water Power Engineering*.

**1'71. Water Power Engineering (B).** 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 (A).** These subjects are supplemented by subjects 1'851, 1'852 and include the study and design of the various portions of some water power project at a site where actual data are available from surveys and reports. Other general problems of power development are also considered, with their basic theory and practice. A field trip of several days' duration to examine typical power and storage developments is included. Textbook: *Barrows' Water Power Engineering*. Reference Book: *Creager and Justin's Hydroelectric Handbook*.

**1'75. Hydraulic and Sanitary Engineering (B).** The first eleven weeks are devoted to a comprehensive study of the principles of water supply engineering, which includes rainfall and run-off, consumption of water, surface and ground water supplies, dams and impounding reservoirs, supply and distribution works, principles of treatment of water and design of treatment works. Opportunities for group inspection of nearby treatment works are included and a limited number of students may be permitted to receive several days' instruction in the operation of the water treatment plant of the City of Providence. The last four weeks are devoted to a study of the principles of design of sanitary sewers and storm drains, including methods for estimating the quantity of sewage and storm water run-off. Textbooks: *Babbitt and Doland's Water Supply Engineering*; *Metcalf and Eddy's Sewerage and Sewage Disposal, a Textbook*.

**1'76. Sanitary Engineering (B).** A continuation of 1'75 covering the principles of design and construction of sewage collecting systems and appurtenances, the principles of sewage treatment and the design and construction of treatment works. Opportunities are offered for group inspection of nearby sewage works and a limited number of students may be permitted to receive several days' training in the operation of the sewage treatment plant of the City of Worcester. Textbook: *Metcalf and Eddy's Sewerage and Sewage Disposal, a Textbook*.

**1'78. Sanitary Engineering (B).** A continuation of 1'75, covering in more detail the subject matter of 1'76 and in addition thereto the elements of disposal of industrial wastes and municipal refuse and garbage. Opportunities are offered for group inspection of nearby sewage works and may be offered for several days' training in the operation of the City of Worcester sewage treatment plant. Textbook: *Metcalf and Eddy's Sewerage and Sewage Disposal, a Textbook*.

**1'79. Hydraulic and Sanitary Design (B).** The design of a sanitary intercepting sewer for a small community followed by the design of a system of storm drains for a small area.

**1'801. Sanitary Design (B).** An investigation for and report on a gravity water supply for a small community.

**1'802. Sanitary Design (B).** The same as 1'79 followed by the design of a sewage treatment plant for the community.

**1'811. Advanced Sanitary Engineering (A).** A comprehensive study of the principles of modern water treatment engineering, including coagulation, sedimentation, filtration, sterilization, softening, corrosion, and removal of tastes and odors. Opportunities are offered for group inspection of nearby treatment works and may be offered for several days' training in the operation of the water treatment plant of the City of Providence. Textbooks: *Notes prepared by Professor Camp and textbooks and professional papers by various authors.*

**1'812. Advanced Sanitary Engineering (A).** A comprehensive study of the principles of modern sewage treatment engineering, including screening, removal of grit, sedimentation, removal of colloids and stabilization by contact surfaces and by aeration with activated sludge, chlorination of sewage, digestion, treatment and disposal of sludge, and collection and utilization of gas. Opportunities are offered for group inspection of nearby sewage works and may be offered for several days' training in the operation of the sewage treatment plant of the City of Worcester. Textbooks: *Notes prepared by Professor Camp and textbooks and professional papers by various authors.*

**1'851, 1'852. Advanced Water Power Design (A).** For description see Advanced Water Power Engineering 1'731, 1'732.

**1'881. Advanced Sanitary Design (A).** The design of a modern water treatment plant to effect the proper treatment of a given water to be used for domestic and industrial consumption. Conducted in parallel with 1'811.

**1'882. Advanced Sanitary Design (A).** The design of a modern sewage treatment plant to effect the proper treatment of a given raw sewage. Conducted in parallel with 1'812.

The following subject is offered as a General Study. For description of subject see Division of General Studies.

**G10. Development of Transportation (B).**

## MECHANICAL ENGINEERING

Subjects 2'00 to 2'99 (see page 74)

*The prerequisites for each subject will be found in the Tabulation.*

**2'00. Applied Kinematics.** A study of the laws of motion, including velocity and acceleration as applied to bodies whose motion is controlled by "mechanical means."

Velocity treated as a vector quantity. Determination of velocities of various points in a chain of connected pieces by both graphical and algebraic methods. Some work along the same lines with acceleration.

Transmission and modification of motion from one piece to another: (a) By direct contact. Illustrated by study of gear tooth action, cam action, etc. (b) By a rigid intermediate connector. Illustrated by studying a variety of linkages. (c) By a flexible intermediate connector. Illustrated by belt, rope or chain, etc.

Resultant motion derived from two independent sources. Illustrated by epicyclic gear trains, certain types of pulley blocks, etc.

A limited amount of work in connection with the motion of a body whose points move in non-parallel planes.

The subject is taught by lectures and informal discussions in the classroom, home study and solution of typical problems and a two-hour period each week in the drafting room, under supervision, employing graphical methods of investigation and solution. Textbook: *Elements of Mechanism, Schwamb, Merrill and James.*

**2'03. Mechanisms.** Combines 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 representative machine are made, together with sufficient drawing lay-out to show the design of the frame casting, and the relation of the parts. Certain problems in automotive design are also included.

**2'04. Mechanical Engineering Equipment.** A description of the construction and mechanical operation of power plant machinery exclusive of boilers and the immediate accessories of a steam boiler. It covers the steam engine and turbine with their valve gears and governors and the auxiliary equipment and accessories necessary for their operation. In addition to the machinery used for power generation such machines as air compressors, pumps, steam steering gears, etc., are studied and a description of internal combustion engines is given. Textbook: *Power Plant Machinery, Vols. I and II, James and Dole, or Elementary Steam Power Engineering, Mac Naughton.*

**2'05. Mechanism of Machines.** 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. Principles involved in the construction of alignment charts are included. Textbooks: *Notes and Lithographs, Mechanical Engineering Department; The Construction of Alignment Charts, Swett.*

**2'06. Mechanism of Machines (B).** Lectures and recitations of 2'05, omitting the lectures on alignment charts.

**2'07, 2'08. Automatic Machinery (A).** 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).** 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 applied kinematics, 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 and Sloane; Elements of Mechanism, Schwamb, Merrill and James.*

**2'102. Mechanical Engineering Drawing.** Modification of 2'10 involving the graphical study of motions and forces. Textbook: *Working Drawings of Machinery, James, Mackenzie and Sloane.*

**2'12. Machine Drawing.** An abridgment of 2'13. Textbooks: *Working Drawings and Machinery, James and Mackenzie and Sloane.*

**2'13. Machine Drawing.** Instruction and practice in the production and use of working drawings, including layout, detail, and assembly drawings. Problems are also included which involve the methods of graphic statics. Lectures are also given on drafting-room practice and 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 and Sloane.*

**2'15. Applied Mechanics (Statics and Dynamics).** Analysis of force systems in two and three dimensions by analytical and graphical methods; the laws of equilibrium; distributed forces; components of stress; centers of gravity; moments of inertia and products of inertia; dynamics of translation including momentum, energy, work and power; the application of the principles of statics to the determination of stresses in simple frames. Textbook: *Applied Mechanics, Vol. I, Fuller and Johnston.*

**2'20. Applied Mechanics (Strength of Materials).** The physical properties of materials; the common theory of bending, including shearing forces and bending moments, the distribution of normal and shearing stresses, the equation of the elastic curve and the determination of slopes and deflections in beams; eccentric loading; stresses due to combinations of axial and transverse loads; theories for determining the strength of columns; the theory of torsion of circular bars; particular emphasis being placed on the application of these theories in the solution of engineering problems. 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, and cylinders; analytical and graphical solutions of some more advanced problems in dynamics, statics and strength of materials including the theory of continuous beams. Textbook: *Applied Mechanics, Vols. I and II, Fuller and Johnston.*

**2'22. Applied Mechanics.** The study of some of the more advanced problems in engineering dynamics including the determination of stresses due to inertia in moving parts of machinery; also, the 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.*

**2'231. Mechanics.** An elementary course especially arranged for the students in Course IV, including a study of the fundamental principles of statics with applications in analytical and graphical solutions for stresses for simple frames and trusses. The determination of centers of gravity and moments of inertia of plane areas. Textbook: *Applied Mechanics, Vol. I, Fuller and Johnston.* (For 1933-34 only.)

**2'232. Mechanics.** A continuation of Course 2'231 especially arranged for students of Course IV. Includes the definitions and relations of the physical properties of materials, simple problems in tension, compression and shear, the common theory of beams, with applications, the analysis of stresses and columns and simple problems in combined bending, and axial loading. Textbook: *Applied Mechanics, Vol. II, Fuller and Johnston.* (For 1933-34 only.)

**2'232T. Elementary Structural Mechanics.** An elementary course especially arranged for the students in Course IV. It includes a study of the fundamental principles of statics, using both analytical and graphical solutions for the determination of the stresses in simple frames and trusses. Formulae are derived for use in figuring the centers of gravity and moments of inertia of plane areas.

**2'233, 2'234. Structural Mechanics.** An elementary course in strength of materials especially arranged for students in Course IV. Deals with the physical properties of materials, simple problems in tension, compression and shear, the common theory of beams, stresses in columns, etc. The course also includes a few exercises in the testing materials laboratory. (In effect 1934-35.)

**2'251. Dynamics of Machines (B).** 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. This course includes also a study of dynamometers for the measurement of power.

**2'254. Dynamics of Engines (A).** Lectures and drawing-room exercises on the inertia forces and the stresses in the running parts of high-speed gasoline engines. Application is made chiefly to the types of engines used in automobiles.

**2'255. Dynamics of Aircraft Engines (A).** An advanced course given to students having considerable knowledge of engine balancing and practical experience with aircraft engines.

**2'256. Dynamics of Rotation (A).** A study of inertia effects in bodies rotating about axes whose directions are changing. Designed for application to gyroscopic control devices. (Open only to students in the courses in Torpedo Design.)

**2'26. Mechanics of Engineering (B).** 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, vibrations in high speed machinery, dynamic balancing, 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. Includes the solution of a considerable number of problems illustrating the application of the theory as developed.

**2'281, 2'282. Advanced Mechanics and Theory of Elasticity (A).** 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 and torsion, stresses in plates, stresses and strains in rotating shafts, cylinders and discs, the design of compound cylinders, temperature effects, vibration, etc.

**2'285. Photoelasticity.** A combined lecture and laboratory course on the analysis of elastic problems by means of the photoelastic method, based upon the temporary double refraction of transparent materials when stressed. The laboratory work includes the solution of well-known classical problems for instruction in the method followed by original research on particular engineering problems suggested by the students or members of the staff. The problems are discussed from a theoretical point of view in lecture or conference hours.

**2'291, 2'292. Theoretical Mechanics (A).** The fundamental principles of statics and dynamics.

**2:295. Applied Hydrodynamics (A).** The continuous medium, compressible and incompressible, viscous and ideal fluid. Absolute and relative streamlines; path lines; steady and unsteady flow; continuity; rotational and irrotational motion, velocity potential. Euler's equations. Applications: Flow in open and closed streams; theory of airplane propellers, turbines. Conformal transformation applied to the study of plane motion; theory of waves; Laminar and turbulent flow. Laws of similitude; secondary motion generated by the influence of skin friction.

**2:296. General Theory of Hydraulic Turbines and Pumps (A).** The modern types; the flow through a turbine as a periodically steady one; simplification and restriction to a unidimensional theory; torque and axial thrust; equation of energy; operating conditions. Discussion of best design for different specific speeds; laws of similitude and theory of model tests; supplementary treatment with respect to a finite number of blades; discussion of cavitation.

**2:297. Laminar and Turbulent Flow.** A continuation of 2:295 with special attention to laminar and turbulent flow.

**2:30. Materials of Engineering.** The manufacture and physical properties of alloys, iron, steel, plaster, lime, cement, brick, timber and other engineering materials. Attention is given to the relationship between constitution and physical properties of materials in general with reference to the effect of change of composition, hot and cold work and heat treatment upon the properties of metals. One of the objects is to give instruction that will enable the student to draw up and interpret specifications for common materials. Textbook: *Materials of Construction, Mills.* (Fourth edition.)

**2:301. Materials of Engineering.** 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.*

**2:32. Applications of Photoelasticity.** Offered for Army and Navy officers only. A combined lecture and laboratory course on the analysis of elastic problems by means of the photoelastic method, based upon the temporary double refraction of transparent materials when stressed.

**2:331. Engineering Metals (B).** Deals with the mechanical properties, structural characteristics and industrial applications of metals and alloys with respect to their engineering significance, the effects of high and low temperatures, repeated stresses, wear resistance, corrosion resistance, etc. Textbooks: *Metals Handbook and Current Technical Publications.*

**2:332. Engineering Metals Problems (A).** Conferences, reports and discussions as outlined for 2:331 with the addition of comprehensive laboratory problems of similar nature. Textbooks: *Metals Handbook and Current Technical Publications.*

**2:35. Testing Materials Laboratory (B).** Covers all of the work given in 2:36 together with the testing of fabrics, the macroscopic examination of metals and the study by means of the photoelastic method of the stress distribution in transparent members. 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. The first part is of routine nature and is common for all students. The last part is varied for the different courses to adapt the work to their needs. 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. Instruction is supplemented by excursions to concrete jobs, concrete products companies and central mixing plants.

**2:363. Testing Materials Laboratory (Concrete).** A brief study of the selection of materials and methods of proportioning concrete mixtures. The

strength, durability and economy of the mix is studied from the contractor's point of view. Methods of field control and factors affecting the quality of the concrete are particularly stressed.

**2'38. Physical Testing of Metals.** A practical manipulative course primarily adapted to the needs of those engaged in the sale, purchase or use of metals. It includes the routine of tensile and hardness tests; the determination of elastic properties; and the proper use of machines and measuring devices. Both ferrous and non-ferrous metals will be studied.

**2'391. Reinforced Concrete Design (B).** Covers by lecture and problem work the design of reinforced concrete floor systems, columns and footings. Special attention is given to the consideration of costs and economical design. Textbook: *Concrete Engineer's Handbook, Hool and Johnson.*

**2'392. Reinforced Concrete Design (B).** A continuation of 2'391 consisting of the complete design of a typical cross-section for a building, including flat slab and ribbed floor systems, also simple and combined footings. Lectures and problems cover moments at beam and column connections.

**2'393. Reinforced Concrete Design, Advanced (A).** 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 (A).** 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. Includes a discussion of economical considerations, cost keeping, and the writing of specifications.

**2'40. Engineering Thermodynamics.** The laws of thermodynamics with their applications to engineering problems; physical properties of gases and saturated and superheated vapors — especially of air and steam; ideal and actual cycles of hot air and internal combustion engines. The fundamental laws governing the flow of fluids with application to orifices and nozzles. The student learns to use the equations, vapor tables and diagrams, through independent solution of problems. Textbooks: *A Standard Textbook on Thermodynamics; The Temperature Entropy Diagram, Berry; Steam Tables.*

**2'41. Boilers and Engines.** Description of different types of boilers, mechanical stokers, fuels and their combustion, conveyors, super-heaters, feed-water heaters, economizers, traps and various accessories of steam boiler plants. Textbook: *Gebhardt, Steam Power Plant Engineering.*

**2'42. Engineering Thermodynamics.** A continuation of 2'40. Completes a discussion of flow of fluids and applications to the steam turbine; a discussion of the efficiency of the ideal and actual reciprocating steam engines. Consideration is also given to air compressors, humidity and air conditioning, cooling towers and other engineering problems. Textbooks same as for 2'40.

**2'43. Refrigeration (B).** 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.

**2'46. Heat Engineering.** Study of valve gears which are treated and designed by both the Reuleaux and Zeuner methods; the laws of thermodynamics and the application of the laws shown by application to engineering problems; 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. Textbook: *Notes on Heat Engineering Prepared for Class.* Reference Books: *Any standard treatise on Thermodynamics; Mechanism of the Steam Engine, James and Dole; Power Plant Machinery, Vol. II, James and Dole; Steam tables.*

**2'461. Thermodynamics.** Series of lectures covering thermodynamics of perfect gases, saturated superheated steam, air compressors, refrigerating machinery, variation of actual gases from perfect gases together with some applications of thermodynamics to engineering problems.

**2'47. Heat Engineering.** A continuation of 2'46. 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. Text-books: *Notes prepared for class*. Reference Books: *Any standard treatise on thermodynamics; Gebhardt's Steam Power Plant Engineering*.

**2'49. Refrigeration (B).** A thermodynamic study of complicated systems of compression and absorption refrigeration of the properties of various brine solutions, of problems encountered in the manufacture of ice, and in other applications of mechanical refrigeration, and a discussion of the effects of bacteria, molds and fungi upon the spoilage of foods.

**2'491. Refrigeration.** Lectures on the types and applications of refrigerating machinery similar in character to 2'49 but less theoretical.

**2'501. Advanced Refrigeration (A).** Use of various equations of state, van der Waals, Dieterici, Keyes, reduced forms, etc., with special application to the liquefaction of air. Thermodynamics of mixtures of gases and vapors with applications to the absorption refrigerating systems and to the separation of gaseous mixtures.

**2'502. Advanced Heat Transmission (A).** The variations of surface coefficients, conductivities, etc., under varying conditions; laws of heat transmission as illustrated in steam condensers, feed water heaters, brine coolers, radiators, steam boilers, engine cylinders, cooling of castings, freezing of ice, etc. It includes the application of Fourier's series of cases involving fluctuating temperature conditions.

**2'504. Refrigeration Engineering (A).** A discussion of various problems arising in the applications of refrigeration to science, engineering and industry. Students prepare and present papers on special topics.

**2'505. Storage and Transportation of Foodstuffs (A).** A study of warehouses, precooling plants, refrigerated cars, trucks, and ships, their insulation and refrigerating equipment. Dry ice shipments, freezing processes, refrigeration load, temperature and humidity conditions required with various products, legal aspects of industry, food laws, relationship between industry and society.

**2'506. Design of Refrigerating Plant (A).** Study of economic needs of a locality. Design of plant to meet industrial needs; layout, insulation, walls, doors, windows, etc. Calculation of refrigeration load and amount of cooling surface. Location of coils, ventilating ducts. Humidity. Design of power plant.

**2'51. Torpedoes (A).** 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 (B).** From a given load curve and from a chart showing the demands for steam used for industrial purposes a complete assembly drawing of a power house is made, the assembly drawing being in sufficient detail to enable one to construct working drawings from it. The work consists largely of calculations combined with drawing room work. The cost of the plant is estimated as is also the cost of operation. Textbook: *Power Plant Design by Miller and Holt*.

**2'581. Power Plants Advanced (A).** An advanced course on modern power plants, including a study of the design and installation of high pressure boilers, economizers, air preheaters, modern fuel burning furnaces and automatic combustion controls. The various steam cycles and types of auxiliary drive will be

studied to show their effect on station heat balance. Includes discussion of deaerators, evaporators, condensers, heaters, etc., including turbine and machinery foundations and layouts. Lectures and problems will be supplemented by trips.

**2'59. Mechanical Equipment of Buildings, Heating and Ventilation.** Elementary principles of the thermodynamics of gases and steam with their application to the equipment of a building; principles and practice of heating and ventilation; discussion of the various other mechanical equipment of a building, such as elevators, dust collecting systems, etc. Fifteen hours are given over to trips. Textbook: *Heating and Ventilation*, by Allen and Walker.

**2'591. Advanced Heating and Ventilation (A).** A complete study of the various types of heating and ventilation systems to include principles of design, type of building for which adapted, methods of control, etc.

**2'592. Heating and Ventilation Design (A).** The choice of type of heating and ventilating system for a particular building, layout of piping and duct system, together with complete calculations and estimation of cost. An investigation and study of existing plants will be made with trips to these plants whenever possible to bring out the practical problems involved in design.

**2'593. Air Conditioning (A).** A complete study of the fundamental laws of Air Conditioning underlying the psychrometric and comfort charts together with application of these charts to air conditioning problems. Typical air conditioning equipment and humidity controls will be studied in detail together with their application to various types of problems.

**2'594. Refrigeration and Air Conditioning Laboratory (A).** Experiments with various refrigeration systems including the application of heating and refrigeration to air conditioning apparatus. Research problems.

**2'595. Mechanical Equipment of Buildings.** Abridgment of 2'59.

**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 steam by orifice, a steam engine test and a test on a single stage air compressor. Hydraulic experiments include flow measurements by orifice, nozzle, Pitot tube, Venturi meter and weirs. A short course on gas and fuel analysis is given as part of this subject.

**2'602. Engineering Laboratory (B).** A continuation of 2'601, involving the testing of larger units including a test of a boiler plant and a few tests on internal combustion engines. More complete and detailed reports of the tests are required than in the previous subject. Six laboratory exercises on heat measurements are given as a part of this subject.

**2'603. Engineering Laboratory.** A continuation of 2'601. More complete investigations of the performance of some of the larger equipment are made including a test on one of the turbines in the power plant. Some practice is given in the treatment of boiler feedwater, also in heat transfer by low temperature radiation and convection.

**2'611. Engineering Laboratory.** An experimental subject teaching the use of various instruments used for testing power machinery preparatory to the subsequent laboratory subjects. 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. Equivalent to the first half of 2'601.

For Courses taking no subsequent Engineering Laboratory some exercises of a more advanced type are included.

**2'612. Engineering Laboratory.** A continuation of 2'611. Tests are run on steam engines, pumps and fans. 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. Equivalent to the second half of 2'601.

**2'614. Engineering Laboratory.** Covers the same ground as 2'601 but less complete reports are required.

**2'615. Engineering Laboratory.** A continuation of 2'612 or 2'614. Part of 2'602 including a test on a steam boiler plant.

**2'62. Engineering Laboratory.** Similar to 2'601 but exercises on internal combustion engines are taken instead of gas and fuel analysis.

**2'621. Engineering Laboratory.** Covers part of 2'62.

**2'622. Engineering Laboratory.** Similar to 2'621.

**2'63. Engineering and Hydraulic Laboratory.** Use of instruments required for testing steam and hydraulic machinery; some practice in conducting tests on such machinery.

**2'631. Engineering and Hydraulic Laboratory.** Similar to 2'63 but more time is devoted to hydraulic experiments.

**2'64. Refrigeration Laboratory (B).** A general experimental course on refrigerating machines and heat transmission. The equipment consists of compression and absorption types and includes small commercial and domestic units using ammonia, sulphur dioxide and methyl chloride refrigerants. A constant temperature room is made use of in the testing of household units together with recording devices for power and temperature measurements.

**2'66. Automobile Laboratory (B).** 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 (B).** 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 operations, 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 (B).** 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. Study of distribution and combustion characteristics by exhaust gas analysis. Effect on engine performance of changes in cooling, lubrication, carburization, and ignition systems studied. Investigations of detonation, distribution, vibration, etc., conducted. Effect of various adjustments and use of accessories on engine performance obtained. Textbook: *Manufacturers 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 (A).** Fifteen hours devoted to lectures and recitations. Sixty-five hours given to testing of motor vehicles. Performance of motor vehicles studied in laboratory and on road. Riding comfort, braking ability, fuel mileage, oil consumption, effect of various accessories on performance, etc., investigated. 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. Automotive Engine Laboratory (B).** Engine mounting, couplings, fuel measuring devices, power measuring devices and instruments used in engine testing. Exhaust gas analysis. 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, Test Forms, etc.*

**2'691. Automotive Engine Laboratory (B).** Lectures on fundamentals of gasoline engine construction, design, and operation. Study in the laboratory of automotive engines and their parts. Short engine tests are conducted to familiarize the student with engine performance and operation of engines and to give experience in handling test apparatus. Textbook: *Manufacturers and Government Handbooks and Reports.*

**2'70. Machine Design.** Typical problems in machine design which may be solved by the application of the principles of statics. Calculations and drawings for the design of one of the simpler machines in which the stresses are statically determinate. 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.*

**2'71. Machine Design (B).** 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.

**2'721. Machine Design.** A discussion of the principles underlying the design of machine elements, including fastenings, shafting, bearings, belting, gearing, balance wheels, etc. Particular emphasis is laid on the proper choice of materials, methods of manufacture, and rational methods of design. Illustrative problems are assigned for solution in the drawing room.

**2'722. Machine Design.** An extension of 2'721 taking up more advanced problems and the complete analysis and report on a production machine.

**2'741. Machine Design, Advanced (A).** A systematic application of the principles of applied mechanics to the design of machines of complicated character. The subjects of centrifugal effects, balancing, lubrication and combined stresses are treated at considerable length. Textbook: *Library research.*

**2'742. Machine Design, Advanced (A).** 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.*

**2'761. Machine Design (A).** 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 (A).** 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 (B).** Lectures and drawing-room exercises in the design of reciprocating engines of stationary type 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 (B).** Problems involved in the organization of a modern manufacturing plant and the planning, construction and equipment of the buildings required: (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.

**2-782. Industrial Plants (B).** An extension of 2-781 with special reference to the design of the structures. The design of a brick and a reinforced concrete factory is included in this course.

**2-79. Gasoline Automobile (B).** Covers the general principles of gasoline automobile construction and operation. Includes the study of 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 (A).** Fundamentals of automotive engineering are the bases of this course — engines and chassis; theoretical considerations of the general principles governing the action and design. Study is made of all important parts; and procedure of design is outlined.

**2-811, 2-812. Automotive Design (A).** 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.

**2-850. Automatic Machinery (B).** 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, labeling 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 (B).** Study of fire-proofing and fire-protective apparatus. The erection, installation and operation of protective devices of all kinds. A number of problems are worked out showing how modern shops and mills may be safeguarded against fire in the most effective manner. Textbook: *Library reference — Notes prepared for class.*

**2-853. Locomotive Engineering (B).** 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 (B).** Description and discussion of the general principles of construction of the mechanical equipment of large buildings, including elevators, pneumatic systems of dust collection, water supply systems, water-heating systems, sewage disposal, etc.

**2-855. Steam Turbine Engineering (B).** Different types of modern steam turbines. 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. Textbook: *Church, Principles of Steam Turbines.*

**2-858. Inspection Methods (B).** 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.*

**2-87. Textile Engineering (B).** 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 is calculated and designed to fit the requirements. Textbook: *Notes prepared for class.*

**2-871. Textile Laboratory.** This subject embraces ninety hours of special work in the Textile Laboratory, including investigations, tests and researches in the physical properties of various textile fibres, yarns and fabrics, or may be devoted to advanced work in textile microscopy. Textbooks: *Laboratory Notes and Library References.*

**2-872. Design of Cotton Machinery (A).** The determination of stresses existing in the fundamental parts of cotton working machines. The analyses of the velocities, especially those of a variable nature, in the twisting and winding mechanisms of spinning and roving machinery. The study of gears, ball and roller bearings, belts, chains and speed cones, and the design of their application to the various elementary parts of textile machinery.

**2-873. Design of Wool Working Machinery (A).** Woolen and worsted machinery with particular reference to the determination of stresses and velocity relationships in the mechanism employed in carding, condensing, spinning and finishing processes.

**2-874. Dynamics of Textile Machinery (A).** A study of the inertia forces present in high speed reciprocating and rotating textile machinery with especial reference to the effect of the same upon manufacturing structure, and upon the accuracy of the machine's product. Textbook: *Hanton, Mechanics of Textile Machinery.*

**2-875. Textile Technical Analysis (A).** A study of the complete analysis of a given woven fabric determining throughout its physical properties, weight, yardage, absorptibility, porosity, tensile strength, elasticity, thickness, "off-square" and yarn properties, together with the determination of the necessary machinery to manufacture the fabric.

**2-876. Principles of Fabric Structure (A).** Construction of felted, woven, knitted and braided fabrics, together with a description of the machines employed. Includes felting machinery; automatic, box, dobby head and jacquard looms with the analyses of typical weaves; circular, warp and jacquard knitting machines; and the principles of operation of braiding machines. Textbook: *Notes prepared for class.*

**2-877. Textile Microscopy (B).** A study of the application of optical and microscopical equipment to the technical analysis of textiles. Lectures and laboratory cover the types of equipment, their use and the technique of textile micro-analysis for fibre, yarn and fabric. Textbook: *Library references.*

**2-88. Ordnance Engineering (B).** Lectures and calculations on gun design, including stresses and strains in built-up and wire-wrapped guns; the design of recoil and counter-recoil mechanisms. The calculation of stresses in gun carriages, foundations, gear trains, roller bearings, and foundation bolts used in different types of mounts, forms an important part of the course.

**2-891. Mechanics.** The fundamental principles of mechanics necessary for the solution of problems arising in the design of ordnance of various types.

**2-90. Forge Shop.** Systematic instruction in the use of each tool, the study of each material worked, with explanation of various grades and of the proper methods of working each; and discussion of methods of making large forgings. Work in steel is included. Training is given in the use of the power hammer; and drop forging is also included.

**2-901. Forging.** Similar to 2-90.

**2-91. Foundry.** Principles and practice of foundry operation and the production of all classes of castings. Lecture, demonstration and practice in hand and machine molding and core making; mixing, melting and pouring metals. Castings are made in white metal 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; application of X-ray tests for internal defects in castings; foundry layout, equipment, safety methods and modern methods of progressive production.

**2:911. Foundry.**

**2:912. Structural Castings.** Essentially, a lecture course describing the principles and practice of foundry operations in the production of iron and steel castings, and giving instruction in designing castings; primarily intended as preparation for the structural designer.

The Foundry lectures will be illustrated by demonstrations and stereopticon slides, and supplemented by visits to foundries.

**2:92. Pattern Making.** 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.

**2:922. Pattern Making.**

**2:941. Machine Tool Laboratory.** Laying-out work, grinding tools, chipping cast-iron, pneumatic chipping and drilling, filing and fitting cast-iron and steel machine parts, alignment and babbiting of bearings, measuring hardness of metals with scleroscope, drilling, reaming, counterboring and tapping, grinding drills, belt lacing, soldering, welding. 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. Instruction is also given in the theory and practice of modern welding.

**2:951. Machine Tool Laboratory.** Instruction in machine processes and the use of hand tools. Each student is assigned problems involving laying-out work, chipping and drilling, filing and fitting cast-iron and steel parts, alignment and babbiting of bearings, scraping machine-slides, pipe-fitting, hardness tests of metals with scleroscope, tapping, grinding drills and other tools; centering, squaring, straight and taper turning and fitting, screw cutting, finishing and polishing, gear cutting, mandrel making, hardening, tempering, grinding and welding. Special attention is given 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. Instruction is given in the theory and practice of modern welding. 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 gauges. 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 gauges 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.*

**2:953. Welding Engineering and Practice (B).** Instruction will be given by lectures and laboratory exercises in the four major processes of fusion welding: Gas or Oxy-Acetylene Welding, Electric Arc Welding, Electric Resistance Welding and Thermit Welding.

The problems are arranged to cover the different types of welds used in manufacturing, fabricating, structural and repair work. Attention will be given to the design of welded joints; to the fabrication of structures; of machines and equipment; to the testing of welds and to gas cutting.

The work will be supplemented by a textbook and special reading assignments.

**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.

**2'971. Machine Tool Laboratory.** Covers a part of 2.951.

**2'972. Machine Tool Laboratory.** A continuation of 2'971.

**2'98. Production Methods.** 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 (A).** Methods of constructing automobiles, trucks 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.

**2'982. Preparation for Manufacturing (B).** A study of many of the engineering problems which must be solved before a finished article can be manufactured in large quantities after the design of the article has been completed; such as engineering organization, estimating costs of production, the design of tools and equipment, factory extensions, and quality control. The practices of large corporations having the most highly organized engineering departments along these lines will be cited as illustrations and used as the foundation for discussion.

**2'983. Production Design (B).** A study of the fundamental principles involved in the preparation of the manufacturing design of a commodity to be produced in large quantities. Includes a study of the fundamental principles of dimensioning detail drawings with tolerances, and preparation of other necessary specifications which are required to convey precise and complete information to the productive departments. The subject is taught by lectures and work in the drafting room preparing complete drawings and specifications for a specific commodity. Textbooks: *Production Design, Olsen; Principles of Interchangeable Manufacturing, Buckingham.*

**2'99. Metrology and Dimensional Engineering Standardization (A).** A study of fundamental units of measure, measuring systems, and calibration of standards; the purpose of measurements in scientific and research work, engineering in general use; a study of conventional measuring instruments, their characteristics and methods of calibration; accuracy of measurements; analysis of measurements; shop measurements and analysis by means of measurements; dimensional engineering standardization; and inspection engineering. Textbooks: *Library Research, American Engineering Standards, S. A. E. Handbook, and Notes prepared for class.*

## MINING AND METALLURGY

Subjects 3'00 to 3'99 (see page 74)

*The prerequisites for each subject will be found in the Tabulation.*

**3'00. Introduction to Mining and Metallurgy.** A brief orientation course designed to inform the student regarding the fields of activity of the mining engineer, the petroleum engineer, the metallurgist and the ceramist. The relation of the fundamental sciences to practice in each of these divisions is discussed and a brief introduction given to the chief professional subjects.

**3'01. Mining Methods.** Prospecting and exploring with applications of churn drilling and diamond drilling; mineral land titles; explosives, mining development, rock excavation, tunneling 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. 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. Economics of Mining (B).** 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.

**3'031. Mining Economics (B).** Lectures simultaneous with 3'03.

**3'04. Mining, Principles of (B).** The principles and practice of mine sampling and examination; the interpretation of data and the writing of reports; inquiry into the risk factor in mining investments and its effect on valuation; the principles controlling methods and extent of development; the character of mechanical equipment; standardization, administration, depreciation and depletion; 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.** 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. 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 (A).** 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 subjects. 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 will be spent in familiarizing the students with processes and operations in mining, crushing and concentrating with visits to various mines in the vicinity.

**3'101, 3'102. Mine Valuation (A).** Interpretation of mine sampling, estimates of ore reserves, design and estimates of cost of plant equipment, determination of operating costs and valuation of the ore deposit. Given by the case system and the time is devoted to lectures, conferences, assigned readings, computations, and written reports. Designed for graduate students who have a background of experience in mining practice.

**3-12. Mining Economics, Advanced (A).** The study and analysis of the reports of mining 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.

**3-13. Geophysical Prospecting, Elements of (B).** Lectures and laboratory instruction in manipulation of geophysical apparatus and field exercises. Elements of prospecting by the various scientific means; including magnetic, electric, seismic and gravimetric methods. The purpose of the laboratory is to train the students in the use of the instruments. The field exercises provide opportunity for taking readings following typical field practice.

**3-21. Ore Dressing (B).** The mechanical concentration of the mine ore to separate the valuable minerals from the waste. The greater part of the time is devoted to wet gravity concentration and flotation, including 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 (B).** 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. Individual tests are made on crushing machines, sizing screens, hydraulic classifiers, magnets and flotation machines. One very important part of this work is the cleaning up, weighing, sampling and analyzing of all the products, the computation of results and the preparation of written reports which are discussed at the weekly seminars.

**3-23. Ore Dressing.** The lectures embody the principles of wet gravity concentration, flotation, amalgamation and magnetic separation. The most important crushing and concentrating machines of interest to the metallurgists are treated briefly. The laboratory work covers three seven-hour periods for three weeks, and three seminars of one hour; it is practically identical with that of 3-22 with the exception that lack of time prevents the student from cleaning up his products and preparing reports. Textbook: *Richards and Locke, Textbook of Ore Dressing.*

**3-241, 3-242. Ore Dressing, Advanced (A).** Somewhat variable in scope and time allotment. Devoted to lectures, conferences and assigned readings in continuation of 3-21 or 3-23.

**3-251, 3-252. Theory and Practice of Flotation (A).** Library readings, conferences and laboratory work, going more deeply into the subject than is possible in undergraduate work, and dealing with special phases in flotation such as fundamental theory, study of reagents, differential flotation, application to oxidized ores and the economics of flotation.

**3-26. Ore Dressing, Economics (A).** Conferences and problems involving the various factors of equipment costs, operating cost, efficiency of operation and profit.

**3-271, 3-272. Ore Dressing, Design (A).** Design of flow-sheets and layout of mills; usually includes a special problem of mill design to cover a set of stated conditions.

**3-31. Fire Assaying.** The sampling of ore and bullion, the assaying of ores for gold, silver and lead, and of bullions, solutions, matte and miscellaneous furnace products. The fire assay of copper, tin, mercury and platinum is briefly discussed. Typical ores, bullions and solutions are used for analysis; the important standard methods are covered. Stress is laid upon the accuracy of results and the neatness of work and of notes. Textbook: *Bugbee, Fire Assaying.*

**3-331, 3-332. Fire Assaying, Advanced (A).** The theory and practice of fire assaying, which includes practice with works methods for gold and silver; the fire assay for tin, mercury and members of the platinum group of metals; also a certain amount of research.

**3'41. Metallurgy: Copper and Lead (B).** 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 coördinated 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: *Hayward, Outline of Metallurgical Practice; Hofman and Hayward, Metallurgy of Copper; Hofman, Metallurgy of Lead.*

**3'411. Metallurgy: Copper and Lead (B).** The lectures are given simultaneously with 3'41. The time for laboratory and library work is shortened. Textbooks: *Hayward, An Outline of Metallurgical Practice, Hofman and Hayward, Metallurgy of Copper; Hofman, Metallurgy of Lead.*

**3'412. Metallurgy: Copper, Lead, Zinc, etc. (B).** The lectures on copper and lead are simultaneous with 3'41. In addition there are twelve lectures covering briefly zinc, aluminum and fuels. The laboratory work is confined to twenty-five hours. Textbooks: *Hayward, An Outline of Metallurgical Practice.*

**3'42. Metallurgy: Gold and Silver (B).** The principles of the subject are covered in thirty lectures. The laboratory work is designed to illustrate some of the standard processes and to give the student experience in testing. Samples of known metallic contents are used and students are held individually responsible for the accuracy of their results.

**3'421. Metallurgy: Gold and Silver (B).** The lectures are simultaneous with 3'42. Less time is devoted to work in the laboratory.

**3'422. Metallurgy: Gold and Silver (B).** The same lectures as 3'42 but no laboratory.

**3'43. Metallurgy: Iron and Steel (B).** 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 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. Textbooks: *Stoughton, Metallurgy of Iron and Steel; Camp and Francis, Making, Shaping and Treating of Steel.*

**3'431. Metallurgy: Iron and Steel (B).** The lectures are simultaneous with 3'43, but less time is devoted to library work and plant visits. Recommended for Army and Navy officers requiring a knowledge of iron and steel for ordnance or structural purposes. Textbooks: *Stoughton, Metallurgy of Iron and Steel; Camp and Francis, Making, Shaping and Treating of 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 (B).** Covers in a general manner the properties of metals and alloys, treats in detail fuels and refractories, discusses the principles which govern pyro, hydro and electrometallurgical processes and considers typical metallurgical apparatus. In zinc and minor metals the work supplements that given in 3'412. Textbook: *Hofman, General Metallurgy; Hayward, An Outline of Metallurgical Practice.*

**3'45. Metallurgy, Heat Treatment of Steel (B).** Heat treatment of steel including 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. Considers 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. Textbook: *Hayward, An Outline of Metallurgical Practice.*

**3'501, 3'502. Metallurgy: Iron and Steel, Advanced (A).** Class work, conferences, plant visits and library work, aiming to supplement and to give a more detailed knowledge of the subject than is possible in the undergraduate courses.

**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.

**3'52. General Metallurgy, Advanced (A).** Fuels, refractories and the principles of roasting and smelting are studied with greater thoroughness than is possible in the undergraduate courses. A critical analysis is made of the manner in which these principles are carried out in present practice and suggested improvements are discussed.

**3'53. Non-ferrous Metallurgy, Advanced (A).** For graduate students who have had fundamental courses in non-ferrous metallurgy and wish to continue the study of one or more of the metals. Latitude is allowed in the choice of subject and the time may be adjusted to suit the requirements of the work which may be a combination of library studies and conferences with laboratory work if desired. The work is confined to production and refining. Those desiring to study the properties of metals and alloys should register for 3'651, 3'652.

**3'54. Gold and Silver Metallurgy, Advanced (A).** 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.

**3'55. Metallurgical Calculations, Advanced (A).** The reactions involved in various metallurgical operations are studied, with special reference to their thermal values. Heat balances and furnace efficiencies are calculated and a critical study made of the results with a view to suggesting improvements in design or operation of apparatus.

**3'56. Metallurgical Plants (B).** 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 (B).** Consists of one week spent in visiting metallurgical plants in New Jersey and Eastern Pennsylvania. The production of iron and steel, zinc, copper and lead 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. Text-book: *Williams and Homerberg, Principles of Metallography.*

**3'615. Metallography.** Conferences and laboratory work dealing with the metallographic examination of metals used in torpedo construction. (Open only to officers of the United States Navy taking course in torpedo design.)

**3'621. Metallography.** An intensive study of the non-ferrous metals and alloys, the construction and interpretation of equilibrium diagrams and the relations between the constitution of alloys and their physical properties. Laboratory practice is included.

**3'622. Metallography.** A continuation of 3'621 in which iron, steel, and the alloy steels are studied. Laboratory practice is included.

**3'641. Physical Metallurgy (Non-ferrous) (B).** An intensive study of the non-ferrous metals and alloys, their mechanical properties, uses, corrosion, methods of testing and similar topics.

**3'642. Physical Metallurgy (Ferrous) (B).** Similar to 3'641 but dealing with iron and steel.

**3'643. Light Alloys (B).** A detailed study of the structure, properties, heat treatment and uses of alloys of aluminum, magnesium and beryllium.

**3'651, 3'652. Physical Metallurgy, Advanced (A).** A series of conferences dealing with recent developments in physical metallurgy, accompanied by laboratory exercises in which brief research problems will be undertaken.

**3'656. X-Ray Metallography.** Conferences and laboratory work dealing with the use of X-rays in the study of metals. Includes radiographic examination of metal parts, as well as the X-ray diffraction study of the atomic and granular structures of metals, and their relations.

**3'657. X-Ray Metallography, Advanced (B).** Conferences dealing with recent advances in the physics of metals as studied by X-ray methods together with laboratory work consisting of a series of brief research problems.

**3'66. Applications of Metallography (A).** Laboratory conferences, arranged to familiarize the student with the applications of metallography to industrial problems.

**3'67. Physics of Metals (B).** A discussion of the modern theories of the metallic state resulting from a study of the physical properties of metals.

**3'673. Physics of Metals, Advanced (A).** Continuation of 3.67.

**3'68. Metallography of Welding.** General consideration of welding processes. Study of welding from a metallurgical viewpoint. Influence of various factors on quality and structure of welds.

**3'69. Corrosion and Heat Resisting Alloys (B).** A study of metals and alloys with respect to corrosion and heat resistance, including a discussion of inter-crystalline failure, corrosion protection, creep and selection of materials.

**3'71. Heat Treatment.** The effect of heat treatment on the physical properties of iron, steel and other metals. Considerable time is devoted to the determination of the proper heat treatment to bring out any particular property desired.

**3'712. Engineering Heat Treatment.** Conferences and laboratory work dealing with the effect of heat treatment on the physical properties of iron, steel and other metals.

**3'713. Heat Treatment.** Conferences and laboratory work dealing with the effect of heat treatment and hot and cold work upon the physical properties of metals used in torpedo construction. Open only to officers of the United States Navy taking torpedo design.

**3'714. Heat Treatment.** A continuation of 3'712, devoted to the study of the effect of heat treatment on the metals used in the automotive industry.

**3'731, 3'732. Physical Metallurgy.** The structure and physical properties of metals used in torpedo construction. Open only to officers of the United States Navy.

**3'74. Theory of Metal Hardening (A).** A critical discussion of the modern theories of the hardening of metals.

**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.

**3'84. Outline of Petroleum Production.** For students outside of the option in Petroleum Production who are interested in the methods of developing, produc-

ing and storing the crude products of the petroleum industry. Includes oil and gas land titles, methods of development and production, transportation and storage of petroleum.

**3·85, 3·86. Petroleum Production (B).** Special methods for increasing the flow of oil and gas to wells; the production and distribution of natural gas; the extraction of natural gasoline from natural gas; the utilization of petroleum products as affecting the oil and gas producer; elements of the valuation of oil and gas lands. Laboratory studies of problems in production, transportation and storage of crude petroleum and natural gas. Examination of cores and samples from producing formations for grain size, porosity and saturation. Testing of cements and muds used in oil wells. Treating of emulsions for the removal of water and sediments.

**3·89. Oil Field Visits.** A five-day trip to the oil and gas fields of Western Pennsylvania.

**3·901, 3·902. Oil and Gas Land Valuation (A).** Considers the factors entering into the valuation of oil and gas properties, given by the case system. Lectures, conferences, assigned readings, drawings, computations and written reports. For graduate students who have had some experience in petroleum production.

**3·911, 3·912. Advanced Petroleum Engineering (A).** For graduate students who 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.

**3·921, 3·922. Oil and Gas Law (A).** Laws and legal forms relating to the acquisition of petroleum rights to production, storage and transportation of petroleum, natural gas and their products.

**3·93. Ceramics (B).** An introduction to the more advanced ceramics courses. The selection of ceramic materials, molding, drying and burning are taken up, as well as the physical properties of finished products. Commercial processes will be carried out in the laboratory on a small scale.

**3·94. Optical Ceramics (B).** Optical Ceramics is primarily a laboratory subject in which the methods of petrography are applied to the study of ceramic products and raw materials, such as clay, cement, glass, porcelain, refractories, etc.

**3·95. Fundamental Ceramic Processes (A).** The work in Fundamental Ceramic Processes will take up the theory and practice of forming, drying and burning of clay articles, such as white wares, refractories, terra cotta, etc. The principles involved in the manufacture and use of glass, cements and abrasives will also be discussed. The principles of kiln and furnace design are discussed and practical examples will be analyzed.

**3·96. Physical Properties of Ceramic Products (A).** The subject of Physical Properties of Ceramic Products includes the various methods of determining the properties of finished ceramic articles. The influence of manufacturing methods on these properties is taken up in order to bring out effective methods of control.

## ARCHITECTURE

## Subjects 4'00 to 4'99 (see page 74)

*The prerequisites for each subject will be found in the Tabulation.*

**4'021, 4'022. Freehand Drawing.** Drawing from the cast and architectural ornament in charcoal. Basic figure construction and anatomy are given followed by quick sketching direct from the human figure in charcoal.

**4'031, 4'032. Freehand Drawing.** A continuation of 4'022. Drawing from the nude and casts; memory drawing from the figure.

**4'041, 4'042. Freehand Drawing.** A continuation of 4'032. Drawing from the nude and casts, memory drawing from the figure in charcoal and pen and ink. The principles of figure design are stressed.

**4'051, 4'052. Freehand Drawing (B).** A continuation of 4'042. Drawing from the nude and casts; memory drawing from the figure. Students work in charcoal, wash, pen and ink and make both large and small drawings to give them a better sense of scale and proportion. Simple problems in figure composition are given with special reference to an architectural application.

**4'053, 4'054. Freehand Drawing (A).** Open only to students who have passed 4'052. This course is a continuation of 4'052, the work and problems in figure composition being of a more advanced nature.

**4'06. Graphics.** The fundamental conceptions of orthographic projections and fundamental problems on lines, planes and solids with supplementary exercises in the application of the principles of descriptive geometry to problems of an architectural nature.

**4'071, 4'072. Modeling.** Aims primarily to develop the student's sense of a third dimension in his study of architectural composition. Sketch exercises in modeling wax upon a given program of an architectural character.

**4'081, 4'082. Color, Composition, Theory and Application.** Aims to familiarize the student with the theories of color, both scientific and aesthetic, and to give him practice in the use of color.

**4'091, 4'092. Color, Composition, Theory and Application (B).** A continuation of 4'081, 4'082, the problems being of a more architectural character.

**4'11. Shades and Shadows.** Fundamental knowledge necessary for casting the conventional shadows employed in architectural design. Drawing-room work in the nature of test exercises based on textbook preparation. Covers the application of descriptive geometry methods and also short methods of construction useful in practice. Textbook: *Notes on Shades and Shadows, H. W. Gardner.*

**4'12. Perspective.** General theories of perspective and the methods of revolved plan and perspective plan. Practical work involving variations, short cuts and office manipulations. Textbook: *Principles of Architectural Perspective, Lawrence.*

**4'13. Perspective.** Fundamental phenomena of appearance, the general theory of conical projection and its application to perspective, the method of revolved plan upon which all shorter methods are based, curves and apparent distortion. The study of direct division, direct measurement, relations between lines and points in the vanishing-point diagram, the cubic system, method of perspective plan, and shadows. Textbook: *Principles of Architectural Perspective, Lawrence.*

**4'211, 4'212. 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.

**4'22. 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.

**4'24. Professional Relations (B).** Designed to give an understanding of the professional character of the practice of architecture. In it are discussed the personal, ethical, business and legal relations of the architect with clients, builders, craftsmen, engineers, etc., with whom he has to work in the practice of his profession; the relations that should exist between the architect, his professional organizations and the community in which he lives. References are made to legal handbooks upon the laws governing architecture and building, and to the various documents that are issued by the American Institute of Architects. Textbooks: *Handbook of the Professional Practice, American Institute of Architects; Law of Architecture and Building, Clinton H. Blake, Jr.*

**4'26. Estimating.** Designed to give the students some knowledge of the methods used in making estimates of cost as applied to building. Textbook: *Mimeograph Notes.*

**4'311, 4'312. Theory of Architecture.** Introduction to the principles of architecture. Drafting room exercises in abstract design to develop a sense of form and structure. Lectures on the fundamental theory of architecture with a general consideration of materials, construction, and elements of buildings.

**4'321, 4'322. Theory of Architecture.** Lectures and drawing exercises supplementing the corresponding course in Design and closely related to it.

**4'331, 4'332. Theory of Architecture.** Lectures and drawing exercises supplementing the corresponding course in Design and closely related to it.

**4'341, 4'342. Theory of Architecture.** Lectures and drawing exercises supplementing the corresponding courses in Design and closely related to it.

**4'411, 4'412. Architectural History.** Lectures, illustrated by stereopticon, covering the periods of Egyptian, Assyrian, Persian, Greek, Roman, Byzantine and Gothic architecture, supplemented by reference reading, theme writing and group conferences.

**4'421, 4'422. Architectural History.** A continuation of 4'412 with illustrated lectures covering the periods of Renaissance and Modern Architecture, supplemented by reference reading, theme writing and group conferences.

**4'461, 4'462. European Civilization: Classical and Medieval Culture.** Constitutes a history of culture, mainly that of Europe. The main currents of science and philosophy are considered; but emphasis is upon literature, sculpture and painting. Lectures, readings, and reports.

**4'471, 4'472. European Civilization: the Renaissance and the Seventeenth Century.** A continuation of 4'462 and 4'471. Second Course.

**4'481, 4'482. European Civilization: the Eighteenth Century and Modern Culture (B).** A continuation of 4'472 and 4'481.

**4'491, 4'492. European Civilization (A).** Selected topics in the history of culture. Supervised study, with conferences, readings, and reports but without lecture hours, for graduate students.

**4'53. Architectural Humanities (B).** A series of lectures by individual lecturers selected for their professional standing and accomplishment.

**4'61. City Planning (B).** The historical background of the modern city planning movement is presented in a series of lectures on the planning of ancient, medieval and renaissance towns. The course deals with the evolution of the modern city and the relation of architecture to problems of city development and civic design, concluding with a study of elementary principles in city and regional planning. Lectures accompanied by reading and work at the drafting board. Textbook: *Outline of City Planning, Thomas Adams.*

**4'641, 4'642. Theory and Practice of City Planning (B).** A comprehensive study of the major factors of modern urban growth. The course deals with the sociological, economic and legal aspects of city planning in a way which enables the student to see them in a broad perspective and to relate them to the practical problems in design which are being worked out in the drafting room. Textbook: *Outline of City Planning, Thomas Adams.*

**4'651, 4'652. Theory and Practice of City Planning (B).** Advanced problems of city and regional planning, including a study of modern solutions to such problems. The work is concluded by a series of lectures on municipal government and city planning administration. Collateral reading, written reports and round table discussions are essential features of both courses on Theory and Practice. Textbook: *Outline of City Planning, Thomas Adams.*

**4'671, 4'672. City Planning Design (B).** The application of fundamental principles in architectural design to problems in the general field of city planning. Individual instruction is given in the drafting room, and the system of preliminary sketches, developed problems and sketch problems is continued.

**4'681, 4'682. City Planning Design (B).** A continuation of 4'672. The practical application of city planning theory to the design of neighborhood units, towns, cities and regions. Includes the preparation of the thesis required for the degree of Bachelor in Architecture in City Planning.

**4'712. Design I.** Beginning the study of the basic principles of architectural composition by means of short, intensive problems, the subjects being analogous to or a part of actual architectural problems. Emphasis is put on abstract design as determined and limited by materials, structure, and purpose. This work forms a continuation and application of the first term Theory of Architecture and is given by individual instruction in the drafting room and criticism of student work before the class. It also serves to teach the student the principles and methods of drawing and rendering.

**4'721, 4'722. Design II.** A continuation of 4'712. Problems in architectural composition as applied to buildings of simple requirements and varied character. Carried on by means of eight hour preliminary sketch exercises in the form of sketch problems. Some of these are further developed to a final result in a period of from four to five weeks.

**4'731, 4'732. Design III.** A continuation of 4'722. The sketch problem exercises in this course are of twelve hours duration and the problems more advanced in character.

**4'741, 4'742. Design IV.** A continuation of 4'732.

**4'751, 4'752. Design V (B).** A continuation of 4'742 in methods, the character of the problems being of an advanced nature. Includes the preparation of the thesis required for the degree of Bachelor in Architecture.

**4'761, 4'762. Design (A).** A continuation of 4'752. Includes the preparation of the thesis required for the degree of Master in Architecture.

**4'78. Planning Principles.** A study of the principles underlying all good planning such as the logical relation to one another of the different parts of a building, the arrangement of proper lighting and circulation, axial development and balance. The student is given some practice in making sketch plans and is required to make a written report upon the plan of some existing building.

**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. Construction.** Methods of analysis and computation, required in elementary architectural construction, treating of the theory of construction, loads, reactions, the design of beams, columns and various details, a wooden roof truss, slow burning construction. Textbook: *Mimeograph Notes.*

**4'812. Construction.** A continuation of 4'811 including simple steel framing, the plate girder, and the elements of design in reinforced concrete. 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 practice in drawing. 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.

**4'911. Structural Analysis.** 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 and concrete and steel are studied. Textbook: *Mimeograph Notes*.

**4'912. Structural Analysis.** 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 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.

The following subjects are offered as General Studies.

**4'461. European Civilization.**

**4'462. European Civilization.**

**CHEMISTRY**

Subjects 5'00 to 5'99 (see page 74)

*The prerequisites for each subject will be found in the Tabulation.***INORGANIC CHEMISTRY****Undergraduate Subjects**

**5'00. Chemistry, Entrance.** Lectures, recitations and laboratory given during the summer to cover the entrance requirements in chemistry.

**5'01, 5'02. Chemistry, General.** The fundamental principles of chemical science and the descriptive chemistry of the more common elements and their important compounds. Textbooks: *Foster, Inorganic Chemistry for Colleges; Blanchard and Phelan, Synthetic Inorganic Chemistry.*

**5'04. Chemistry, General.** Covers in abbreviated form the subject matter of 5'01 and 5'02. Textbook: *Smith-Kendall, College Chemistry.*

**5'05. Atomic Structure, Elementary.** A non-mathematical presentation of modern views on this subject.

**5'061, 5'062. Inorganic Chemistry (B).** Presents in a correlative manner the physical and chemical properties of the elements and compounds. Much time is devoted to recent investigations in inorganic chemistry.

**Graduate Subjects**

**5'07. Inorganic Chemistry, Advanced (A).** Special topics in inorganic chemistry such as the chemistry of the less common elements, the more complex reactions of the commoner elements, and reactions in non-aqueous solvents.

**5'08. Inorganic Laboratory, Advanced (A).** Preparation of inorganic substances planned to develop manipulative skill and laboratory technique and requiring reference to the original literature for experimental details; intended to acquaint the student with typical research methods which will aid him in carrying out his own major investigation.

**ANALYTICAL CHEMISTRY****(A) Qualitative and Quantitative Division****Undergraduate Subjects**

**5'10. Qualitative Analysis.** Preliminary experiments illustrate principles and give practice in writing equations and in manipulation. The student is required to analyze simple substances and industrial products such as minerals, pigments, slags and alloys. Textbooks: *A. A. Noyes, Qualitative Analysis.*

**5'11. Qualitative Analysis.** Abridgment of 5'10. For students not specializing in chemistry.

**5'12. Quantitative Analysis.** Volumetric and gravimetric analysis, illustrating the more important typical processes. Special attention is given to manipulation, stoichiometry and modern theories of solution. Textbooks: *Hall, Textbook of Quantitative Analysis; Hamilton and Simpson, Calculations of Analytical Chemistry.*

**5'13. Quantitative Analysis.** Continuation of 5'12. Analysis of silicates minerals, ores and alloys including electrolytic and electrometric methods, and when possible, an original study of some special analytical problem.

**5'141. Analytical Chemistry.** Gas analysis (5'31); special methods (5'39).

**5'142. Analytical Chemistry.** The chemistry of the rarer elements with special reference to methods of separation, identification, and quantitative determination. Application of general analysis to special industries; specifications and interpretation of results.

**5-16. Analytical Chemistry.** Special methods designed for laboratory conditions of the practice school in chemical engineering.

**5-18. Qualitative Analysis, Advanced (A).** A study of the reactions of the rarer elements and their detection. Textbook: *Noyes and Bray, Qualitative Analysis for the Rare Elements.*

#### (B) Food and Water Division

##### Undergraduate Subjects

**5-20. Chemistry of Water and Sewage.** Chemical examination of potable waters and sewage with lectures on the sanitary significance of the results.

**5-23. Sanitary Chemistry.** Chemical problems in the selection and examination of water; the purification of water supplies and the treatment of municipal and industrial wastes. Laboratory technique of water purification and sewage disposal plants.

**5-25. Chemistry of Foods.** Analytical methods, fundamental basis of nutrition, extent, character and legal status of food adulteration. Textbook: *Woodman, Food Analysis.*

**5-251. Chemistry of Foods (B).** Abridgment of 5-25.

**5-26. Food Analysis (B).** Problems in state and municipal food control, systems of food inspection and methods of food analysis.

#### (C) Technical Analysis Division

##### Undergraduate Subjects

**5-30. Proximate Analysis (B).** Examination of alkaloids, asphalts, inks, oils, paints, paper, rubber, soaps, tanning materials, etc. Develops a critical spirit of investigation rather than merely the technique of analytical methods.

**5-31. Gas Analysis.** The technical analysis of commonly occurring gaseous mixtures and consideration of losses due to waste gases. Textbooks: *Gill, Gas Analysis for Chemists, or Gill, Gas and Fuel Analysis for Engineers.*

**5-33. Study of War Gases.** Manufacture and testing of war gases and their absorbents.

**5-35. Applied Chemistry.** Properties, testing and applications of paints, oils, varnishes, lubricants, wood preservatives, alloys.

**5-37. Chemistry of Road Materials (B).** Application and tests of bitumens, tars, oils, paints and chemicals used in roads and road structures.

**5-38. Lubricating and Fuel Oil Testing.** Technology and physical and chemical testing of the mineral, animal and vegetable oils, to determine their applicability and safety. Means of detecting adulteration of different oils. Textbook: *Gill, Handbook of Oil Analysis.*

**5-381. Oil Testing and Petroleum Refining.** 5-38 with increased time assignment for petroleum chemistry and petroleum refining.

**5-39. Special Methods.** Use of the microscope, polariscope, saccharimeter, viscosimeter, refractometer, turbidimeter, nitrometer, and precision centrifuge.

## ORGANIC CHEMISTRY

### Undergraduate Subjects

**5-41. Organic Chemistry I.** The fundamental principles of the chemistry of the carbon compounds, based on a study of important substances of the aliphatic, aromatic, and heterocyclic divisions.

**5-412. Organic Chemistry.** Lectures and recitations cover in abbreviated form the subject matter of 5-41 and 5-42. Laboratory experiments include the preparation, class reactions and identification of typical organic compounds. (Army Ordnance only.)

**5-413. Organic Chemistry.** Continuation of 5-412. (Army Ordnance only.)

**5'414, 5'424. Organic Chemistry Laboratory.** Ultimate analysis by macro and semi-micro methods, organic preparations, typical reactions associated with each class of organic compounds, identification of organic compounds and special experimental problem.

**5'416, 5'426. Organic Chemistry Laboratory.** Organic preparations, typical reactions associated with each class of organic compounds and methods for their identification of organic compounds.

**5'418. Organic Chemistry Laboratory.** Abridgment of 5'416.

**5'42. Organic Chemistry I.** Amplification and extension of 5'41.

**5'425. Organic Chemistry Laboratory.** Differs from 5'424 in the emphasis placed upon compounds of military importance and in shorter time required.

**5'427. Quantitative Organic Analysis.** Determinations of carbon-hydrogen, nitrogen, halogens and sulphur by macro and semi-micro methods of analysis; conferences and discussions.

**5'428. Organic Chemistry Laboratory.** Preparations, class reactions and identification of typical organic compounds.

**5'43. Powder and Explosives (B).**

#### Graduate Subjects

**5'51, 5'52. Organic Chemistry II (A).** The important principles of the science are emphasized from a more mature point of view.

**5'53. Organic Chemistry III (A).** Topics, varied from year to year, are presented in lectures accompanied by assigned reading and discussion.

**5'541, 5'542. Organic Chemistry IV (A).** Designed to produce a familiarity with the phenomena exhibited by organic compounds. The laws and principles of organic chemistry are inferred from the known behaviour of the substances.

**5'55. Organic Qualitative Analysis (A).** The study of systematic methods for the identification of organic compounds.

**5'56. Technical Organic Chemistry (A).** The theoretical factors involved in the industrial applications of organic chemistry.

**5'57. Chemistry of Dyes (A).**

**5'572. Stereochemistry (A).** Lectures on the present status of knowledge of the optical and geometrical stereoisomerism of the compounds of carbon, nitrogen, and some of the less important elements, emphasizing methods of configurational determination and the relation between such configuration and the physical and chemical properties.

**5'574. Free Radicals and Organo-Metallic Compounds (A).** The history and current developments in these fields will be discussed.

**5'576. Seminar in Recent History of Organic Chemistry (A).** One two-hour session each week devoted to an informal discussion of recent important developments in Organic Chemistry, of their background and interrelations, and of the men who produce them.

**5'581, 5'582. Advanced Organic Laboratory (A).**

**5'584. Molecular Structure of Organic Chemical Compounds (A).** Deals with the classical and the newer methods for determining the molecular structure of organic compounds.

**5'591, 5'592. Recent Advances in Organic Chemistry (A).**

#### PHYSICAL CHEMISTRY

##### Undergraduate Subjects

**5'61. Physical Chemistry I.** Pressure-volume relations of gases; vapor pressure; boiling point and freezing point of solutions; chemical equilibrium; phase equilibrium. Textbook: *Noyes and Sherrill, An Advanced Course of Instruction in Chemical Principles*; *Sherrill, Laboratory Experiments in Physico-Chemical Principles*.

**5'611. Physical Chemistry I.** Same topics as 5'61, without Laboratory. Textbook: *Millard, Physical Chemistry for Colleges.*

**5'62. Physical Chemistry II.** Continuation of 5'61. Thermochemistry; reaction velocity; free energy of chemical changes; transference; conductance; electromotive force of cells. Textbook: *Noyes and Sherrill, An Advanced Course of Instruction in Chemical Principles; Sherrill, Laboratory Experiments in Physico-Chemical Principles.*

**5'63, 5'64. Physical Chemistry III and IV (B).** Continuation of 5'62. Application of the laws of thermodynamics to the equilibrium of chemical reactions and to the electromotive force of voltaic cells. General principles relating to surface phenomena and to the colloidal state, atomic structure based on the nature of radiations emitted by atoms.

**5'683. Physical Chemistry, Elementary.** For students specializing in Mechanical and Aeronautical Engineering. Textbook: *Millard, Physical Chemistry for Colleges.*

**5'684. Physical Chemistry, Elementary.** For students specializing in Biology and Public Health. Textbook: *Gillespie, Physical Chemistry.*

#### Graduate Subjects

**5'71, 5'72. Physical Chemistry (A).** For graduate students who have not had the equivalent of 5'62. Textbook: *Noyes and Sherrill, An Advanced Course of Instruction in Chemical Principles.*

**5'73. Free Energy (A).** Discussion of methods for determining the free energy of substances, and a systematization of such values. Textbook: *Lewis and Randall, Thermodynamics and the Free Energy of Chemical Substances* (for supplementary reading).

**5'741. Kinetic Theory of Matter I (A).** Statistical Mechanics and the theory of intermolecular forces with applications to the equation of state problem.

**5'742. Kinetic Theory of Matter II (A).** Applications of spectroscopy to thermodynamic calculations and to the study of molecular structure.

**5'75. Thermodynamics (A).** The principal general equations of thermodynamics from the entropy point of view.

**5'76. Thermodynamics and Chemistry (A).** The development of equations for the treatment of chemical reactions and of equilibria in chemical systems. Textbook: *Gibbs, Thermodynamics.*

**5'77. Thermodynamics and Chemistry (A).** The phase relations for heterogeneous systems are treated, special attention being given to binary mixtures. Textbook: *Roozeboom, Die Heterogenen Gleichgewichte.*

**5'79. Theory of Solutions (A).** The properties of solutions are related to those of the components, with special emphasis on solutions of strong electrolytes.

#### SPECIAL TOPICS IN CHEMISTRY

**5'81. Chemical Literature I.** Reading and discussion of German and French Scientific Literature.

**5'82. Chemical Literature II.** Methods of using the journals, books and indexes.

**5'83. History of Chemistry (B).**

**5'842. Optical Methods (B).** Laboratory practice in the use of the polarizing microscope for the identification of crystalline material. Equipment is available for both microchemical tests and such optical tests as refractive index, interference figures and optical character.

**5'843. Engineering Chemistry.** The manufacture and testing of paints, varnishes, paper, ink, leather, explosives, illuminating gas, coal tar and petroleum products, animal and vegetable oils. Applications of organic chemistry to engineering.

**5·844. Engineering Chemistry.** The applications and tests of bitumens, tars, pitches, paints, oils, and varnishes. For students specializing in Building Construction.

**5·851. Methods of Electrochemical Analysis (A).**

**5·852. Organic Physical Chemistry (A).** Alternate years. (Offered in 1933-34.)

**5·855. Theories and Applications of Catalysis (A).**

**5·89. Chemistry.** Six hours each week are assigned for review, study, and conference with instructors. Examinations are given to determine to what extent students have assimilated the chemistry given in the first three years.

#### RESEARCH

**5·90. The Logic of Scientific Inquiry (A).** Discussion of the methods used in making an inquiry into the phenomena of nature; uses of reasoning and of the relations between logic and experiment.

**5·911, 5·912. Journal Meeting in Inorganic Chemistry (A).**

**5·921, 5·922. Journal Meeting in Organic Chemistry (A).**

**5·931, 5·932. Journal Meeting in Physical Chemistry (A).**

**5·941, 5·942. Research Conferences in Inorganic and Organic Chemistry (A).**

**5·943, 5·944. Research Conferences in Physical Chemistry (A).**

**5·96. Thesis Conference.**

**5·961, 5·962. Thesis.** Minor researches to test ability to do work of an original character. Written reports and conferences are required and a formal record must be presented for acceptance. The student may select a problem in inorganic, analytical, organic or physical chemistry.

**5·98. Research (A).** Research for any of the advanced degrees in inorganic, analytical, organic or physical chemistry.

## ELECTRICAL ENGINEERING

Subjects 6'00 to 6'99 (see page 74)

*The prerequisites for each subject will be found in the Tabulation.*

**6'00. Principles of Electrical Engineering (Electric, Dielectric and Magnetic Circuits).** 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).** Mathematical and physical interpretation of the principles underlying the design, construction and performance of direct-current machinery. Textbook: *Langsdorf, Principles of Direct-Current Machines. Fourth Edition.*

**6'02. Principles of Electrical Engineering (Alternating Currents and Alternating-Current Transformer).** Mathematical vector and symbolic methods of representing alternating currents, single and polyphase alternating currents both sinusoidal and non-sinusoidal, series and parallel circuits including simple networks and coupled circuits, brief treatment of the method of symmetrical phase components for handling unbalanced polyphase circuits, air-core and iron-core transformer for power and communication circuits. The course deals principally with the steady-state condition. Textbooks: *Lawrence, Principles of Alternating Currents; Lyon, Problems in Alternating Currents; Lawrence, Principles of Alternating-Current Machinery; Lyon, Problems in Alternating-Current Machinery, Second Edition.*

**6'021. Principles of Electrical Engineering.** First half of 6'02.

**6'023. Principles of Electrical Engineering.** Last half of 6'02 and first half of 6'03.

**6'03. Principles of Electrical Engineering (Alternating-Current Rotating Machinery).** Discussion of the different types of alternating-current rotating machinery for the generation and transformation of electric power. Method of symmetrical phase components and its application to unbalanced conditions in certain types of machines. Textbooks: *Lawrence, Principles of Alternating-Current Machinery; Lyon, Problems in Alternating-Current Machinery, Second Edition.*

**6'031. Principles of Electrical Engineering.** First half of 6'03.

**6'032. Principles of Electrical Engineering.** Last half of 6'03.

**6'04. Principles of Electrical Engineering (Electric Power Transmission) (B).** A general survey of transmission-line problems, calculation of line constants, short line solutions, skin effect, corona, insulator stresses and insulation breakdown, hyperbolic-function solution of long line problems, graphical methods, circle diagrams, inductive interference, transients, system stability, solution of networks. Textbook: *Woodruff, Principles of Electric Power Transmission and Distribution*

**6'041. Principles of Electrical Engineering.** First half of 6'04.

**6'042. Principles of Electrical Engineering.** Second half of 6'04.

**6'09. Principles of Electrical Engineering (Alternating-Current Rotating Machinery).** Recitations and supervised problem work. A shorter course than 6'03. Textbooks: *Lawrence, Principles of Alternating-Current Machinery; Lyon, Problems in Alternating-Current Machinery, Second Edition.*

**6'20. Power Transmission Equipment (B).** 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 (B).** A treatment of electricity in industry with the aim of establishing a scientific basis for applications of motor drives, electric heating, thermionic tubes, photo-electric cells and their connection with the economical use of electric power. The use of electricity as an aid in production and process control is exemplified. Problems involving duty cycles, handling of materials, machining metals and the use of electric furnaces and ovens are given to illustrate these features.

**6-221. Central Stations (B).** The thermal principles and economic considerations influencing the generation of electric power. The generating station is studied with regard to those factors which influence the fuel consumption and the cost of generation 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.

**6-222. Central Stations (B).** The theoretical electrical principles and economic considerations influencing the generation of electric power. The generating station is studied with regard to the influence of bus layout and reactor location on synchronizing power, limitation of short circuits currents, maintenance of bus voltage and transfer of power under normal and abnormal operating conditions; the operation of synchronous machinery under short-circuit conditions; principles of relay selection and applications for generating stations; the layout and design of the cell structure of the electrical equipment; factors influencing selection of electrical equipment.

**6-241, 6-242. Electric Railways (B).** An introductory subject 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. Motors, control, layout of equipment, operation, mechanical design of rolling stock and maintenance are studied. Various systems, service requirements and existing electrifications are also discussed from economic and engineering viewpoints.

**6-251. Electric Machinery Design (B).** Transformers and induction machines. Materials of construction, methods of construction, and the influence of the various factors of design on manufacture and operation of machines.

**6-252. Electric Machinery Design (B).** Design of synchronous and direct-current machines. A continuation of 6-251 but also complete within the term.

**6-26. Electric Insulation and Its Behavior (B).** Lectures and laboratory work covering the theory and behavior of insulating materials and their use in high-tension equipment. The treatment includes an introduction to classical electrostatics, after which the latest experimental results on conduction, dielectric loss, and breakdown are considered, as well as the theories which have been developed to explain these results. The subject concludes with practical applications to cables, condensers, etc. The laboratory work includes breakdown tests on insulating materials at voltages up to 100,000 volts as well as the measurement of dielectric loss, dielectric constant, and resistivity.

**6-27. Illumination (B).** Classroom work, problems, and laboratory investigations covering the scientific basis of illuminating engineering as well as practical applications such as industrial lighting, flood lighting, airport lighting, electric signs, etc.

**6-281. Principles of Wire Communication (B).** Transmission over long lines with distributed constants in the steady state, transformers, insertion loss, networks, loading, filters, balancing networks, repeaters and carrier.

**6-282. Principles of Radio Communication (B).** Elementary theory underlying radio communication. Circuits under free and forced vibrations are discussed with emphasis upon their applications to radio communication. High-frequency power sources are described. Particular attention is given to thermionic oscillators and regenerative systems. Modulation, demodulation, high- and low-frequency amplification, and commercial-frequency rectification by present methods are studied. Some time is spent on applications of the thermionic tube. Transmitting and receiving systems are considered.

**6-29. Storage Batteries.** Theory, construction, care and application of storage batteries.

**6-301. Principles of Electrical Communication.** An introductory survey of electrical communications. Forms of intelligence; elementary characteristics of speech and hearing; philosophical aspects of steady-state and transient effects;

the translation of intelligence into variations of a mechanical, electrical, or acoustical nature, and their interpretation in terms of undulatory motion with help of the concept of frequency. Frequency-response characteristics of transmission facilities; elastic and electromagnetic waves; discussion of various complete systems such as the telegraph, telephone, and radio facilities. At appropriate points the historical development and its relation to contemporary scientific progress is emphasized.

**6'302. Principles of Electrical Communication.** The classical analysis of networks relating to the communications field. The subject is introduced with the help of mechanical analogies to simple aperiodic and oscillatory electrical systems in order to emphasize the heuristic viewpoint as an aid to the mathematical attack. The steady-state and transient behavior of simple networks is treated simultaneously for the purpose of showing that an agreement between initial conditions and degrees of flexibility in the formal solution is necessary in order to arrive at unique solutions. The subject is then generalized and the network behavior interpreted in the light of normal modes and normal functions. The use of the superposition principle as well as the treatment of periodic force functions in the complex form, are given. Textbook: *Guillemin, Communications Networks, Vol. I.*

**6'311. Principles of Electrical Communication (B).** General treatment of the principles of ionic conduction in gases and in vacua. A comprehensive study is made of the characteristics of thermionic tubes, photo-electric cells and of gaseous-conduction tubes in use today with special emphasis upon their engineering applications and limitations as circuit elements. Includes a consideration of networks containing such circuit elements.

**6'312. Principles of Electrical Communication (B).** The electrical transmission properties of lines and cables in the transient and steady states. Some time is spent to show that the usual analytic definitions of inductance and capacitance are first approximations only. A criterion is established which shows the conditions under which the solutions of the transmission problem are valid. The steady-state solution is obtained, and its application to lines and cables illustrated for various typical cases. Line behavior is studied as a function of frequency in order to introduce the problem of distortion and the means used to combat it. The consequent discussion of lumped loading leads to the representation of this type of line by lumped-constant sections and to a consideration of the cut-off properties of such sections. A brief discussion of the use of such sections as filters, follows. Textbook: *Guillemin, Communications Networks, Vol. II.*

**6'330. Electrical Communications Laboratory.** Embraces in general the subject matter of 6'331 and 6'332, but is not so extensive.

**6'331, 6'332. Electrical Communications Laboratory.** Study of various apparatus involved in communications measurements; problems in manipulation. Includes bridge measurements, vacuum-tube measurements and artificial line and other network measurements including those at radio frequencies. General object to associate intimately theoretical deductions with actual observations, to stimulate appreciation of the value of creative experimental investigation.

**6'39. Engineering Electronics.** Recitation and laboratory work covering the more important engineering aspects of thermionic and gaseous-conduction circuit elements, associated circuits, apparatus and related topics, with a consideration of the fundamental processes involved. The various applications studied in the laboratory include the cathod-ray oscillograph, the thermionic tube, the mercury-arc and tungsten-arc rectifier, the grid-controlled gas-filled tube, and the photo-electric cell.

**6'40. Elements of Electrical Engineering.** Applications of the general principles of the electric and magnetic circuit to the generation, distribution and utilization of direct- and alternating-current power. Textbook: *Hudson, Engineering Electricity.*

**6·42. Elements of Electrical Engineering.** Applications of the general principles of the electric and magnetic circuit to the generation, distribution and utilization of direct- and alternating-current power with special reference to ordnance service. Textbook: *Hudson, Engineering Electricity*.

**6·43. Generation and Distribution of Electric Energy.** The thermal, economic and electric principles of electric generating stations, the electric principles and economic considerations affecting the transmission and distribution of electric energy and an analysis of the cost of electric energy.

**6·44. Electric Transmission and Control.** Theoretical principles and economic considerations influencing the transmission of electrical energy. The effect of hydro-electric generating equipment on the power limits and stability of the transmission system.

**6·48. Electrical Equipment of Buildings.** Lectures on the design of electric wiring, lighting and elevator systems for buildings. Textbook: *Cook, Interior Wiring*.

**6·501, 6·502. Electrical Engineering Seminar (A).** 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.

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 (A).** Methods of solving power-circuit problems. Calculation of short-circuit currents in networks. The theory of multi-circuit transformers. Treatment of unbalanced circuits by the method of symmetrical components, with applications. General circuit constants. The theory and construction of performance charts for transmission lines. A comprehensive graphical treatment of transmission systems in the steady state. Textbook: *Dahl, Electric Circuits. — Theory and Applications, Vol. I*.

**6·512. Electric Circuits (A).** The theory and construction of performance charts for synchronous machines. A general discussion of the problem of power-system stability. A comprehensive exposition of analytical and graphical methods for the determination of static power limits and static stability. A brief introduction to transient stability. Textbook: *Dahl, Electric Circuits — Theory and Applications, Vols. I and II*.

**6·513. Electric Circuits (A).** Regulators and excitation systems. A comprehensive discussion of their action, involving determination by analytical and graphical methods of performance during the process of voltage build-up and build-down, etc. Stability of power systems during disturbances. The effect of short circuits and sudden switching. Solution by simplified methods as well as by complete point-by-point methods of analysis. Discussion of methods for improvement of stability. Effect of damper windings. Effect of different methods of grounding the neutral points of the system. Textbook: *Dahl, Electric Circuits — Theory and Applications, Vol. II*.

**6·521, 6·522. Advanced Alternating-Current Machinery (A).** Devoted to the analysis of the more intricate electrical problems met in the operation of alternating-current machinery. The following are some of the problems discussed. The effect of unbalanced conditions on the operation of synchronous and induction machines. Eddy currents in laminations, solid rotors and the conductors of direct-current and alternating-current machines. Harmonic analysis of the magnetic density existing in the air gap of synchronous and induction machines and its effect on the generated e.m.f., the torque, and on vibration. Transient conditions due to the sudden alteration of the electric circuits or to the sudden application of the shaft load of synchronous and induction machines, particularly the effect of sudden short circuit on the current and torque and the conditions arising during pulling into step and phase swinging.

About one-third of the time is allotted to work in the machine transients laboratory upon advanced problems. Induction and synchronous machines are tested for their steady-state and transient characteristics by the aid of special laboratory facilities and a nine-element oscillograph having two power vibrators.

**6-531, 6-532. Organization and Administration of Public Service Companies (A).** Lectures associated with reading, study of financial and operating statistics and forms of organization, and written dissertations by the students. The intention is to give the students a knowledge of the business and engineering characteristics of public service companies and the place held by them in national life.

**6-541, 6-542. Power Generating Stations (A).** The theoretical principles and economical considerations relating to electric generating stations. Thermal efficiency and commercial economy of the different steam cycles, reheating, regeneration, binary cycles; the effect of load factor and the load curve on station design; feed-water heating for maximum thermal economy, layout and calculation of heat balances; the limitation of short-circuit currents; maintenance of voltage and stability; the calculation of short-circuit currents and the selection of circuit breakers. The control and transfer of power under normal and abnormal operating conditions as influenced by the bus layout of the generating station; principles of relay characteristics and their selection and applications within the station.

**6-551, 6-552. Railroad Electric Traction (A).** Gives 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. Equipment, operation and mechanical design of rolling stock; energy consumption and economy; study of distribution systems. Specialized details of design are necessarily omitted.

**6-561. Advanced Network Theory (A).** Characteristics of four-terminal networks; synthesis of two-terminal reactances, their equivalents and inverses; conventional filter theory; impedance correction; series and parallel operation of filters for band separation. Laboratory work is given.

**6-562. Advanced Network Theory (A).** Latest contributions to analysis and synthesis of networks. Generalization of conventional filter theory; transient behavior of selective systems; synthesis of two-terminal dissipative impedances and of four-terminal reactive networks; two- and four-terminal equivalents; corrective networks.

**6-571, 6-572. Illumination (A).** Lectures, problems and laboratory investigations covering the elements of the subject as well as the more advanced aspects. Modern light sources, the use of photo-electric cells for photometric measurements, recent developments in interior illumination and in the daylighting of buildings, projection of light, floodlighting, and similar subjects.

**6-58. Operational Circuit Analysis (A).** The fundamental properties of circuits studied by means of the Heaviside Operational Calculus. The substantiation of this method by classical analysis, especially by the Fourier Integral. Special circuit problems. Textbook: *Bush, Operational Circuit Analysis*.

**6-59. Communications Laboratory (A).** A graduate laboratory course in communications in which special problems in measurements and laboratory analyses are assigned.

**6-62. Principles of Electrical Communications (A).** Deals with thermionic gaseous conduction and photo-electric tubes and their associated external networks. The class work is supplemented with laboratory problems.

**6-651, 6-652. Electric Power Distribution (A).** The theoretical principles of electric power distribution. The distribution system in theory. Calculation of power-system short-circuit transients. Limitation of short-circuit currents, maintenance of voltage, and the control and transfer of power. Theory of electric power cables, dielectric properties, calculation and limitation of sheath currents. Low-voltage and medium-voltage distribution networks. Interlacing of primary cables, load division and transformer spacing. Theory of relays, methods of obtaining

selectivity and their applications. Load characteristics, economic problems in electric distribution, allocation of demand costs, determination of cost of energy loss and rate structures.

**6'661, 6'662. Principles of Electric Machine Development (A).** Design of transformers and direct-current and alternating-current machines and pre-determination of characteristics. Voltage wave-form of generators. Special constructions of machines. Principles of the magnetic and other circuits. Calculation of natural frequency of mechanical vibration. Unbalanced magnetic pull. Flux plotting. General methods of comparing engineering formulas.

**6'68. Transmission-Line Transients (A).** A comprehensive study of transients on long lines. The general theory of travelling waves, followed by a consideration in detail of reflections and refractions at junction points, circuit discontinuities and terminals, the effect of resistance, inductance and capacitance in series and in parallel with the line, the effect of choke coils, etc. Lightning and its effect on transmission lines. Review of laboratory and field test methods and apparatus. Principles and practice involved in lightning protection of lines. Reference books: *Ruedenberg, Elektrische Schaltvorgänge* and *Bewley, Traveling Waves on Transmission Systems*.

**6'69. Sound in Electrical Communications (A).** The acoustical principles involved in the production, measurement, transmission and reproduction of sound by electrical means.

**6'71. Electrical Engineering Laboratory.** Divided into two parts: (a) Electrical Measurements.—More advanced work of the nature of that given in 6'75. (b) Electrical Machinery.—Single-phase and polyphase circuits, symmetrical components, rectifiers, transformers; efficiency, regulation, heating, and polyphase connections. Textbooks: Same as 6'75 and 6'76.

**6'72. Electrical Engineering Laboratory.** Characteristics and fundamentals of alternating-current machinery, including synchronous machines, induction motors, converters, and various other more special apparatus as may be selected. Textbooks: Same as 6'76.

**6'73. Electrical Measurements, Advanced (A).** Further work of the nature of that given in 6'75, the choice of problems being suited to the individual student.

**6'74. Electrical Engineering Laboratory, Advanced (A).** The work is laid out in accordance with the needs of the individual student, being selected from the following: Special problems on direct and alternating-current machinery, and power-network analysis using the network analyzer (an alternating-current calculating table). Problems on the latter include those relating to steady-state operation; to symmetrical and unsymmetrical faults; and to steady-state and transient stability. Problems to be solved are preferably submitted by the student.

**6'75. Electrical Engineering Laboratory.** This subject illustrates methods of measurement of electrical and closely-related quantities, and in addition offers opportunity for the student to become familiar with recently developed electronic devices, both as subjects of measurement as well as from the standpoint of their applicability in measuring technique. Choice of work from a broad selection of topics is left to the student within the limit of his proved ability and interest, and subject to the counsel of his instructor. A list of available apparatus is posted in the laboratory at the beginning of each term. Textbooks: *Laws, Electrical Measurements; Special Notes; Instructions for Students in Electrical Engineering Laboratory, Seventh Edition, 1932.*

**6'76. Electrical Engineering Laboratory.** Characteristics and fundamentals of direct-current machinery. Textbooks: *Ricker and Tucker, Electrical Engineering Laboratory Experiments, Second Edition; Instructions for Students in Electrical Engineering Laboratory, Seventh Edition, 1932.*

**6'77. Electrical Engineering Laboratory.** Similar to 6'71a.

**6'78. Electrical Engineering Laboratory.** Similar to 6'71b, and 6'72. Textbooks: Same as for 6'76.

**6'781. Electrical Engineering Laboratory.** Similar to 6'78 but somewhat abridged.

**6'80. Electrical Engineering Laboratory (B).** For students who desire to do more than the regularly required amount of undergraduate laboratory work. Arranged to suit the requirements of the individual student.

**6'81. Electrical Engineering Laboratory.** An abridgment of 6'75 and 6'76.

**6'83. Electrical Engineering Laboratory.** Similar to 6'72 but somewhat abridged.

**6'85. Electrical Engineering Laboratory.** Eleven exercises designed to familiarize students with the elements of electrical measurements and with the characteristics and fundamental principles of operation of the ordinary types of electrical machinery. Textbooks: *Ricker and Tucker, Electrical Engineering Laboratory Experiments, Second Edition; Instructions for Students in Electrical Engineering Laboratory, Seventh Edition, 1932.*

**6'88. Electrical Engineering Laboratory.** Study of electrical measurements and the testing of dynamo machinery.

In electrical measurements the students calibrate portable indicating instruments, watt-hour meters and instrument transformers.

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. Textbooks: *Ricker and Tucker, Electrical Engineering Laboratory Experiments, Second Edition; Instructions for Students in Electrical Engineering Laboratory, Seventh Edition, 1932.*

**6'89. Electrical Engineering Laboratory.** Nine laboratory exercises similar in subject matter to those of 6'85. Textbooks: Same as 6'85.

**6'901 to 6'904. Manufacturing Practice.** These numbers cover the manufacturing subjects taken by the cooperative students at the plants of the General Electric Company in Lynn, Schenectady, Pittsfield and Erie. The students are not all assigned to the same jobs; neither are they always assigned to the same departments. The following is the list of the various departments to which students are assigned and it also indicates the approximate order in which the manufacturing practice is given:

#### General Electric Company

Machine Shop Training Room, Assembling and Inspecting. Armature Winding.

Drafting and Design, including work on Motors, Transformers and Turbines.

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 Lynn, Schenectady and Pittsfield 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 plants of General Electric Company.

**6'902. Manufacturing Practice.** Second term's work at plants of General Electric Company.

**6'903. Manufacturing Practice.** Third term's work at plants of General Electric Company.

**6'904. Manufacturing Practice.** Fourth term's work at plants of General Electric Company.

**6'911 to 6'924. Public Utility Practice.** The courses in Public Utility Practice are given by the Edison Electric Illuminating Company and the Boston Elevated Railway Company. The various departments to which the students are assigned are listed below in the approximate order in which the work is given at:

**Edison Electric Illuminating Company of Boston**

Maintenance of Line Departments.  
Standardizing and Testing Departments.  
Steam Division of Generating Department.  
Electrical Division of the Generating Department.  
Sales Department.  
Installation Department.  
Supply Department.  
Electrical Engineering Office.  
Scientific Research and Study covering the many Public Utility Problems.

**Boston Elevated Railway Company**

Department of Rolling Stock and Shops.  
Maintenance Department.  
Transportation Department.  
Power Department.  
Miscellaneous Work.

**6'911. Public Utility Practice (Edison).** First term's work at the plants of the Edison Electric Illuminating Company of Boston.

**6'912. Public Utility Practice (Edison).** Second term's work at the plants of the Edison Electric Illuminating Company of Boston.

**6'913. Public Utility Practice (Edison).** Third term's work at the plants of the Edison Electric Illuminating Company of Boston.

**6'914. Public Utility Practice (Edison).** Fourth term's work at the plants of the Edison Electric Illuminating Company of Boston.

**6'921. Public Utility Practice (Elevated).** First term's work at the plants of the Boston Elevated Railway.

**6'922. Public Utility Practice (Elevated).** Second term's work at the plants of the Boston Elevated Railway.

**6'923. Public Utility Practice (Elevated).** Third term's work at the plants of the Boston Elevated Railway.

**6'924. Public Utility Practice (Elevated).** Fourth term's work at the plants of the Boston Elevated Railway.

**6'941 to 6'944. Communications Practice.** These numbers cover the Communications work taken by the cooperative students at the various plants and laboratories of the Bell Telephone System. The first assignment is spent in the Western Electric Company's Plant at Kearny, N. J., and with the installation department in or near New York City, the second with the New York Telephone Company, and the third in the Bell Telephone Laboratories in New York City. The fourth training period is spent with any one of these organizations, depending upon the individual interest of the students.

**6'941. Communications Practice.** First term's work at the plants of the Bell System.

**6'942. Communications Practice.** Second term's work at the plants of the Bell System.

**6'943. Communications Practice.** Third term's work at the plants of the Bell System.

**6'944. Communications Practice.** Fourth term's work at the plants of the Bell System.

## BIOLOGY AND PUBLIC HEALTH

Subjects 7·00 to 7·99 (see page 74)

*The prerequisites for each subject will be found in the Tabulation.*

**7·01. General Biology.** An introduction to the study of living things. Essentially a general discussion of the fundamental facts and principles common to all the biological sciences. Elementary and preparatory in character and in aim.

**7·03. Theoretical Biology (B).** Advanced lectures and recitations in general biology designed to acquaint the student with the principal theories and hypotheses which have played an important part in the development of biological science, and particularly of those which underlie the more fruitful research work of the present day. The two major problems discussed are heredity and morphogenesis. Special reading assigned. Textbook: *Sinott and Dunn, Principles of Genetics.*

**7·06. Botany.** Beginning with the lowest forms of vegetable life, the various groups of algae and fungi are systematically studied and afterwards, higher cryptogams. Some attention is paid also to the structure and development of flowering plants, particularly from the economic aspect. The fundamentals of plant physiology are stressed. Textbook: *Mottier, Textbook of Botany for College Students.*

**7·07. Mycology.** Many decomposition processes are caused by the attacks of fungi of various kinds. 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 molding of foods and on mildewing of cotton and fabrics, and on methods for its prevention make up a part of the laboratory work.

**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, Introduction to Human Parasitology, 1930.*

**7·09. Parasitology, Advanced (A).** Advanced work involving intensive study of some of the more important parasites causing diseases of domestic animals and man. The student will be required to study fresh materials from original sources, the aim being to acquaint him with methods of isolation and investigation which he could apply in problems of this character which might arise in his professional career.

**7·10. Zoölogy.** A systematic study of the invertebrate animals, considering their form, structure, distribution, and economic value. Textbook: *Hegner, College Zoölogy, third edition.*

**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: *Walter, Biology of the Vertebrates; Kingsley, Guides to Dissection, the Dogfish; Bigelow, Directions for Dissection of the Cat; Bremer, Textbook of Histology; Harman, Laboratory Outlines for Embryology.*

**7·131. Advanced Histology (B).** A seminar and laboratory course intended to give the student practice in the preparation and interpretation of special histological materials and in embryology.

**7·132. Advanced Histology (A).** Continuation of 7·131 in the direction of cytological and similar special materials.

**7-14. History of Biology (A).** 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. Textbook: *Norden-skiöld, History of Biology.*

**7-15. Essentials of Anatomy.** A brief course in mammalian anatomy designed to give students of food technology an insight into the gross and microscopic structures of the animal body. Given as a series of lectures accompanied by demonstrations of the structures.

**7-18. Technical Aspects of Entomology (A).** Numerous insects and mites are known to be of the highest importance to public health and the food industries due to their abundance and destructiveness. The general problems of their recognition and control are considered. Attention is also given to the insects beneficial to man.

**7-20. Physiology, Elements of.** Lectures, laboratory and reports on the physical and chemical bases of a physiological function. The nature of protoplasm, and the nature of energy conversions, metabolism and special application of general principles in organ functions comprise the topics covered. Designed to show the general bearing of physiology upon all biological studies. Textbook: *Martin and Weymouth, Elements of Physiology (1928 edition).*

**7-22. Personal Hygiene and Nutrition (B).** Consideration of personal health and disease, their conditions and causes; exercise, work, play, oral hygiene, hygiene of clothing, of the feet, of the alimentary canal, mental hygiene, etc. Special attention is given to diet from the standpoint of the science of nutrition. Required reference book: *Bulletin 28, United States Department of Agriculture, American Food Materials.*

**7-23. Applied Nutrition (A).** 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 cooperation of the Dispensary Staff) is carried out at the Food Clinic of the Boston Dispensary.

**7-28. Limnology.** A specialized study of the microorganisms important in the examination of water for drinking purposes. The organisms are especially considered in relation to each other and to their environment. Reference Book: *Whipple, Microscopy of Drinking Water, Fourth Edition.*

**7-29. Bacteriology (B).** Deals with fundamental principles of bacteriology and the general relations of microorganisms to chemical changes such as fermentation, putrefaction and disease. Particular emphasis is placed on the examination of water supplies and the protection of community water sources. Textbook: *Euchanan, Bacteriology; Prescott and Winslow, Elements of Water Bacteriology.*

**7-301, 7-302. Bacteriology (7-302, B).** Fundamental work in the biology of the bacteria. The first term is devoted to general bacteriology with a thorough study of selected types. The second term is devoted to special study of the bacteriology of water, sewage, air and foods. Textbooks: *Tanner, Bacteriology; Prescott and Winslow, Elements of Water Bacteriology, Wiley, 1931; Standard Methods of Water and Sewage Analysis; Standard Methods of Milk Analysis; Hammer, Dairy Bacteriology.*

**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 (A).** Reports and discussions of bacterial metabolism and growth, the more important diagnostic tests, and recent developments in bacteriology. In the second term laboratory problems and demonstrations include agglutination tests, production and testing of toxins, etc., and special problems.

**7-33. Plant Diseases.** A brief survey of the types of plant diseases of economic significance which are caused by bacteria and fungi. Textbook: *Owens, Principles of Plant Pathology, John Wiley & Sons, 1929.*

**7-34. Limnological Fieldwork.** (At Camp Technology.) A study of the biological and chemical characteristics of stream and lake waters and the relation of these to suitability for use as water supply. Includes sampling at various depths, the use of field kits in the microscopic examination of the plankton and for the examination for color, turbidity and dissolved oxygen and carbon dioxide, etc. Textbooks: *Whipple, Microscopy of Drinking Water; American Public Health Association: Standard Methods of Water Analysis.*

**7-35. Planktonology (A).** 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. The identification, life history and distribution are particularly considered.

**7-36. Microbiology.** A broad survey of the theory and practice involved in fermentation processes, and the industrial and economic applications of microbiology in agriculture and the manufacture of biochemical preparations. Industrial alcohol, vinegar, acetone, butyl alcohol, glycerin, fermentation acids, and the applications in the leather and food industries are especially considered, as are also enzymes and their technical applications. Textbooks: *Marshall, Microbiology; Blakiston, 1921; Fuhrmann, Einführung in die Grundlagen der technischen Mykologie.* Numerous other books of collateral reading.

**7-361. Industrial Microbiology (B).** The same as Microbiology (7-36) but with extended laboratory work.

**7-362. Industrial Microbiology (B).** A continuation of the preceding with more detailed laboratory investigation on a semi-commercial scale.

**7-371, 7-372. Industrial Microbiology (A).** Seminar work and laboratory studies involving comprehensive reports and investigations of selected problems in the applications of microbiology to the fermentation and food conservation industries. Among the problems which may be considered are the development or improvement of culture and biochemical methods employed in the manufacture of industrial alcohol, acetone, glycerin, butyl alcohol and organic acids, and the study of special relations of microorganisms in the food, textile, fiber, timber and leather industries.

**7-421, 7-422. Food Fishes.** Lectures, recitations, or conferences, and laboratory work on economically important fishes and shellfish; 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 shellfish, 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.** 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 (B).** 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. Communicable Diseases (B).** The fundamental biological facts of infection, resistance and immunity. The biological characteristics of infectious diseases of special interest to the sanitarian are considered in detail. Textbooks: *Park and Williams, Pathogenic Microorganisms, Lea and Febiger; Hiss and Zinsser, A Textbook of Bacteriology, D. Appleton and Company.*

**7-52. Industrial Hygiene (B).** The various prejudicial effects of factory life upon health, including occupational accidents, 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. Consideration is given to recent research dealing with those factors related to employee effectiveness.

**7-53. Air Examination (B).** A study of the relation of the composition and physics of air to welfare, efficiency and comfort. The greater part of the course will be devoted to laboratory examination, use of special instruments for air testing, and the determination of dangerous gases, mineral and organic dusts and microbic organisms in air, and the relation of these to industrial hygiene.

**7-541, 7-542. Public Health Administration (B).** Lectures and discussions on the history, organization and administration of health departments and private health agencies, local, state and national, and on current public health problems, their valuation and the methods by which they are handled in health departments. A systematic study of the procedures of official public health agencies.

**7-551. Public Health Laboratory Methods (B).** 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.

**7-552. Serological Methods (B).** Practical methods used in serological laboratories and production of the materials used therein are studied in detail. The Wassermann test, Kahn test, etc., are included.

**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 Wassermann and Kahn tests. This course is valuable for physicians, laboratory technicians and those preparing for administrative positions in public health.

**7-56. Public Health Surveys (A).** 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 and community health score cards, and suggested satisfactory schemes of organization for municipal health activities will also be made. Textbook: *Horwood, Public Health Surveys*; *A. P. H. A. City Health Appraisal Form*.

**7-57. Municipal Sanitation (B).** Lectures and problems dealing with the general principles of sanitation as applied to the community, and including water supply, sewage and sewage disposal, sanitation of swimming pools, collection and disposal of refuse, street cleaning, housing, school sanitation, sanitation of food-stores and restaurants, control of insects and rodents, ventilation, etc. Textbook: *Horwood, Sanitation of Water Supplies*.

**7-58. Vital Statistics (B).** Lectures, recitations and problems by which the student acquires a working knowledge of statistical methods, consideration of errors, and the preparation, graphic representation, critical analysis, and interpretation of data. Textbook: *Whipple, Vital Statistics*.

**7-59. Sanitation (B).** Engineering aspects of public milk supplies, including sanitation of production, transportation and mechanical equipment used in pasteurization and handling, and other machinery incidental to the handling of milk and milk products; the principles of public health surveys; street cleaning; drainage in relation to mosquito control and control of other insects; rodent control and rat-proofing in buildings; inspection and control of shellfish areas; the sanitary aspects of food manufacturing, including plant sanitation, inspection of operatives, etc.; garbage disposal practice; smoke and noise prevention; relation of animal diseases to human welfare; general sanitary inspection methods and the principles of epidemiology.

**7-601, 7-602. Health Education (A).** A consideration of the procedures and methods used by health departments and school departments in health education. The health program of the school system is discussed in detail as to both organization and method. Practical field work is provided to allow the student an opportunity to study and participate in these activities.

**7-603. Health Education Methods.** 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 may be arranged if desired. If this subject is taken for credit no other subjects may be taken for credit simultaneously.

**7-604. School Health Administration (A).** Deals, not with the technique and methods of school health work, but with the organization of the health work expected from teachers, doctors, nurses, physical educators, nutritionists and others, presenting the objectives and measurements of accomplishment for each phase of the work. Special consideration is given to the development of a systematic health education program.

**7-605. Health Education Subject Matter.** Presenting fundamental scientific facts upon which Health Education is based, with consideration of the recent discoveries in nutrition, heliotherapy, 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.

**7-63. 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 carried out in the neighborhood of the metropolitan district.

**7-64. Public Health Problems (A).** Seminar work in which the student makes an investigation of the methods of study of special problems in laboratory technique or in public health administration, such as the control of communicable diseases, the organization and supervision of food inspection or the application of the principles of sanitary science to other problems.

**7-65. Health Hazards in Special Industries (A).** The specialized study of the dangers in particular industries, such as the rubber, textile, steel and fiber industries, and those involving the possibility of infection or of injury through abrasive particles, by poisonous gases or solvents, or other special dangers. Preventative or palliative measures in such cases are also considered.

**7-66. Epidemiology (A).** Conferences devoted to a detailed consideration of the natural history of epidemics, such as typhoid fever, diphtheria and scarlet fever, and their causes in their relation to public water supplies, milk supplies, sewage systems, insects, and personal causative factors. The student by critical examination of the more celebrated and instructive examples is enabled to prepare himself for the interpretation of corresponding phenomena arising in actual practice. A thorough review of the literature on other infectious diseases, including measles, whooping cough, influenza, tuberculosis, poliomyelitis, cerebro-spinal meningitis, is included.

**7-67. Functional Pathology (A).** Lectures and recitations, to correlate Mechanics, Physics, Chemistry, Biochemistry, and Physiology with disease manifestations.

**7-68. Pathology (A).** The principles of general pathology, with laboratory studies on prepared slides.

**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. Textbooks: for 7-701, *J. R. Smith, The World Food Resources*; for 7-702, *H. S. Eakins, Military Meat and Dairy Hygiene*.

**7-711. Technology of Food Products (B).** 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. Textbook: *Moulton, Meat Through the Microscope; Tressler, Marine Products of Commerce*.

**7-712. Technology of Food Products (B).** A continuation of 7-711, with laboratory studies on selected phases of certain industries. Textbook: *W. V. Cruess, Commercial Fruit and Vegetable Products*.

**7-722. Advanced Food Technology (A).** Advanced technical problems in special food industries, involving the use of dehydration, sterilization, homogenization equipment and special applications of physics, chemistry and biology in food technology.

**7-80. Biochemistry (B).** Primarily a laboratory course with experiments designed to illustrate basic principles of biochemical procedure, as applied in various fields. The laboratory work does not lay emphasis upon clinical aspects of physiological chemistry. Lectures cover the nature of chemical processes in plants and animals with special attention to the metabolism of foodstuffs and the nature of protoplasts.

**7-81. Enzyme Chemistry (A).** Lectures, recitations and reports, with laboratory work on quantitative study of enzyme hydrolyses, their products, and the conditions governing activity.

**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.

**7-931, 7-932. Biological Seminar (A).** Meetings of staff and graduate students for the consideration of current problems in biology and its applications. All candidates for higher degrees are required to prepare digests on assigned topics for presentation and discussion at these meetings.

The following subjects are offered as General Studies. For description of subjects see Division of General Studies.

**G63. Economic Geography.**

**G71. Principles of Biology and Heredity.**

**G75. Biological Reproduction.**

## PHYSICS

Subjects 8'00 to 8'99 (see page 74)

*The prerequisites for each subject will be found in the Tabulation.*

## GENERAL PHYSICS

**8'00. Physics (Entrance).** Covers the entrance requirements in Physics. Students passing the course are not required to take the entrance examination. No laboratory work is given. Textbook: *Practical Physics by Black and Davis, Revised Edition.*

**8'01. Physics (Mechanics).** Lectures, recitations, supervised problem and laboratory work devoted to a study of the fundamental laws of point and rigid body mechanics. Free use is made of elementary calculus.

**8'012. Physics (College Transfer).** Given during the first term for those college transfer students who already have been allowed partial credit for 8'01 and 8'02 on the basis of a substantial course in general physics taken prior to their transfer. The course is not to be taken by any student under requirement to take or to repeat 8'01 and 8'02. It is designed to supplement the transfer students' training in amount necessary to cover the requirements of 8'01 and 8'02. Free use is made of the calculus.

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

**8'03. Physics (Electricity).** A study of the laws of electrostatics, followed by a discussion of steady flow in conductors, properties of conductors, electrical energy and power, magnets and magnetic fields, galvanometers and their uses, meters, capacitance and inductance, and gaseous conduction. The calculus is used freely, and many types of problems are discussed.

**8'034. Physics (College Transfer).** Given during the second term for those college transfer students who already have been allowed partial credit for 8'03 and 8'04 on the basis of a substantial course in general physics taken prior to their transfer. The course is not to be taken by any student under requirement to take or to repeat 8'03 and 8'04. It is designed to supplement the student's training in amount necessary to cover the requirements of 8'03 and 8'04. Free use is made of the calculus.

**8'04. Physics (Electricity, Optics, and Modern Physics).** 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, and electric waves are discussed. Discussion of waves in general leads to optics, the geometrical optics of lenses and optical systems, and the physical optics of interference and diffraction. Spectra are treated, their explanation in terms of the structure of the atom is given, and various branches of modern physics are discussed.

**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 matters 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. The course is intended as an introduction to research or thesis work. Textbook: *Goodwin's Precision of Measurements and Graphical Methods.*

**8'091, 8'092. Physical Measurements.** Laboratory work in mechanics, properties of matter, and heat.

## HEAT MEASUREMENTS

**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 (B).** 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 (A).** An advanced subject consisting of selected experiments followed by a laboratory investigation of problems connected with the industrial application of heat such as thermal conductivity, thermal expansion, specific heat, ceramics, etc.

## OPTICS AND PHOTOGRAPHY

**8:15. Photography.** An elementary course in photography intended primarily as an elective for students not in Course VIII. It is concerned principally with such applications of photography as record photography, artistic photography, stereoscopic photography, color photography and motion pictures.

**8:152. Advanced Photography.** A laboratory course in photography open only to students with credit for 8:161. The experiments are concerned chiefly with the actual determination of the various characteristics of photographic materials and are designed to give practice in photographic technique.

**8:161. Optics.** Fundamental principles of geometrical, physical and physiological optics. Includes refraction at spherical surfaces, thick lenses, the limitation of rays by apertures, lens aberrations, the resolving power of optical instruments, diffraction, interference, polarization, radiation, light sources, the eye, photometry, color, photoelectricity, the design and construction of optical instruments, stereoscopy, and a detailed description of the performance of well-known optical systems such as telescopes, microscopes, photographic objectives, and projection systems.

**8:162. Optical Measurements.** Laboratory exercises illustrating the principles, methods and manipulation of optical instruments.

**8:171. Advanced Optics (B).** A course covering the same general subject matter as 8:161 in a more advanced manner.

**8:173. Color Measurements (B).** A course in the theory of methods of measuring and specifying color in both the objective and subjective sense and the application of such methods to industrial problems. The experiments are designed to illustrate the photometric and chromatic properties of the human eye and to give experience in the technique of spectrophotometry and colorimetry.

**8:174. Motion Picture Photography (B).** A lecture course of a semi-professional character intended primarily for students planning to enter the motion picture industry. The subject matter of the course is included in the *Journal of Transactions of the Society of Motion Picture Engineers*. (Not offered in 1933-34. Offered in alternate years.)

**8:181. Optics Seminar (A).** A discussion of important problems in photography and optics, including a review of the current literature and the results of researches in these fields at the Institute.

**8:191. Microscopy and Photomicrography.** Experimental lectures, approximately one-half of which are devoted to the optics of the microscope and the technique of photomicrography. The second half of the course is concerned with the application of the microscope to such fields as biology, chemistry, crystallography, metallography, ceramics, and textile engineering. The lectures during the latter half of the course are given by experts in the above-mentioned fields.

**8-193. Advanced Geometrical Optics (A).** Lectures intended primarily for students intending to specialize in optics. Open only to graduates or to seniors who have previously demonstrated marked ability in this field. (Not offered 1933-34.)

**8-194. Advanced Physical Optics (A).** Lectures intended primarily for students intending to specialize in optics. Open only to graduates or to seniors who have previously demonstrated marked ability in this field. (Not offered 1933-34.)

#### ELECTRICITY AND ELECTRONICS

**8-201. Electricity and Magnetism.** An intermediate course covering the mathematical theory and experimental aspects of electrostatics, magnetostatics, steady and variable currents, and electron theory.

**8-202. Electronic Laboratory.** A course in intermediate electrical and electronic measurements, to accompany 8-201.

**8-21. Electronic Phenomena (A).** An introduction to modern electron theory including an elementary treatment of Maxwell-Boltzmann and Fermi-Dirac statistics with applications of these theories to thermionic and photoelectric emission from metals and to gas discharge phenomena.

**8-212. Experimental Electronics (A).** The theory and use of modern experimental apparatus as applied to electronic investigations. This includes experiments with the Compton quadrant electrometer, the FP-54 vacuum tube "Electrometer," the cathode ray oscillograph and the thyratron, as well as experiments of a fundamental nature on thermionic emission, photoelectric effect, and gas discharge phenomena.

**8-213. Advanced Electronics (A).** A comprehensive introduction to the fundamental investigations of thermionic and photoelectric emission of electrons from metals and of the general problems associated with gas discharge phenomena. Both the theoretical and the experimental aspects of these problems are discussed in detail. (Offered in alternate years.)

**8-214. Advanced Electronics (A).** Continuation of 8-213.

**8-215. Special Problems in Electronics (A).** An advanced problem in electronics, with assigned reading and consultation.

#### X-RAYS AND THE STRUCTURE OF MATTER

**8-26. Polar Molecules (A).** Debye's theory of dielectrics and its application to related phenomena. Theory of dispersion and scattering of light, Kerr effect, electrostriction and electrocaloric effects. The dipole moment and the structure of molecules. Textbook: *P. Debye, Polar Molecules.*

**8-27. X-rays and Crystal Physics (B).** Lecture and laboratory work dealing with the theoretical consideration of X-ray emission and absorption and the general properties of the radiations. A considerable portion of the work will be devoted to the consideration of the diffraction of X-rays by crystals.

**8-28. X-ray Diffraction (A).** The theory of X-ray diffraction and its application to the study of the structure of matter. Elementary theory of X-ray diffraction in crystals, the Lorentz factor, temperature effect, integrated intensity, the Darwin theory of diffraction in mosaic and perfect crystals. Atomic scattering and F curves. The Fourier method of determining the electron distribution in crystals and in the atom. The Scherrer particle-size equation. X-ray scattering in liquids and gases. (Not offered 1933-34.) (Offered in alternate years.)

**8-29. Lattice Theory of the Solid State (A).** The methods and results of crystallography and the X-ray investigations of crystal structure will be discussed. The following topics will be considered: homopolar 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. (Offered in alternate years.)

**8'30. Special Problems in Crystal Physics (A).** An advanced problem in X-ray diffraction or crystal physics, with assigned reading and consultation.

#### ATOMIC STRUCTURE AND SPECTROSCOPY

**8'311. Atomic Structure.** Lectures and discussions on the phenomena leading to modern theories of the structure of matter and the nature of radiation. The photoelectric effect, properties of electrons and positive nuclei, optical and X-ray spectra, radioactivity, current models of the atom and their use in explaining the structure of the periodic table, and related topics will be considered.

**8'312. Atomic Structure Laboratory.** Experiments on selected topics in modern physics.

**8'32. Line Spectra (A).** Deals with the characteristics of atomic spectra and their description in terms of quantum numbers, their interpretation in terms of current theories of atomic structure, and their use in explaining the chemical properties of the elements.

**8'341, 8'342. Spectroscopy Seminar (A).** Discussion and reports by students of special topics in spectroscopy.

**8'343. Special Problems in Spectroscopy (A).** Supervised experimental work in the Spectroscopy Laboratory, designed to be taken concurrently with the Spectroscopy Seminar (8'341, 8'342) by students who desire to carry out special investigations which do not come under the head of thesis work.

**8'35. Excitation of Spectra (A).** Lectures and laboratory on fundamental processes of excitation, including excitation by absorption, by electron impact and by radiationless transfer of energy; arc, spark and furnace spectra; complex excitation; mixed gas discharges; optical and electrical methods of critical potential measurements; line intensities under different conditions of excitation.

**8'36. Radiation Measurements (B).** Aims to familiarize the student with modern instruments and methods employed in the measurement and analysis of ultra-violet, visible and infra-red radiation, as photoelectric cells and thermopiles. The laboratory instruction includes comparison and calibration of detectors, analysis of radiation by various methods, and practice with radiometric instrument. s. Special emphasis is placed on line intensity measurements during the last half of the course.

#### THEORETICAL PHYSICS

**8'361. Radiation Measurements Laboratory, Advanced (A).** The student will work with the instructor on some part of the latter's current research.

**8'45. Introduction to Physical Science.** A non-mathematical representation of the methods and ideas of theoretical physics, illustrated by lecture demonstrations of various phases of modern physics.

**8'461. Introduction to Theoretical Physics I (B).** Mechanics, vibrating particles, strings, and membranes, with study of ordinary and partial differential equations, Fourier series, and vector analysis.

**8'462. Introduction to Theoretical Physics II (B).** Elasticity and hydrodynamics, heat conduction, electromagnetic theory, potential theory, and the electromagnetic theory of light.

**8'463. Introduction to Theoretical Physics III (A).** Wave mechanics and quantum theory, classical and quantum statistics, structure of atoms and molecules, and the properties of matter.

**8'471. Historical Development of Physics (B).** A survey of physics up to 1900, intended to correlate the various branches, present them in their historical order, and provide a means of filling in any gaps that there may be in the student's previous training.

**8'472. Recent Developments of Physics (B).** A survey similar to 8'471, of physics since 1900. More advanced and mathematical treatment of most subjects than in 8'311.

**8'481. Advanced Mechanics I (A).** The mechanics of particles and rigid bodies treated by the generalized methods of Lagrange and Hamilton. (Offered in alternate years.)

**8'482. Advanced Mechanics II (A).** A continuation of 8'481, including the transformation theory of dynamics, the elements of perturbation theory and the general theory of orbits, non-holonomic and dissipative systems and the theory of vibrations. (Offered in alternate years.)

**8'49. Elasticity and Fluid Dynamics (A).** Theory of static elasticity and elastic vibrations. The general theory of the flow of perfect fluids, steady and turbulent flow of viscous fluids, and wave motion in fluids. (Not offered in 1933-34. Offered in alternate years.)

**8'491. Boundary Value Problems in Theoretical Physics (A).** Applications of the theory of boundary value problems to vibrations of elastic bodies, to sound and electromagnetic vibrations, and to wave mechanical oscillations. A study of the general methods used in the solution of such problems. (Offered in alternate years.)

**8'50. Heat and Thermodynamics.** First and second laws of Thermodynamics, with applications to properties of gases, change of state, and chemical equilibrium. Elementary kinetic theory, Maxwell distribution of velocities, and the Maxwell-Boltzmann formula.

**8'512. Statistical Mechanics (A).** A course in the basic principles of statistical mechanics with applications to physical problems. (Not offered in 1933-34. Offered in alternate years.)

**8'521. Quantum Mechanics (A).** General principles of wave mechanics. Analogy with optics, Newtonian mechanics as limiting case, Schrodinger's equations, stationary states for particular problems. Orthogonality, matrix representation. Variation method, perturbation method with applications of Zeeman effect, etc. Exclusion principle, resonance effects, in systems with several electrons. Aperiodic phenomena. (Not offered in 1933-34. Offered in alternate years.)

**8'522. Theory of Spectra (A).** Application of wave mechanics to the theories of line and band spectra with detailed study of the structure of atoms and molecules, and of molecular binding. (Not offered in 1933-34. Offered in alternate years.)

**8'541. Electromagnetic Theory (B).** 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.

**8'542. Electromagnetic Wave Propagation (B).** A continuation of 8'541 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.

**8'56. Electromagnetic Wave Theory I (A).** The fundamental circuital laws, energy and energy flow, scalar and vector potentials, with application to the electromagnetic theory of light. (Not offered in 1933-34. Offered in alternate years.)

**8'57. Electromagnetic Wave Theory II (A).** Mechanics of the electron, and introduction to restricted relativity. (Not offered in 1933-34. Offered in alternate years.)

**8'58. Theory of Relativity (A).** Restricted and general relativity, cosmological considerations, attempts at a unification of electricity and gravitation, quantum theory and relativity. (Offered in alternate years.)

**8'591, 8'592. Theoretical Seminar (A).** Discussion and reports by students on special topics in theoretical physics.

#### ELECTROCHEMISTRY

**8'801, 8'802. Principles of Electrochemistry.** The fundamental principles of physics and physical chemistry underlying electrochemical phenomena are discussed from the standpoint of thermodynamics and kinetics. Particular emphasis is directed to the study of electrical conduction in solutions. The instruction is by lectures, discussions and the solution of problems. Reference text: *Millard's Physical Chemistry; Buller's The Fundamentals of Chemical Thermodynamics.*

**8'82. Electrochemistry (B).** Electrical conduction in liquids, solids and gases, theories of the voltaic cell, polarization and electrolysis, the principles involved in the corrosion, electrodeposition, and refining of metals, and the energy relations underlying the mutual transformations of chemical and electrical energy. Reference: *Buller's The Fundamentals of Chemical Thermodynamics, Standard texts on Electrochemistry, and Scientific Journals.*

**8'83. Electrochemistry, Advanced.** The application of thermodynamics to electrochemical problems, including electromotive force of reversible cells, electrolytic oxidation and reduction phenomena and high temperature equilibria in electric furnaces. Reference books: *Lewis and Randall's Thermodynamics; Journal articles.*

**8'85. Applied Electrochemistry (B).** Consideration of the industrial applications of electrochemistry. Includes the theory and construction of different types of electric furnaces, electrometallurgical processes, accumulators and primary cells, and the electrolytic production of chemical compounds. The work also includes the design of one or more electrochemical plants for specific processes. Textbook: *Thompson, Theoretical and Applied Electrochemistry.*

**8'86. Electrochemical Laboratory (B).** Carried on in conjunction with 8'82. Electrical conductance, single potentials, decomposition voltages, over-voltages, polarization, and electrolysis including practice in electroplating, also efficiency tests on technical processes involving electrolysis in aqueous solutions, e.g., the production of hypochlorite, chlorate, etc. Textbook: *Special notes.*

**8'87. Electric Furnace Laboratory (B).** Carried on in conjunction with 8'85. 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. *Admission limited to the capacity of the laboratory.* Textbook: *Neostyled notes.*

**8'89. Electric Furnaces (B).** Intended for fourth year and graduate students who desire to obtain some acquaintance with electric furnace operation, without having had any previous training in applied electrochemistry. Descriptive lectures on electric furnace operation accompanied by a selected number of laboratory exercises described under 8'87. Textbook: *Thompson, Theoretical and Applied Electrochemistry and Neostyled 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. Electrochemical Colloquium (B).** 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 and electrochemistry.

**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 first term, and offered only to fourth-year and special students in Course XIV.

The following subject is offered as a General Study. For description see Division of General Studies.

**G66. Descriptive Astronomy.**

## CHEMICAL ENGINEERING

Subjects 10'00 to 10'99 (see page 74)

*The prerequisites for each subject will be found in the Tabulation.*

**10'11. Problems of the Chemical Engineer.** Describes the field of activity of the chemical engineer and the preparation along both chemical and engineering lines which the practice of the profession requires.

**10'15. Thesis Reports.** Intended to give seniors training in the presentation of the results of technical investigations by oral and written reports. An attempt is made to reproduce the variety of situations which confront the practicing engineer in presenting oral reports to groups with varying degrees of engineering training and experience.

Thesis reports consist of periodic oral and written reports on progress of thesis before fellow students and staff members in chemical engineering.

Committee reports consist of oral reports on some technical problem before student groups from various branches of engineering. The Department of English cooperates with the engineering departments in this work.

**10'17. Industrial Chemistry.** Deals chiefly with the industrial aspects of fuels, combustion and furnaces through the solution of numerous problems. Textbook: *Lewis and Radasch, Industrial Stoichiometry.*

**10'18. Industrial Chemistry.** The more important industrial chemical processes are studied from the point of view of both the chemical reactions forming the basis of the process, and the plant necessary to carry on these reactions. In this way the interrelationships of the different industries as to raw materials, sources of energy, and standard types of apparatus are developed and a general survey of the field obtained. Extensive problem work is included.

**10'191. Chemical Engineering Literature.** Readings in technical literature in both French and German, including researches in reference books and journals.

**10'192. Chemical Engineering Literature.** Continuation of 10'191.

**10'201. Industrial Chemistry.** Similar to 10'18 except that problems are of a less advanced character.

**10'203. Industrial Chemistry.** Similar to 10'18 except that problems are of a less advanced character.

**10'21. Industrial Chemistry (B).** A continuation of 10'18. Devoted to those industries which deal with amorphous solids, including glass, ceramics, leather, paints, textiles, paper, rubber, etc.

**10'25. Industrial Stoichiometry (A).** Offered for graduates of other institutions where the instruction received in physical and organic chemistry has been similar to that given at the Institute but where the instruction received in industrial chemistry has been descriptive in character. The work involves a thorough study of typical processes of chemical industry by the solution of numerous quantitative problems.

**10'26. Industrial Chemical Laboratory (B).** A study of the evolution of a chemical process from the idea as originally formulated through the successive stages of laboratory development to the design and equipment of the necessary plant.

**10'28. Chemical Engineering.** A study of the thermal properties of matter and the energy relationships underlying mechanical and elementary chemical processes. Emphasis is laid upon the application of fundamental principles to such operations as combustion, heat recovery in both continuous and discontinuous processes, heat engines, compression and pumping of fluids with particular reference to the handling of corrosive substances and to the quantitative phases of applying and dissipating heat in the control of chemical reactions on an industrial scale.

**10'29. Chemical Engineering.** Continuation of 10'28.

**10'30. Engineering Equipment.** Intended to give students selecting the Chemical Engineering Practice Option, X-B, instruction and practice in testing engineering equipment such as pumps, fans, turbo-blowers, blowing engines, motors, generators, etc. commonly used in chemical engineering operations. Emphasis will be placed on the determination of the operating characteristics of such equipment under plant conditions.

**10'31, 10'32. Chemical Engineering (B).** These subjects cover the basic principles underlying the unit operations of chemical industry. Because most of 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.*

**10'38. Chemical Engineering.** This subject offered for officers of the Ordnance Department includes a brief survey of the fundamentals of physical chemistry and chemical engineering and their application to the industrial operations involved in the manufacture of propellants and high explosives.

**10'41, 10'50. Special Topics in Chemical Engineering.** The purpose of each of these 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).** 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.

**10'42. Drying (A).** A detailed study of the basic principles of drying of solids and gases. Particular attention is given the fundamental mechanism of the drying of solids, with quantitative problems illustrating the application of the theoretical equations for the diffusion of liquids through solids. The work includes a study of those phases of Mechanical Separation, such as pressing, centrifuging, etc., which are frequently involved in industrial drying operations.

**10'43. Evaporation (A).** 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.

**10'46. Absorption and Extraction (A).** The basic principles of equilibria, mechanism and rate of interaction are studied in detail. Quantitative applications include the absorption of single gases, such as sulfur dioxide, ammonia and hydrochloric acid, and complex mixtures, such as light oil, casing-head gasoline, refinery gases, and the like. Particular attention is paid to graphical methods.

Includes a study of the basic principles of adsorption phenomena followed by problems in decolorization of oils, sugar syrups and the like; solvent recovery by adsorption and the leaching of various solids.

**10'50. Heat Transmission (A).** 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, finned surfaces, etc. Special attention is paid to the correlation of data by the methods of dimensional analysis, and to the interrelationships between heat transfer, fluid friction and absorption. For problems involving the batch warming and cooling of solids, the Fourier equations are applied graphically.

**10'52. Chemical Engineering II (A).** Offered for graduates of other schools whose training in Chemical Engineering has been along somewhat different lines from that given in 10'31 and 10'32. Emphasis is placed on basic theories in flow of fluids and flow of heat and application is made to problems of an advanced character. Attention is paid to recent developments in Chemical Engineering.

**10'53. Chemical Engineering Design (A).** Open only to students who have taken the fieldwork of 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.

**10'54. Economic Balance in Chemical Industry (A).** Lectures and conferences planned to develop original power in the solution of problems in chemical industry. The problems 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.

**10'55. Economic Balance (A).** A shorter course of the same character as 10'54, offered primarily for students of the School of Chemical Engineering Practice who have completed the field station work.

**10'62. Applied Chemical Thermodynamics (A).** Presents and illustrates those elements of thermochemistry and thermodynamics of most importance in the field of chemical engineering.

**10'63. Applied Colloid Chemistry (A).** 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.

**10'65. High Pressure Processes (A).** A study of the principles involved in the use of high pressures and catalysts in certain chemical reactions, such as the synthesis of ammonia, synthesis of mixtures of aliphatic compounds, alcohols and hydrocarbons from water gas, hydrogenation of coal and oils, cracking of mineral oils, etc., together with a discussion of industrial applications, equipment requirements, and opportunities for research.

**10'68. Corrosion (A).** Designed to assist in the selection of equipment for use in Chemical Engineering processes. Major emphasis is placed on resistance to corrosion, and considerable time is devoted to theories of corrosion and methods of prevention. The strength of materials and other factors are discussed in relation to the choice of the most economic design.

**10'70. Principles of Combustion (A).** Open to graduate students who have majored in a non-chemical branch of engineering or science and who wish to specialize in the engineering rather than the chemical phase of fuel engineering. As emphasis will be placed on the application of fundamental principles in combustion reactions, the subject matter will include instruction in physical and organic chemistry of particular importance in fuel engineering. Numerous problems, illustrating the quantitative application of these principles in fuel processing and utilization, will be assigned.

**10'71. Fuel Engineering (A).** An advanced subject in fuel engineering for students with an adequate background of physical and organic chemistry and thermodynamics. The subject includes such material as the mechanism of the combustion reactions, and the application of combustion principles to problems of design or use of equipment for fuel processing and utilization.

**10'72. Fuel Engineering Practice (A).** At the Lackawanna Plant of the Bethlehem Steel Co. (near) Buffalo, N. Y., an opportunity is provided for a study of fuel engineering under unusually favorable conditions. Coal is processed in modern coke ovens to produce metallurgical coke for blast furnaces. By-product fuels from these processes include coke breeze, coke oven gas, tar, benzol and blast furnace gas. The fuel engineer has the problem of the effective utilization of these

fuels in meeting the requirements of blast furnace stoves, soaking pits, reheating furnaces, open hearth furnaces, lime kilns, coke ovens, boiler furnaces and internal combustion engines.

Within the Buffalo area, gas plants, petroleum refineries, central power stations and industrial plants furnish a wide diversification of fuel problems. Arrangements have been made for inspection trips and plant tests to round out the student's training in those phases of fuel engineering not encountered in the steel plant.

**10-73. Fuel Engineering Design (A).** This subject, open only to men who have completed the work in Fuel Engineering Practice or who have had an equivalent industrial experience, involves the design, selection and layout of equipment needed in the solution of a major problem in fuel engineering.

**10-74. Furnace Design (A).** A study of principles and calculations of furnace design and construction dealing with rates of heat transfer and with flow of gases in furnaces. The quantitative design and layout of several furnaces, retorts or still-settings will be carried out.

**10-76. Seminar in Radiant Heat Transmission (A).** Will stress the theory and derivations incident to heat transfer in furnaces. Among the subjects considered will be the general law of total radiation in its differential form, its applications to radiation between finite solid surfaces with evaluation for special shapes of engineering importance, the law of spectral energy distribution of radiation, its application to radiation from luminous and non-luminous gases, powdered coal flame radiation, and optical pyrometry.

**10-78. Fuel Engineering Laboratory (B).** Open only to men who have had 10-70, Principles of Combustion, or its equivalent. Instruction will be given in those phases of analytical chemistry and physical measurements which are of special interest to the fuel engineer, *viz.*, analysis of gaseous, liquid and solid fuels, and products resulting from their processing and utilization; analysis of boiler feed water and its treatment with special reference to its foaming, scaling and corroding properties; determination of heats of combustion; determination of total carbon content of fuels for carbon balances in plant testing; special measurements such as the fusion temperature of ash, true temperature of gases and flames, etc.

**10-79. Automotive Fuels (A).** A brief discussion of refinery technology, particularly cracking; the mechanism of combustion in Otto and Diesel cycle engines; the relation of "engine knock" to chemical structure of a fuel; thermodynamics of engine cycles, allowing for dissociation; the volatility of motor fuels; gum in gasoline; theory of bearing lubrication. Problems illustrating these subjects will be assigned throughout the term; in addition, a comprehensive report is required at the end of the term on some motor fuel subject.

**10-81. School of Chemical Engineering Practice — Bangor Station (A).** At this station emphasis is placed on the study of electrolysis, drying, humidification, evaporation, absorption and causticization. This work is carried out in the plants of the Eastern Manufacturing Company at South Brewer, Maine, manufacturers of writing papers and sulphite pulp and of the Penobscot Chemical Fibre Company at Oldtown, Maine, manufacturers of soda and sulphite pulp. Offered from July to December and from January to May, inclusive, and may be taken only in conjunction with two of the other field stations.

**10-82. School of Chemical Engineering Practice — Boston Station (A).** 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 Everett plant of the Merrimac Chemical Company which manufactures heavy chemicals, and at the Revere Sugar Refinery, Charlestown, Massachusetts. Offered from July to December and from January to May, inclusive, and may be taken only in conjunction with two of the other field stations.

**10'83. School of Chemical Engineering Practice — Buffalo Station (A).** The work at the Buffalo Station deals primarily with flow of fluids, flow of heat and combustion, the work extending over a wide field. Quantitative studies are made and tests run on coke ovens, blast furnace stoves, gas producers and the like. Experimental work on flow of heat, flow of fluids, absorption and other unit studies of chemical engineering is carried out in connection with the recovery of light oil and ammonia from coke oven gas. The work is done at the Lackawanna Plant of the Bethlehem Steel Company, Lackawanna, New York. Offered from July to December and from January to May, inclusive, and may be taken only in conjunction with two of the other field stations.

**10'84. School of Chemical Engineering Practice — Bangor Station.** Similar to 10'81. Given during the second period of the academic year. May be taken only in conjunction with 10'85 or 10'86.

**10'85. School of Chemical Engineering Practice — Boston Station.** Similar to 10'82. Given during the second period of the academic year. May be taken only in conjunction with 10'84 or 10'86.

**10'86. School of Chemical Engineering Practice — Buffalo Station.** Similar to 10'83. Given during the second period of the academic year. May be taken only in conjunction with 10'84 or 10'85.

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

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

**10'941. Organization and Methods of Industrial Research (A).** A series of lectures on the methods of conducting scientific research, including such subjects as research organizations, problem selection, literature surveys, laboratory methods, notebooks, report writing and research direction. Specific problems on these subjects are assigned to each member of the class who is required to outline in detail, for discussion in class, his solution. Offered primarily for the staff of the Research Laboratory of Applied Chemistry.

**10'942. Organization and Methods of Industrial Research (A).** Continuation of 10'941, with major emphasis on reports and discussion of methods of attack on specific problems of industrial importance.

**10'991, 10'992. Seminar in Chemical Engineering (A).** Offered primarily for students preparing for the oral examination for the Doctor of Science degree. The first term is devoted to a consideration of special topics in applied chemistry and the second term to unit operations in chemical engineering.

## GEOLOGY

## Subjects 12'00 to 12'99 (see page 74)

[The prerequisites for each subject will be found in the Tabulation.]

**12'01. Mineralogy.** Lectures and laboratory work on the fundamentals of crystallography and mineralogy. The introductory study of crystal models is followed by instruction in blowpipe analysis. These preliminaries are then applied to the study of minerals by intensive work in determinative mineralogy. A close acquaintance is made with about one hundred and ten of the commonest minerals. The lectures cover elementary geometrical and physical crystallography and descriptive mineralogy. Textbooks: *Warren, Determinative Mineralogy*; *Dana, Manual of Mineralogy*.

**12'02. Mineralogy.** Crystallography and mineralogy of a somewhat more advanced character than that of 12'01. The laboratory work consists of the study of some of the less symmetrical crystal classes, simple crystal measurement and projection, followed by intensive determinative work on certain important minerals as well as some less common ones. The lectures include an introduction to the theory underlying our present knowledge of the structure of crystals, the application of this knowledge to mineralogy, and the genesis of certain minerals. Textbooks: *Dana-Ford, Textbook of Mineralogy, Fourth Edition*; *Clarke, Data of Geochemistry (Bull. 770, U. S. Geological Survey)*.

**12'05. Mineralogy, Advanced (A).** Seminar hours devoted to the presentation and discussion of literature bearing on certain phases of theoretical mineralogy. In the laboratory, each student pursues an original investigation of some mineralogical or crystallographic problem.

**12'15. Petrography.** Lectures on the occurrence and genesis of rocks of all types and laboratory work using the polarizing microscope in the study of thin sections of rocks. Supplemented by field excursions to instructive nearby localities. Textbooks: *Harker, Petrology for Students*; *Tyrrell, Principles of Petrology*.

**\*12'17. Petrographic Research (A).** Laboratory study of selected suite or suites of rocks. Seminar hours devoted to presentation and discussion of literature of petrogenesis. Textbook: *Bowen, The Evolution of Igneous Rocks*.

**12'211. Optical Crystallography (B).** Study of the optical properties of crystals with special reference to the identification of crystalline substances with the aid of the polarizing microscope. Students primarily interested in mineralogy and petrography study, in the laboratory, the optical properties of mineral crystals; other students receive instruction on the properties of common inorganic crystals. Textbooks: *Winchell, Elements of Optical Mineralogy, Fourth Edition, Part I. Larsen, Microscopic Determination of the Nonopaque Minerals (U. S. Geological Survey Bull. 679)*.

**\*12'212. Optical Crystallography, Advanced (A).** A continuation of 12'211, with special reference to advanced technique in the use of the polarizing microscope and its accessories. The instruction includes: the Mallard method of measuring the optic angle, the use of high index immersion melts, the Emmons' variation methods, the theory and technique of the universal stage, the direct determination of the optical constant of crystals, and heavy mineral separation. Textbook: *Winchell, Elements of Optical Mineralogy, Fourth Edition, Part I; and lecture notes*.

**12'25. Physical Crystallography (B).** This course is intended as an introduction to the study of crystalline material, with special reference to the needs of students of metallography. The subject matter includes: Elementary geometrical crystallography, with laboratory study of crystal models; simple crystal measurement and projection. Crystal structure theory: point groups, space lattices, space groups. Common structural types. The properties of crystals, especially habit,

\*12'17 and 12'212 are both not given in the same year; ordinarily these courses will be given in alternate years, but at the request of the graduate students concerned, and at the discretion of the instructor, the order of alternation may be changed.

plastic deformation, recrystallization and hardness, and the relation of these properties to crystal structures.

**12·30. Geology.** General dynamical geology. Textbook: *Grabau, Textbook of Geology, Part I.*

**12·31. Geology.** Continuation of 12·30. Historical geology, and laboratory work in lithology and on the study of geologic structures and maps. Also several geologic field trips are taken. Textbooks: *Shimer, Introduction to Earth History, Pirsson and Knopf, Rocks and Rock Minerals, Second Edition.*

**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.

**12·351, 12·352. Geological Surveying Advanced (A).** Field investigation and mapping of assigned areas with research in connected problems. Also excursions to areas of special interest.

**12·36. Field Geology.** A ten-day summer course in an area in New Jersey and Pennsylvania where an interesting geological history is presented, and where paleozoic sediments are conspicuously folded and faulted. Instruction and practice is given in detailed geological mapping and in field methods of geological work

**12·38. Physiography.** A study of the characteristics and development of land forms and the methods of interpretation of topographic maps.

**12·39. Field Geology Methods.** Standard methods of fieldwork and the making of field records; reconnaissance methods; cross sections; route geology and methods of plotting; sampling and recording of samples; use and records of photographs and sketches; and a real and detailed geologic mapping. Given partly in the laboratory and partly in nearby field localities.

**12·40. Economic Geology.** Lectures on the occurrence and origin of ore deposits. Textbook: *Lindgren, Mineral Deposits, Fourth Edition.*

**12·41. Economic Geology Laboratory (B).** The student is trained in the determination of ore minerals and their relationships in hand specimens and in polished sections. The laboratory results are correlated with the geological occurrence of the ores. Intended as a laboratory supplement to 12·40.

**12·42. Applied Economic Geology (B).** Considers the application of geology to: prospecting for new ore bodies, geophysical prospecting, alluvial prospecting, diamond drill core interpretation, mine sampling and ore estimation. The various methods of underground geological mapping are discussed.

**12·431, 12·432. Economic Geology Laboratory, Advanced (A).** 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 (A).** Seminar including reading and reports based upon the literature of ore deposits.

**12·44. Economic Geology of Fuels (B).** The origin and the geological occurrence and utilization of deposits of natural gas, petroleum and coal.

**12·46. Economic Geology of Non-Metallic Deposits (B).** 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. Microstructure of Ores and Metals (B).** Class and laboratory exercises devoted to microscopic examination of polished specimens of metals and alloys; also the identification of common ore minerals in polished sections and the preparation and examination of the products arising in the various stages of ore dressing and metallurgy.

**12·48. Engineering Geology and Hydrology (B).** 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 architectural engineering and building construction who have had no previous work in geology. Describes the character and mode of occurrence of materials of construction, and their application to problems of excavation and building.

**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, Second Edition*.

**12·521, 12·522. Paleontology, Advanced (A).** Laboratory work and assigned reading upon some aspect of Stratigraphy or Index Fossils; such as environment of fossil faunas; faunas and strata of particular regions and periods; correlation of faunas; succession of Tertiary mammals; fossil floras.

**12·53. Index Fossils (A).** 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, Second Edition*.

**12·54. Micropaleontology (A).** A study of fossil microscopic plants and animals, especially foraminifera.

**12·55. Organic Evolution, Advanced (A).** Study of various phases of organic evolution, such as evolution of man; laboratory work upon series of animals and plants to illustrate laws of evolution; evolution of plants.

**12·581, 12·582. Stratigraphy, Advanced (A).** Consists of lectures, assigned reading and laboratory work on sedimentary rocks. Also the petrographic study of sediments and methods of heavy mineral correlation.

**12·60. Structural Geology (B).** A descriptive course in types of structures found in rocks, their mode of origin, and methods of their interpretation. A review is given of the principal views on the major structural elements of the earth, and the evidence for and against such views is presented. Textbook: *Willis, Geologic Structures, 1929*.

**12·61. Diastrophism and Vulcanology (B).** The subject matter is divided into two parts. In the first, the problems of mountain building and major earth movements are considered; the cause of the movements; criteria for their interpretation; and a description of important examples. In the second part, the problem of vulcanology is treated; the genesis and history of volcanoes; the nature of the process of eruption; and the reasons for their distribution. Then the major active volcanic regions of the world are described.

**12·631, 12·632. Geological Seminar, Advanced (A).** Reading and reports based upon various phases of geologic literature. For graduate students.

**12·64. Geology of North America (A).** The physiography, stratigraphy, igneous bodies and general geologic structures of North America.

**12·65. Geology of Europe (A).** Similar in plan to 12·64, but dealing with the continent of Europe.

**12·80. Geology of Coal and Petroleum (B).** Presents in detail the geological occurrences of petroleum and coal deposits and the methods of investigating petroleum and coal properties.

**12·81. Geology of Petroleum, Advanced (A).** The stratigraphy and structure of the oil fields of the world, with special reference to those of the United States, are considered. Application is made of data in known petroliferous provinces to illustrate methods of exploration in the development of new regions.

**12·851, 12·852. Theoretical Geophysics, Advanced (A).** Dynamics of the earth's crust, isostasy, seismology, the terrestrial magnetic and electric fields, and other topics in terrestrial physics. Textbook: *The Earth, Jeffreys*.

**12·86. Elements of Seismology (B).** The course deals chiefly with the origin and propagation of earthquake vibrations and their relation to the structure of the earth. Types of earthquakes are studied as illustrating the seismic behavior

of diverse geologic structures. Seismographic instruments, records, and the application of seismology to prospecting and engineering are more briefly considered.

**12'87. Introduction to Geophysical Prospecting.** This orientation course is designed to acquaint the student with the geophysical prospecting methods as a geological tool. The principles, possibilities and limitations of the methods are discussed, and the nature of the problem of interpreting results is indicated through copious field examples.

The following subjects are offered as General Studies. For description see Division of General Studies.

**G60. Geology.**

**G62. Mineral Resources in Relation to Civilization.**

**G64. Organic Evolution.**

## NAVAL ARCHITECTURE AND MARINE ENGINEERING

Subjects 13'00 to 13'99 (see page 74)

*The prerequisites for each subject will be found in the Tabulation.*

**13'01. Naval Architecture (B).** General theory of naval architecture; units of measurement employed, methods of quadrature exact and approximate; principles of flotation, including displacement, stability and trim; longitudinal strength. Preparation of ship's lines for required conditions. Geometry of ship forms.

**13'02. Naval Architecture (B).** Continuation of 13'01, including grounding, docking, launching, tonnage, freeboard, steering and theory of sea waves; effect of rolling, pitching and heaving on strength.

**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; rolling and pitching; flooding of compartments.

**13'03. Naval Architecture (B).** 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. Subdivision for safety at sea. Estimation of weights and application to design.

**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, construction of lines, and stability and behavior in a seaway. Textbooks: *Modern History of Warships, Hovgaard, Spon, London; General Design of Warships, Hovgaard, Spon, London; Speed and Power of Ships, D. W. Taylor, Ransdell, Inc., Washington, D. C.*

**13'12. Theory of Warship Design.** Completion of the lectures on general design comprising 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; General Design of Warships, Hovgaard, Speed and Power of Ships, D. W. Taylor.*

**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; Modern History of Warships, Hovgaard.*

**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. Docking stresses. Riveted joints. Textbook: *Structural Design of Warships, Hovgaard.*

**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 in continuation of 13'22, including calculation of displacement, stability and strength by the methods used by the Bureau of Construction and Repair.

**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.

**13'33. Ship Construction.** Continuation of 13'32 dealing with carpenter and joiner work, plumbing, ventilating, heating and lighting.

**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 reconditioning for their original work when the war service is completed.

**13'38. Shipyard Organization (B).** 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.

**13'41. 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.

**13'42, 13'43, 13'45. Ship Design 13'45 (B).** Further instruction in drawing lines, calculations for displacement, curves of form and stability calculations. Calculation of launching problem, laying out inboard profile and deck plans, mid-ship 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, also to indicate plating on this model.

**13'471, 13'472. Ship Design.** Drawing-room exercises for students in ship operation. Each student works up the preliminary design of a merchant ship, and determines the dimensions, coefficients, displacement, freeboard, power and propeller requirements, and stability under various conditions of loading. He also draws an 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.

**13'50. Marine Engineering.** Describes the design of marine engines and boilers with special reference to avoidance of trouble in operation at sea.

**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.*

**13'54. Marine Engineering (B).** Includes the determination of stresses and the methods of proportioning the parts of reciprocating machinery. The vibration of ships, balancing of engines, inertia forces, dimensional analysis, and other interesting problems of the marine engine designer are treated. Textbooks: *Marine Power Plant, Chapman.* *Notes on Marine Engineering.* Reference book: *Marine Engineering, Peabody.*

**13'56. Marine Engineering.** An advanced course devoted mostly to the economic aspects of marine engineering; comparison of fuels, and the various types of steam and Diesel propelling machinery for different types of ships and trade routes; the economical operation of propelling machinery and auxiliaries at sea and in port; boilers, main engines, auxiliaries and auxiliary systems.

**13'58. Marine Engineering.** A study of the marine power plant as applied to naval vessels. Discussion and comparison of fuels, boilers, types of modern propelling machinery, auxiliaries, high pressure steam and other improvements in marine engineering.

**13'61. Marine Engine Design (B).** Computations and drawings are made for certain parts of a marine engine and a boiler. The design of riveted and welded joints, simple machine parts, choice and advantage of different engineering materials and other design problems are also discussed. Textbook: *Marine Engineer's Handbook*, Sterling.

**13'62. Marine Engine Design (B).** A continuation of 13'61. Includes the calculation of sizes and layout of main propelling units and auxiliaries of a steamship, together with diagrammatic arrangement of the principal piping systems. Propeller design and similar marine engineering problems are also treated.

**13'64. Marine Engineering Design.** The calculations for power plants of naval vessels, including boilers, main engines, and auxiliaries. The student makes a layout of the machinery arrangement for the warship design prepared in Courses 13'22, 13'23 and 13'24.

**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.

**13'70. Marine Steam Turbines (B).** Following a preliminary résumé of nozzle and blade design, based on fundamental principles, 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. Descriptions of different marine geared turbine installations, of the marine helical reduction gear and turbine auxiliary equipment are also included together with discussion of the application of fan and mechanical similitude laws.

**13'72. Marine Diesel Engines.** A detail study of Diesel engines and motorship auxiliaries; fuel injection, valve gears, types of engines, Diesel fuels; Diesel-electric drive, and calculations for auxiliaries for motorships.

**13'81, 13'82. Ship Operation (B).** The engineering and economic aspects of ship operation, a study of the various items making up the operating disbursements and incomes; calculations for operating expenses and profits on various trade routes, comparison of different types of fuels and machinery for different sizes of ships and various lengths of voyage; influence of size of ship and speed on operating expenses; turn-around and port expenses; cubic and deadweight ships; the design of cargo and passenger vessels from the owner's point of view; tonnage measurements, fuel conservation, repairs and maintenance; study of present and future trade routes, cargo movements, and factors influencing ocean freight rates. Coastwise, inland water transportation and interrelation of land and marine transportation. Numerous problems in both cargo and passenger ship operation are assigned to the student.

**13'83. Terminal Facilities.** A study of ports and port layouts, the handling and storage of ships' cargoes; piers, transit sheds, warehouses, railroad facilities, pier equipment; the design of the ship with reference to cargo handling, influence of turn-around on ship operation, longshore labor problems; marine passenger terminals. Special consideration is given to harbor and inland water transportation and the influence of the trends and developments in marine transportation on ports and terminal facilities.

## AERONAUTICAL ENGINEERING

Subjects 16'00 to 16'99 (see page 74)

*The prerequisites for each subject will be found in the Tabulation.*

**16'00. Aerodynamics of Airplane Design.** Application of aerodynamic theory to airplane design and aircraft propellers. Textbook: *Warner, Airplane Design, Vol. I; Weick, Aircraft Propeller Design.*

**16'01. Aerodynamics of Airplane Design (B).** Performance problems and general theory of longitudinal, lateral and directional stability, controllability, and maneuverability of airplanes. Textbook: *Warner, Airplane Design, Vol. I.*

**16'02. Aircraft Structures (B).** Covers the analysis of fittings and details, the use of the Precise Method for spar design, and introduction to methods for determining the deflection of beams and trusses and to the method of least work. The determination of reactions on and stresses in simple space frames is also covered. Textbook: *Niles and Newell, Airplane Structures.*

**16'05. Airplane Structures (B).** Covers the determination of load factors and the assumptions as to load distribution on airplanes, the analysis of structures by least work and by comparison of deflections, the use of methods of analysis currently employed in the design of all-metal aircraft. Textbook: *Niles and Newell, Airplane Structures and notes.*

**16'06. Advanced Airplane Structures (A).** 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, the method of least work and the method of calculating deflections. Textbook: *Niles and Newell, Airplane Structures.*

**16'08. Airplane Design Problems (B).** Lectures, discussions and drafting-room exercises devoted largely to the choice of type of airplane to be used for a given service. Several problems are assigned, and each student makes a selection of type, executes a preliminary design, and estimates the airplane weight and performance. Textbook: *Warner and Johnson, Aviation Handbook.*

**16'13. Airplane Design Practice (B).** Actual practice in design. Each student carries through the "layout" and calculations for a simple airplane. Textbook: *Niles and Newell, Airplane Structures.*

**16'14. Airplane Design Practice, Advanced (A).** The student selects his own design problem and investigates thoroughly the particular phase of the design which interests him most.

**16'21. Airship Theory (A).** A study of the aerodynamic and aerostatic forces which must be borne by an airship structure, including consideration of airship stability and control. A preliminary study is made of the properties of aerostatic gases and of the general theory of sustentation of lighter-than-air craft.

**16'22. Airship Structures (A).** Methods of stress analysis employed in the design of rigid airships, following a brief discussion of the general arrangement and design of the hull structure and of the external loading conditions.

**16'26. Advanced Aeronautical Problems (A).** Covers individual advanced work by properly qualified graduate students. Problems are selected in consultation with the instructor, and the hours are arranged to suit the individual case.

**16'30. Aircraft Propeller Design (A).** Theory and practice of propeller design including the study of propeller stresses. Classroom work is supplemented by actual design practice. Textbook: *Weick, Aircraft Propeller Design.*

**16'35. Aircraft Instruments (A).** Discussion of the use of instruments in aircraft, with analysis of the theoretical and practical problems entering into their design.

**16'52. Airplane Shop Work.** A shop and lecture course on the handling of materials used in airplane construction, and on methods of fabrication including an elementary course in airplane welding, and in fitting design and fabrication, rib and spar making, wing covering, doping, et cetera, and an elementary study of

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the various airplane types, parts and designs. Textbook: *The Airplane and Its Engine*, by Chatfield and Taylor.

**16'53. Aircraft Production Methods.** A course in which a carefully selected list of factories is visited and their basic processes studied in detail, such processes being of the type which are either directly used in aircraft production or which are allied to such production. Plants such as production machine shops, foundries, forges, mills, metal working shops, production wood working shops, and instrument makers, are included in the list. Each exercise is very carefully outlined in advance and the students enter the factories in small groups in direct charge of an instructor, and are required to submit a definite report on each visit. The course will include a week's visit to Hartford, Connecticut, where the students will spend their time in carefully studying the methods of engine and aircraft production, as developed at the shops of the United Aircraft and Transport Corporation. The pupils will be in residence in Hartford in small groups while the remainder of the men stay in Cambridge.

**16'55. Airplane Design (B).** Drafting board problems and lectures dealing with the detail design of the airplane structure, and power plant installation.

**16'62. Aeronautical Laboratory (B).** Lectures on the methods and equipment used in aeronautical research, and experience in the making of tests in the Institute wind tunnels.

**16'63. Aeronautical Laboratory and Research Methods (B).** A continuation of 16'62, with lectures on more advanced laboratory methods, and on free-flight testing, together with training in the application of these methods.

**16'69. Aeronautical Seminar (A).** Intended primarily for students conducting theses in aeronautics. Consists of a series of meetings with discussions of new publications and of current research work by both graduate students and members of the staff.

**16'73. Advanced Aeronautical Mechanics (A).** Selected advanced topics in continuation of M44, including the theory of flow potentials, the flow equations of Euler, the energy equations of Bernouilli and Kelvin, ideal two dimensional flow, theory of finite wings and wing combinations, instability of discontinuous layers, Karman streets and boundary layer.

**16'74. Advanced Aeronautical Mechanics (A).** Continuation of 16'73 with practical application of its theory and methods.

**16'76. Aeronautics (B).** Aircraft and the general principles of flight.

**16'78. Aeronautics (B).** Contains material on airship design, aerial propeller design and theory, and aeronautical laboratory methods. Intended to be supplementary to 16'76.

**16'82. Internal Combustion Engines (B).** A thorough study of the fundamentals of the internal combustion engine. Laboratory work is so planned as to illustrate principles discussed in the classroom. Textbook: *D. R. Pye, The Internal Combustion Engine*.

**16'84. Internal Combustion Engines (B).** A continuation of 16'82. Same textbook.

**16'85, 16'86. Airplane Engine Design Practice (B).** Lectures and drafting-room exercises covering certain fundamental problems in aircraft engine design.

**16'901. Introductory Meteorology (B).** Intended to give a simplified almost non-mathematical treatment of the fundamental physical laws which hold in the atmosphere and their practical working out in the usually observed meteorological phenomena. A brief study of weather maps and polar front analysis is included together with a short discussion of the principles underlying weather forecasting. Textbook: *Humphreys, Physics of the Air*.

**16'902. Aeronautical Meteorology (B).** Applications of meteorology to aviation. Includes a study of wind structure with special reference to motorless flying. Also a brief discussion of American and European aeronautical weather services.

**16'911, 16'912. Synoptic Meteorology (A).** A non-mathematical study of the phenomena of the weather map, starting with the modern conception of the structure of extra tropical cyclones, the polar front theory and the general circulation of the atmosphere. A detailed discussion of the forecasting of local weather phenomena, especially fog, showers and thunder storms.

**16'921, 16'922. Meteorological Laboratory (B).** Decoding and plotting of the daily weather reports broadcast from the Arlington radio station, analysis of weather maps and practice forecasting for selected areas.

**16'931, 16'932. Dynamic Meteorology (A).** The application of hydrodynamical and thermodynamical methods to the study of the atmosphere in rest and in motion.

**16'941, 16'942. Meteorological Seminar (A).** Weekly reviews and discussions, by staff members and students, of recent meteorological contributions published in current periodicals, and of original research.

**16'95. Meteorological Instruments and Methods of Observation (B).** Discussion of the principles of the standard meteorological instruments and practical exercises in testing and calibration of instruments. Discussion and application of aerological observation methods.

**BUILDING ENGINEERING AND CONSTRUCTION**

Subjects 17'00 to 17'99 (see page 74)

*The prerequisites for each subject will be found in the Tabulation.*

**17'20. History of Construction.** A series of illustrated lectures on the development of the art of building. The course is designed to show how man's work as a builder may be taken as an index of his cultural attainments; it reviews the history of architecture from the viewpoint of the builder; and the development of architectural forms and detail, in order to familiarize the student with the vocabulary of construction.

**17'21. Building Construction.** A study of the sequence of the construction of a dwelling of the first class. Commencing with the excavation, the materials ordinarily used in dwelling house work and their assembly are studied in the same order and sequence as the work is done in the field. Instruction is given by lectures illustrated with data sheets and from demonstration from models and samples, after which the student makes scale drawings of key details and writes a complete text describing each step of the operation.

**17'22. Building Construction.** A study of the dwelling. A continuation of 17'21.

**17'31. Building Construction.** A study of the sequence and construction of an industrial building of brick and timber. Standard mill and semi-mill construction. Excavation with power tools; sheet piling, timber joints and splices; heavy timbering and bracing; brick and brick work and the structural details characteristic of buildings of this kind.

**17'32. Building Construction.** A study of the sequence and construction of an industrial building in reinforced concrete. Typical plant layout; forms of wood and metal; reinforcing materials and appurtenances. Heavy duty floors and the structural details common to buildings of this type.

**17'41. Building Construction.** A study of the sequence construction and management of steel framed structures below and above grade; structural steel erection; fireproof floor systems; enclosure walls of brick and stone; architectural terra cotta; partitions; marble and tile work; floor finishes. Sequence of the trades; job management with special emphasis upon safety in building.

**17'42. Building Construction.** A continuation of 17'41.

**17'46. Building Construction.** General intensive course in the mechanics of building construction in wood, steel and concrete, arranged for students in other courses who desire to get a general idea of the mechanics of building.

**17'50. Job Management.** A series of lectures on the management and control of an operation in the field. Includes a study of job organization; the time schedule; the progressive and orderly sequence in which the materials should flow to the job; the coördination of the several crafts, their regulation and management; the elimination of the hazard of fire and accident. Under this heading will also be included lectures on Professional Relations; Organized Labor; Business Experience, etc.

**17'51. Structural Analysis.** A lecture and supervised drafting-room course in the graphical analysis of structures as applied to building construction and engineering. Intended to establish a connection by graphical and analytical methods between the study of applied mechanics and structural theory. Textbook: *Wolfe, Graphical Analysis.*

**17'52. Structural Analysis.** A study of the structural design of timber, including an analysis of compound beams, trussed girders, floor frames, mill construction, roof trusses and details, timber and concrete-filled columns, and special details such as stair frames and the like. Textbook: *Wood Construction, Voss and Varney.*

**17'53. Structural Analysis.** A study of the structural design of reinforced concrete, including the development of the theory of concrete design, a study of the specifications for stress, the design of fireproof slabs of several standard types,

both solid and ribbed, the design of beam and girder construction, flat-slab construction, columns reinforced with vertical steel and spirals. Textbook: *Recommended Joint Code Handbook of Reinforced Concrete and Special Notes*.

**17-54. Structural Analysis.** A study of the structural design of the steel framed commercial building, including shoring, needling and underpinning, derrick loads, standard code requirements, typical floor arch systems, beams and girders of rolled and built-up sections, study of riveted joints, review of plate-girders and trusses, columns and column loads, grillage footings, and caissons. Textbook: *Steel Construction, Voss and Varney*.

**17-65. Quantity Surveying and Estimating.** Theory and methods of preparing standardized quantity surveys for building and engineering construction estimates.

**17-73. Materials — Wood.** A study of wood designed to meet the special needs of building engineers and architects. The following subjects are discussed: growth, formation and structure; species and their characteristics; mechanical properties; decay; preservatives and fireproofing; shrinkage and drying; wood-working and finishes; plywood. Textbook: *Koehler, Properties and Uses of Wood*.

**17-74. Materials — Masonry.** Intended to give the student a well-grounded scientific and technical knowledge of the usual masonry materials used in construction. Includes a study of brick and mortars, natural and cast stone, hollow tile and block, concrete mixes, architectural terra-cotta, decorative wall and floor tile, and cements, limes, gypsum, etc. Textbook: *Departmental notes*.

**17-75. Materials — Metals and Corrosion.** Presents a fundamental background in the properties of non-ferrous and ferrous metals and alloys. Applications to construction are discussed and the problem of corrosion is considered in some detail. Textbook: *Leighon, Chemistry of Engineering Materials*.

**17-81, 17-82. Seminar.**

**DRAWING**

**Subjects D1 to D99** (see page 74)

*The prerequisites for each subject will be found in the Tabulation.*

**D11. Drawing and Descriptive Geometry.** Instruction in the correct use of drafting instruments and materials, practice in lettering and in making drawings in pencil, including the theory of dimensioning. Objects are studied in plan, elevation and section and in isometric and in oblique projection. A study of the fundamental conceptions of orthographic projection and problems on lines, planes and solids. Neatness and accuracy are required and especial emphasis is placed upon the ability to visualize the problems and the processes of solution. Textbook: *Bradley, Descriptive Geometry; French, Engineering Drawing.*

**D12. Drawing and Descriptive Geometry.** A continuation of D11. The making of dimensioned, freehand sketches of machine parts and of accurate detail and assembly drawings from the sketches. Tracings on cloth are made from the finished drawings. The study of orthographic projection through its more complex phases, including sections, developments, tangents and intersections of surfaces of revolution and elementary perspective. Textbook: *Bradley, Descriptive Geometry; French, Engineering Drawing.*

**D13. Descriptive Geometry** (College Class). Intensive work covering in the first term the complete requirements in Descriptive Geometry. Open only to undergraduate students transferring from other colleges with advanced standing who have received full credit in first-year drawing. Textbook: *Descriptive Geometry, Bradley.*

**D23. Descriptive Geometry** (College Class). Intensive work covering in the first term the complete requirement in descriptive geometry, open only to graduate students who do not require first-year drawing. *Descriptive Geometry, Bradley.*

## BUSINESS AND ENGINEERING ADMINISTRATION AND ECONOMICS

In these Departments are grouped the business subjects provided for the Course in Business and Engineering Administration (XV) and the instruction given in general economics to students of all Courses.

**Subjects Ec1 to Ec99** (see page 74)

*The prerequisites for each subject will be found in the Tabulation.*

**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.

**Ec33. Current Economic Problems (B)** Will cover a selection of the more important economic problems of the present day. Among these are the following: the problem of technological unemployment; high wage theory; the problem of full working days; gold standard; banking gold reserves; price fixing; international balances; control of speculation; tariff problem; financing by bonds vs. taxation. Instruction will be carried on through the seminar method rather than by lectures.

**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, and foreign exchange.

**Ec39. International Finance (A).** A study of the financial position of the United States, United Kingdom and other important commercial countries based upon an analysis of international payments. Consideration is given to the mechanism of exchange, international banking institutions and money markets, the financing of foreign trade, international short term and long term investments. Attention is devoted to the influence of international factors upon American business conditions and to the economic effects of nationalism as manifested in tariffs, raw material and exchange controls and other types of trade restriction.

**Ec46. Industrial Relations (B).** 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 the principles and to some extent the technique of employment management or personnel work. Outside lecturers cooperate in this course.

**Ec471, Ec472. Personnel Management (A).** Principles and technique of personnel work, sometimes called human engineering. Problems that arise in practice in recruiting, training and maintaining a labor force. Comparative studies of the methods and practices in selection, 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. Other topics for investigation will include methods of wage payment; benefit plans, including pensions and insurance; health and welfare work; housing; labor legislation, including safety supervision and workmen's compensation.

**Ec50. Accounting.** Systematic recording of financial data is a requisite of business; its basis double entry bookkeeping. But more important for management, stockholders and the general public is analysis directed toward useful conclusions. Instruction, therefore, deals with balance sheets, profit and loss statements, surplus, depreciation reserves, methods of report analyses, etc. Actual corporation reports and records are studied.

**Ec51. Industrial Accounting (B).** The application of accounting control to industry. Includes the principles of cost analysis as applied to problems of manufacturing, distribution and administration. Material used is based on a wide variety of business situations.

**Ec521. Analysis of Business Statements (A).** Aims to develop analytical ability in the interpretation of business statements and reports. Will include analysis of actual statements, study of type and information needed for complete analysis, adequacy of accounting methods used, structure and content of statements. Points of view of the creditor, the investor and the manager will be considered. Will include study of statements of financial condition, statements of earnings, operating and cost reports, both published statements and internal reports. Particular emphasis is placed upon the importance of adequate standards for comparison.

**Ec522. Control Through Business Records (A).** Control of any but the smallest business depends upon an adequate system for the gathering of information needed by executives. Examines the fundamental principles behind records systems and the extent to which various actual systems meet the requirements for which they were set up. Periodic reports, budgets, costs, cash control, internal check, inter-company and branch office control, voucher procedure, inventory records, pay roll procedure, expense control, sales records, machine accounting and special problems of control in various industries will be considered. A general study of some complete record system or a detailed study of some special problem of control will be required of each student.

**Ec53. Building Finance (B).** Describes the financing of new building projects as well as the financing of the building constructor. A general survey of the financial policy of corporations and a more detailed study of the valuation of real estate, methods of appraisal, depreciation, financing by first and second mortgages, mortgage companies, building and loan associations, construction loans and the use of bank credit. Special attention is devoted to those aspects of building finance involved in the constructor's effort to secure new business.

**Ec56. Corporations.** Deals primarily with business ownership organization and control. The economic and legal aspects of corporations receive much attention and some time is devoted to other forms of business. Consideration is given to the procedure and problems of promotion and incorporation, relationships of the parties in the corporation, and combinations of corporations in our large industrials. The development of anti-trust laws and the regulation of business by the Federal Trade Commission constitute an important part of the work. The closing weeks of the course are devoted to the study of public utility corporations with special reference to regulation and rates. (Not given in 1933-34.)

**Ec56T. Economics of Corporations.** Deals with the nature of corporations, their powers in various states, and the principles underlying their promotion, financial structure, control and reorganization. Consideration is given to the rise of trusts and combinations, the anti-trust laws and the work of the Federal Trade Commission. Particular attention is devoted to public utility operating and holding companies, their economic and legal basis and to the leading problems of rates, valuation and regulation.

**Ec57. Corporation Finance and Investments.** Deals with the 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 brokerage, speculation and the methods of the exchanges. Lecturers from investment houses assist in this branch of the subject. (Not given in 1933-34.)

**Ec581. Financial Administration of Industry (A).** Covers the fundamental principles of financial organization and management but emphasis is placed on the ordinary problems of business finance which arise in the day to day work of average manufacturing and trading enterprises. Among the topics devel-

oped are the promotion and organization of corporations, holding companies and their uses, problems of capitalization, the marketing of securities, the administration of income, expansion and reorganization. Attention is given to the relations of corporations with such financial institutions as banks, commercial paper houses, and credit agencies. Other topics considered are working capital requirements, analysis of securities, financial statements and their interpretation, corporation income tax reports, credits and collections, insurance, price policies and budgetary control.

**Ec582. Financial Administration of Industry (A).** Deals chiefly with the practical problems of internal financial management as those problems emerge in concrete situations. Based upon the principles developed in Ec581, the course proceeds with an analysis of the specific problems confronting business managers in the manufacturing, mercantile and public utility fields. The case method is used throughout and the cases represent actual business situations. Oral and written reports constitute an important part of the work.

**Ec591. Public Utility Organization and Finance (A).** A study of the ownership organization and financial management of public utility corporations. The subject matter includes a brief study of corporations in general, followed by the application of the general principles of finance and management to public utility enterprises. Among the topics considered are: capitalization, the marketing of securities, the managing of income, surplus and dividend policies, accounting practices and the interpretation of financial statements. Special attention is given to questions connected with public utility holding companies.

**Ec592. Public Utility Regulation and Rates (A).** Deals with the nature and scope of public utilities, their legal organization, the development of the agencies of regulation, the work of the Commissions and the history of judicial review. Among the topics studied are: Valuation for rate making, the rate of return to investors, depreciation policies, rate structures, taxation, public relations, and public ownership. Lectures, recitations and reports constitute the method of study and each student is required to attend and report upon certain hearings before the Massachusetts Public Utilities Commission, when such hearings are in progress.

**Ec61, Ec62. Business Law (B).** This subject acquaints the student with the legal system in its relation to the problems and policies of business administration, and deals with those rules of general law that have frequent and direct application to the more familiar business transactions and business relations. Covers A: business transactions; (1) the relation of buyer and seller, (a) general principles of contracts, (b) sales of personal property; (2) the relation of debtor and creditor, (a) guaranty and suretyship, (b) mortgages, pledges and conditional sales, (c) mechanics' liens, (d) negotiable instruments, (e) bankruptcy; B: business relations; (1) employer and employee, (a) contracts of employment, (b) agency, (c) workmen's compensation; (2) types of business organization, (a) sole proprietorships, (b) partnerships and unincorporated associations, (c) corporations.

**Ec63. Business Law and Organization (B).** 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. (For graduate students in Course VI-A only.)

**Ec64. Business Law.** This subject acquaints the student with the legal system in its relation to the problems and policies of business administration, and deals with those rules of general law that have frequent and direct application to the more familiar business transactions and business relations. When considering business transactions, he learns of the relation of buyer and seller, the general principles of contracts, sales of personal property, the relation of debtor and creditor, mortgages, pledges, and conditional sales. When studying business relations, he investigates legal relationships between employer and employee, contracts of employment, agency, workmen's compensation, and types of business organization. (For graduate students only.)

**Ec65. Statistics.** Elementary instruction in the methods of analysis, presentation, and interpretation of statistics. Includes averages, measures of dispersion, index numbers, correlation, analysis of time series, and the preparation of statistical tables and charts. Consideration is also given to the precision of measurements and computations.

**Ec661, Ec662. Statistical Methods (A).** Determination of historical trends and periodic fluctuations of economic time series with applications to the making of index numbers of business conditions. Some of the other topics included are association, correlation, and applications of elementary probability to sampling and inspection. Either term may be taken independently of the other.

**Ec681, Ec682. Business Cycles (A).** A study of the fluctuations in the different phases of business. In this is involved statistical interpretation, theories of the business cycle, studies of the intercausation of the different types of business changes, the interpretation and experimental tests of forecasting methods.

**Ec70T. Production.** Deals with problems encountered in the production of manufactured goods. Among the more important topics considered are: organization; plant location, layout and equipment; purchasing; intra-factory transportation; traffic; inspection; stores control; design; time, motion and fatigue study; and production control.

**Ec71. Business Management (B).** Deals with the application of the principles of scientific management to production and distribution. Topics covered include research, both technical and commercial; standardization and simplification; production control; sales forecasting; quotas; budgets and incentives for production and sales. By parallel study of production and marketing practices, the development of similar principles in both fields is emphasized.

**Ec72. Business Management (B).** Deals with the management and administration of business enterprises. Subjects considered are: technique of executive control; sales management, determination of selling policies and advertising; administrative problems.

**Ec73. Management Laboratory.** Designed to give the students practice in the application of (a) Fundamentals of Motion and Time Study; (b) Modern Office Equipment.

The work will be carried on through the use of case problems; moving picture film analysis of factory operations and processes; illustrated lectures; and demonstrations of modern office equipment.

**Ec74. Contracting 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, coordination of sales, finance and construction programs, organization and management of small construction enterprises, cost accounting, and the law of contracts.

**Ec751. Manufacturing Analysis (A).** Deals with the analyses of management methods in a manufacturing establishment. Schedules are prepared for the critical investigation of such functions as organization, arrangement and maintenance of buildings and equipment, product research and design, purchasing, traffic control, storage of materials and product, intrafactory transportation, quality control, salvage, time study and production control. Library research, field interviews and inspections, and a brief thesis are requirements of the course which is conducted as a seminar.

**Ec761. Industrial Marketing (A).** An advanced course in the methods and problems of marketing goods to manufacturers and other industrial users. Deals with the basic problems presented by this type of marketing, and compares them with the problems involved in marketing manufactured goods for consumption. Special emphasis is given to the coordination of selling methods and to the fundamentals underlying sales policies. Specific problems of individual concerns engaged in this type of marketing form the basis for class discussion.

**Ec762. Retail Marketing (A).** The course is designed primarily for students who plan to enter retail chain or department store organizations, or concerns marketing their products through such outlets. It covers such topics as merchandising organization and control buying, retail advertising and sales promotion, personnel, store operation, credit management, and general retail management problems. The case method of instruction is used. Reports of individual investigations are required from time to time.

**Ec766. Advertising.** Deals with the underlying principles and technique of advertising, with particular emphasis on the viewpoint of the business man, using advertising as a tool. The subject deals with the advertising of both industrial and consumer goods.

**Ec781. Standards of Measurement in Industrial Management (A).** Measurement in management is as essential to the successful conduct of any industrial enterprise as measurement in the strictly engineering field is to the successful design, construction and functioning or operation of some structure or machine. It is the application to management of the principle that a quantitative unit of measure is essential to the scientific regulation of any activity. Classroom discussions will be based upon specifically prepared notes, typical problems, and original inquiries by the student into the fundamentals upon which management is based. Measures to be studied will apply to men, methods, money, machines and materials in manufacture and other places of business activity, typical of which are economic lot sizes, economic life of equipment, economic control of quality efficiency of human effort, the economic characteristics of industry and financial ratios.

**Ec782. The Business Audit (A).** For the successful administration of business the executive must have a highly developed sense of values and a keen appreciation of what constitutes the "total situation" which confronts him at any instant in this era of rapid economic change. Judgment must be supported by a careful evaluation of all factors if the decisions of the executive are to be sound and this entails a thorough comprehension of the true standards for business. Based on original investigations, classroom discussions will be devoted to a study of the nature, relationship and behavior of the fundamentals governing all business activity with the objective of evolving a basic philosophy, with accompanying criteria by means of which adequate business policies may be determined. To establish the necessary criteria and technique for a business audit consideration will be given to economic forces, human behavior, laws and functions of management, organization, business ethics, inter- and intra-industrial relationships and the overall efficiency of management as it relates to the combined effectiveness of purchasing, manufacture, marketing, finance, accounting, research and office management.

**Ec80. Ocean Shipping Administration.** Deals with the types of ocean services and traffic agencies and their organizations; rate and traffic agreements; ocean shipping documents; ocean rates and regulation; marine insurance; and admiralty law. Its purpose is to acquaint the student with the more important aspects of the business administration of ocean shipping activities.

**Ec81, Ec82. Marketing.** An elementary course in the marketing of manufactured products, with particular emphasis on those goods sold for general consumption. Such topics as the following are covered: the principles of consumption, determination of markets, merchandising, or product control, methods of retail distribution, types of retail and wholesale institutions, sales planning and budgets, sales management, sales promotion and advertising.

**Ec85. Government Control of Industry (A).** A study of the relationship of the state to economic activity. Two main aspects will be considered: A. Development, nature and extent of government control; B. Proposed extensions of control. Under A, emphasis is laid on the following topics: instruments of control such as taxation and the administrative commission as developed in the United States, notably the Interstate Commerce Commission, the Federal Trade Commission and the state public utility commissions; protection of consumers and wage-earners; control of the corporation, security issues and accounts; holding company

regulation; monopolies, trade associations and the anti-trust laws. Under B is included a critical consideration of proposed changes in the anti-trust laws, and of the current proposals for economic planning, extension of government ownership and control, and socialism.

**Ec90. Investments (A).** Deals with the mathematics and accounting of investments, the classes of investors, the work of the investment merchants, the nature of investments and the characteristics of the various types of investment contract. A more detailed analysis is then given to the various types of obligors. Particular attention is paid to the investment attributes of the bonds of governments and of railroad, public utility and certain industrial corporations.

**Ec91. Investment Analysis (A).** Various methods of analyzing financial reports of companies whose securities are placed upon the market. Risks versus yield of junior and senior obligations; yields and risk of common stock; problems raised by convertible securities; measurements of risks and yield of the securities of new enterprises; of the securities of established enterprises in expanding stationary and dwindling industries; relation of price to earnings; risk and yield of securities of holding companies and investment trusts; railroad records and derivative ratios; analysis and interpretation of statements of public utility and industrial corporations; measurement of trends within an industry; tests of ratios applicable to investments and of systems of rating.

**Ec95. Industrial Traffic Management (A).** A detailed study of the organization and operation of a traffic management department of an industrial plant. The course deals with industry's conception, interpretation and use of such matters as freight classifications, rate structures, routes, carrier-shipper relations, common carrier liabilities, general and special services, national and state common carrier regulations and protective insurance. Due consideration is given to the types of transportation agencies such as rail, water, air, motor truck, mail, parcel post and express. Seminar discussions are supplemented with classroom conferences conducted by traffic managers from representative industries.

**Ec98. Industrial Research Methods.** Presents the technique essential to the proper conduct of thesis investigations in industry.

**Ec99. Industrial Problems (B).** This course will coördinate the previous subjects which the student has taken. The work will consist of a series of readings and problems illustrating the application of underlying principles to specific business situations. The emphasis will be upon the formulation of a well rounded administrative policy as distinguished from the previous functional approach. In this way, the interdependence and interrelations of Marketing, Finance, Accounting, Production, and Statistics will be indicated.

The following subjects are offered as general studies. For description of G25 see Division of General Studies.

**Ec46. Industrial Relations.**

**G25. Investment Finance.**

## ENGLISH AND HISTORY

## Subjects E1 to E99 (see page 74)

*The prerequisites for each subject will be found in the Tabulation.*

**E1. English (Entrance).** For description see entrance requirements.

**E11. English.** Provides training in oral and written English. In addition to the class exercises, the students meet in small groups for the presentation of short informal talks; there are frequent themes based on the student's experience and on supplementary reading, and conferences in which the written work of the individual student is corrected by the instructor.

**E12. English.** A continuation of E11, with provision for special types of writing and of reading in accordance with the interests of different groups of students.

**E15. English Composition.** A course in composition to be taken by any third or fourth year student whose written work in his professional courses shows that he needs further training.

**E21. English and History.** The subject matter of the course is in the field of history, a choice being offered among several options. As in the first year, the writing of themes, practice in public speaking, and individual conferences on written work form an integral part of the course.

**E22. English and History.** Deals with the chief ideas of nineteenth century and contemporary thought as expressed in the literature of the period. Alternative courses are offered for men properly qualified. The writing of themes, practice in public speaking, and individual conferences on written work form an integral part of the course.

**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.

**E41. Problem Analysis.** The object is to train students in architecture to present in definite and clear form the reasons that have actuated them in preparing plans for any given project. Emphasis is placed especially on careful preparation in written form and in oral delivery before final presentation.

**E42. Problem Analysis.** The theory and practice of effective and convincing presentation of an architectural proposition to a non-professional audience. This course consists almost entirely of group work.

**E44. 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.

**E45. 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.

**E46. 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.

The following subjects are offered as general studies. For description see Division of General Studies.

**G1, G2. History of Science.**

**G41. Contemporary English Literature.**

**G42. Contemporary European Literature.**

**G43. American Literature.**

- G44. The Philosophic Dramas of Literature. (Not offered in 1933-34.)
- G45. The Bible as Literature. (Not offered in 1933-34.)
- G46. Public Speaking.
- G47. Committee Reports.
- G48. Appreciation of Music.
- G49. Literature and the Fine Arts.
- G51. Biography in Science.
- G54. Science and Civilization.
- G55. French Revolution and Napoleon. (Not offered in 1933-34.)
- G56. Beethoven and Wagner. (Not offered in 1933-34.)
- G591, G592. Problems of Modern Philosophy.

## GENERAL STUDIES

This division includes those subjects of a general and essentially non-vocational character which are offered for the purpose of giving the student an opportunity to broaden his education. They are designed to introduce him to fields of thought and interests outside of his chosen professional work.

Sixteen units of general study subjects are required, eight of which may be selected by the Department, others elected by the student. 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.

European Civilization 4'461, 4'462 and Industrial Relations Ec46 are offered as general studies.

Elementary or Intermediate Language in excess of the entrance requirement, included in certain courses, may be accepted as general studies up to eight units. In other courses students may elect such language subjects as general studies, but only up to eight units.

## SOCIAL, POLITICAL, ECONOMIC AND BUSINESS SUBJECTS

First Term	Second Term
G3. International Law and American Foreign Policy.	G6. Psychology of Social Adjustment.
G5. Psychology; General Principles.	G10. Development of Transportation.
G25. Investment Finance.	G28. Introduction to Business Management.
G27. Introduction to Business Management.	G32. Humanics.
G31. Humanics.	G92. Military History and Policy of the United States.
	Ec46. Industrial Relations.

## SCIENCE

G1. History of Science.	G2. History of Science.
G60. Geology.	G63. Economic Geography.
G62. Mineral Resources in Relation to Civilization.	G64. Organic Evolution.
G651. General Science.	G652. General Science.
G71. Principles of Biology and Heredity.	G66. Descriptive Astronomy.
	G75. Biological Reproduction.
	G76. History of Philosophy.

## FOREIGN LITERATURE

G821. French.	G822. French.
G831. French.	G832. French.
G921. German.	G922. German.
G931. German.	G932. German.

## LITERATURE, ENGLISH, HISTORY AND FINE ARTS

First Term	Second Term
G42. Contemporary European Literature.	G41. Contemporary English Literature.
G46. Public Speaking.	G43. American Literature
G47. Committee Reports.	G44. Philosophic Dramas of Literature. (Not offered in 1933-34)
G49. Literature and the Fine Arts.	G45. The Bible as Literature. (Not offered in 1933-34)
G51. Biography in Science.	G47. Committee Reports.
G55. French Revolution and Napoleon. (Not offered in 1933-34)	G48. Appreciation of Music.
G591. Problems of Modern Philosophy.	G50. Fine Arts in Modern Life.
4'461. European Civilization.	G51. Biography in Science.
	G54. Science and Civilization.
	G56. Beethoven and Wagner. (Not offered in 1933-34)
	G592. Problems of Modern Philosophy
	4'462. European Civilization.

## Subjects G1 to G99 (see page 74)

*The prerequisites for each subject will be found in the Tabulation.*

**G1. History of Science.** The history of science from its beginnings. The Babylonians and Egyptians, the development and decline of Greek Science; the transmission of science into Western Europe; the science of the renaissance. The course centers around the physical and biological sciences, but attention is paid to technical arts and sciences. Emphasis is placed on the development of scientific spirit and method.

**G2. History of Science.** A continuation of G1 covering in some detail the history of the various sciences to the end of the eighteenth century. Nineteenth century science is studied along the two lines of its most important developments — geology, biology, and the theory of evolution; chemistry, physics, and the atomic nature of matter.

**G3. International Law and American Foreign Policy.** Lectures with textbook as an outline. Designed to help a student to an intelligent understanding of international relations from the standpoint of American interest. One report will be required on a current international topic based on outside reading and chosen by the student with the approval of the instructor. Selected reports will at times be presented orally and discussed.

**G5. Psychology.** General principles of psychology.

**G6. Psychology of Social Adjustment.** The psychology of social adjustment; personality, normal and abnormal; the individual in the group; social pressures and social sanctions; personal adjustment in the family, the vocational group and the community.

**G10. Development of Transportation (B).** A series of thirty lectures on the history and development of transportation from the beginning down to the present day. It deals with land, water and air transportation, and includes, as transportation agencies, the railways, highways, ocean, coastwise and inland waters, and commercial airplanes. The influence of these various means of transportation upon the industrial, economic and social development of the world forms the fundamental thesis of this course. The interrelation of the arts, general sciences and transportation is emphasized.

**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 stock exchanges, brokerage, speculation and the various kinds of business houses which deal in securities and investments. Students in Course XV will receive no credit for G25 as this subject is covered by Ec57.

**G27, G28. Introduction to Business Management.** Designed to introduce the student to the functions and methods of business. The principal fields touched are corporate organization, finance, accounting, production, marketing, and the legal principles applicable thereto. Emphasis is placed on the inter-relations between these various functions. Consideration of business problems in the order they would be encountered were a new business to be launched, namely; analyzing the field for a new venture; promoting the concern; organization; operation; control; and problems of expansion or liquidation. (Not open to Course XV and XIII-C.)

**G31. Humanics.** A series of conversations and discussions regarding the great variety of conditions and human contacts which arise in the course of employment, together with desirable methods by which to meet such conditions when they occur. The need for the development of specific traits of character and habits will be emphasized as well as their bearing upon the chance for success or failure in business. Typical situations together with an account of what was actually done, will be presented as a basis for other problems to which the student will be asked to think out a solution. In addition to these problems, actual situations will be handled in the classroom. Selected students will act as foreman, superintendent, etc., in cases dealing with discipline, requests for promotion, and other problems which an executive must meet adequately. The person taking the part of the employee is brought in from industry and the technique of the students handling the situation is subsequently criticized by actual business executives.

**G32. Humanics.** A continuation of G31.

**G41. Contemporary English Literature.** Treats of a number of the most important English men of letters from 1890 to the present time.

**G42. Contemporary European Literature.** An introductory study of some of the chief figures in European Literature of the past century and today.

**G43. American Literature.** American writers, particularly those of the nineteenth and twentieth centuries, discussed with emphasis on their relation to contemporary life.

**G44. The Philosophic Dramas of Literature.** The study of a selected number of the most important poems and dramas of literature. The choice will be made from among the following: *The Book of Job*, *Prometheus Bound*, *The Divine Comedy*, *Hamlet*, *Paradise Lost*, *Faust*, *The Ring* by Richard Wagner, *The Dynasts*. (Not offered 1933-34.)

**G45. The Bible as Literature.** A study of the historical background and the literary treatment of the material of the Old and New Testaments. (Not offered 1933-34.)

**G46. 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.

**G47. Committee Reports.** 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 required. Many musical illustrations are performed in the classroom. The lectures and textbook endeavor to give simply and clearly the knowledge needed by an intelligent listener. Textbook: *Scholes, Listener's Guide to Music; Landormy, History of Music*.

**G49. Literature and the Fine Arts.** The problems, purposes, and products of the contemporary artist, especially in literature, seen against the past, the object being to give the student a breadth of outlook on the artistic activity of our day.

**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. Textbook: *Reinach, Apollo, the Story of Art (Scribner's)*; *The Significance of the Fine Arts (Amer. Inst. of Archts.)*.

**G51. Biography in Science.** Offers training in the preparation and oral presentation of papers before organized groups, such as section meetings of a professional society. The papers are based on reading in the field of biography, chiefly of men of science. Not open to students below the fourth year.

**G54. Science and Civilization.** The position and importance of science in the history of civilization. The emphasis is on the major influences of science upon the development of our present-day civilization.

**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. (Not offered 1933-34.)

**G56. Beethoven and Wagner.** An introduction to the lives and the works of the two most significant composers of the past 150 years. (Not offered 1933-34.)

**G591. Problems of Modern Philosophy.** The self and the will. Lectures and discussions, outside readings and reports.

**G592. Problems of Modern Philosophy.** Idealism and realism. The same methods as in G591.

**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*.

**G62. Mineral Resources in Relation to Civilization.** The physical environment of the human race is first considered from a general viewpoint. The following resources of the earth are then discussed: sources of power; minerals used in industry, including iron and other metals; cements, clays, salts and other non-metallic natural products. The items broadly covered are geology, prospecting, mining, beneficiation, economics and reserves.

**G63. Economic Geography.** Deals with the seas and the land masses of the world, with the geography of the human races, with the world's resources in mineral wealth and its resources of plant and animal origin; also with the distribution of commodities, with manufactured products, with the economic basis of world trade and with national control of raw materials.

**G64. Organic Evolution.** A discussion of evolution, what it is and how it is shown in the organic world. There is especial reference to the evolution of man, his physical ancestry, his inherited impulses, and the development of his cultural environment. Textbook: *Shimer, Evolution and Man*.

**G651, G652. General Science.** Non-technical and designed to impart a cultural appreciation of the natural sciences. The treatment emphasizes the aspects of each science that bears upon the architect's interests.

**G66. Descriptive Astronomy.** A general survey of the facts and theories relative to the solar system and the sidereal universe illustrated by slides. Textbook: *Duncan, Astronomy*.

**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: *Waller, Genetics, Third Edition, 1930*.

**G75. Biological Reproduction.** For students without previous training in biology. Lectures, lantern slides, moving pictures, and clay modeling, in illustration of the basic phenomena of reproduction in plants and animals from proto-

zoa 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. Reference book: *Outlines of Modern Biology*, Plunkett, Henry Holt Company, 1930.

**G76. History of Philosophy.** A general survey of modern philosophy from the time of Descartes.

**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.

**G831, G832. French.** Outline of the history of French literature. Reading of illustrative specimens and some masterpieces complete: Chanson de gestes, medieval theatre, Villon, Montaigne, Rabelais, Corneille, Racine, Moliere, Voltaire, Rousseau, the Romantic School and subsequent movements.

**G921, G922. German.** Practice in understanding spoken German, expression in German of scientific ideas, general and technical. Reading of texts on science and industry. Each term may be taken independently.

**G931, G932. German.** A brief survey of some period of school of German literature with the reading of some masterpieces. A brief outline of the history of German literature is given, but the attention is chiefly centered on such topics as Goethe and Schiller, the novel, the modern theatre. Each term may be taken independently.

**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 or of the political or other factors leading up to the events referred to except where a clear understanding of the situation requires it. Required of students registered in any Advanced R. O. T. C. Unit. Ordinarily taken during the second term senior year, but may be taken during second term junior year.

## MATHEMATICS

### Subjects M1 to M99 (see page 74)

*The prerequisites for each subject will be found in the Tabulation.*

**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 algebraic functions; derivatives; differentials; maxima and minima; applications to simple problems in geometry and mechanics, such as the determination of velocity, acceleration, areas, volumes and pressure. A brief discussion of the analytic geometry of the straight line and the conic sections, and the plotting of the curves in rectangular coördinates. Textbook: *Woods and Bailey, Elementary Calculus, Revised Edition.*

**M111. Calculus.** An elementary course adapted to the needs of students of Architecture.

**M12. Calculus.** Differentiation and graphical representation of trigonometric, inverse trigonometric, logarithmic and exponential functions, with applications to simple problems of geometry and mechanics, including related velocities, maxima and minima, simple harmonic motion, and curvature; series. Textbook: *Woods and Bailey, Elementary Calculus, Revised Edition.*

**M21. Calculus.** Partial differentiation; integration of functions of one variable including use of tables; definite integrals; geometrical applications to areas and lengths of plane curves, volumes of solid; 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, Revised Edition.*

**M22. Differential Equations.** A treatment of ordinary differential equations including the principal types of first and second order equations, simultaneous equations, and linear equations with constant coefficients. The work is illustrated by numerous applications to geometry, chemistry, physics and mechanics. Textbook: *Phillips, Differential Equations.*

**M23, M24. Algebra and Geometry.** Determinants, matrices, theory of equations, quadratic forms, conics and quadrics, curvilinear coördinates, elements of analytic geometry.

**M26. Least Squares (B).** 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. Textbook: *Franklin, Differential Equations for Electrical Engineers.*

**M36, M37. Advanced Calculus (A).** Fundamental principles, power series, partial differentiation, implicit functions, Gamma and Beta functions, line, surface and space integrals, vectors, ordinary differential equations, Bessel functions, partial differential equations, calculus of variation, elliptic integrals. Textbook: *Woods, Advanced Calculus.*

**M41. Differential Equations.** Especially adapted to the needs of students in chemical engineering. Textbook: *Hitchcock and Robinson, Differential Equations in Applied Chemistry.*

**M43, M44. Theoretical Aeronautics (B).** Elementary dynamics of particles, fluids, and solid bodies, with applications to aeronautics.

**M441, M442. Geometry.** Selected topics from differential and algebraic geometry. (Not offered in 1933-34.)

**M451, M452. Fourier's Series and Integral Equations (A).** 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.

**M461, M462. Theory of Numbers (A).** Elementary theory, divisibility, properties of numbers, congruences, quadratic residues, linear forms, binary quadratic forms, higher theory of numbers, algebraic domains, ideals.

**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.*

**M551, M552. Functions of a Real Variable (A).** The first term is primarily devoted to a formulation of the fundamental concepts of infinitesimal analysis more precise than the intuitive treatment in the elementary calculus course. Among the topics treated are real numbers, functions, continuity, derivative, integral, sequences of functions, equi-continuity, uniform convergence, existence theorems, Taylor's series, Fourier series. (Not offered in 1933-34.)

**M561, M562. Functions of a Complex Variable (A).** A study of the elementary functions for complex values of the variable. Development and application of the fundamental theorems of the analytic function theory. Elements of the theory of the Gamma function, the elliptic functions, and other special functions.

**M571, M572. Differential Equations (A).** Presupposing the formal solution of differential equations as given in undergraduate courses, this subject deals with the following topics: existence theorems of the various types, Cauchy polygons, Picard successive approximations, power series and majorant functions; the properties of functions defined by differential equations, especially linear differential equations; and partial differential equations. An idea of the direction of the subject can be had by consulting Goursat-Hedrick, "A Course in Mathematical Analysis," Volume II, part 2, and Bieberbach, "Differentialgleichungen."

**M581, M582. Continuous Groups.** A study of the basic concepts of group-theory, such as group, sub-group, invariant sub-group, finite and infinitesimal transformations; one-parameter groups and their applications to differential equations and geometry;  $r$ -parameter groups, structure constants, the fundamental theorems of Lie; invariant theories associated with continuous groups; differential invariants and applications to systems of partial differential equations.

**M62. Modern Algebra.** Polynomials, determinants, linear equations, linear transformation, matrices, bilinear, quadratic, and Hermitian forms, introduction to fields and algebras.

**M631, M632. Differential Geometry (A).** Introduction to differential geometry of curves and surfaces in ordinary space. Differential invariants. Generalization to  $n$  dimensional Riemannian manifolds with the aid of the Ricci calculus. (Not offered 1933-34.)

**M641, M642. Advanced Differential Geometry (A).** This subject, a continuation of M632, contains some of the modern developments in differential geometry, especially those involving tensor calculus, and is particularly useful for students who wish to do research work in this field.

**M651, M652. Analytical Mechanics (A).** Analytical dynamics of particles and rigid bodies is treated mainly by Lagrange's equations in generalized coordinates and Hamilton's canonical equations. Contact Transformation, the Hamilton-Jacobi theory, the theory of vibrations, and non-holonomic systems are among the topics discussed. (Not offered 1933-34.)

**M661, M662. Algebra of Quantum Theory (A).** An introduction to the non-commutative algebras employed by Dirac, Weyl, Heisenberg and others, including the theory of group characters. Slater's matrices, and homopolar va-

lence. Lectures, problems and assigned reading. Familiarity with quantum theory is not prerequisite.

**M671, M672. Potential Theory (A).** In the first term, the elementary theory. Logarithmic, Newtonian, potential. Potentials of simple and double distribution. Laplace's and Poisson's equations. Harmonic functions. Connection with function theory in the case of two dimensions. Harnack's theorems. Boundary value problems for the circle and the sphere. Poisson's integral. Spherical harmonics. Applications to physics. In the second term, general treatment of the boundary value problems of potential theory. Integral equations. The method of Perron-Remak. Green's function. Applications to conformal mapping. (Not offered 1933-34.)

**M681, M682. Calculus of Variations (A).** Extension of the theory of maxima and minima as begun in calculus. The determination of functions, curves or surfaces with given maximum or minimum properties. Applications to geometry and physics; geodesics, minimal surfaces, isoperimetric properties of circle and sphere, Fermat's principle of least time (optics), Hamilton's principle, catenary, brachistochrone. Reference books: *Bolza, Lectures on the Calculus of Variations; Bliss, Calculus of Variations; Goursat, Cours d'Analyse, vol. 2, chapter XXIII; Courant-Hilbert, Methoden der Mathematischen Physik, chapter IV.* (Not offered 1933-34.)

**M70. History of Science (B).** Same as G1 with two extra hours preparation. (Not offered 1933-34.)

**M731, M732. Mechanics.** The fundamental principles of mechanics with applications mainly to the statics and dynamics of rigid bodies.

**M76. Theory of Probability (A).** Permutations and combinations. Elementary principles of the theory of probabilities. Bernoulli's Theorem. Bayes' Theorem. Distributive functions and continuous variables. Averages. Curve fitting. Textbook: *Th. C. Fry, Probability and Its Engineering Uses.* (New York, Van Nostrand Co., 1928.)

**M77. Vector Analysis (B).** A treatment of the vector functions and operations required in theoretical work on electricity. Textbook: *Phillips, Vector Analysis.*

**M781, M782. Advanced Geometry (A).** Coördinate systems in plane, space and  $n$  dimensions. Properties of conics and quadrics. Projective geometry. Non-Euclidean geometry.  $N$ -dimensional geometry. Textbook: *Woods, Higher Geometry.*

**M791, M792. Theoretical and Applied Elasticity (A).** The fundamental mathematical theory of elasticity in three dimensions; elastic work of deformation, stress equations; stress functions; Mohr's stress diagram; bending of bars, plates, and tubes; instability; vibration of elastic systems; modern theory of strength; plasticity. Principles and methods used in practical engineering problems; principles of minimum energy and of virtual velocities; method of deflections, Ritz's method and the application of calculus of variation.

Reference books: *Love, Theory of Elasticity; Föppl, Drang und Zwang; Timoshenko and Lessells, Applied Elasticity.*

**M831, M832, M841, M842. Analysis.** A rigorous treatment of the calculus and a discussion of properties of functions of real and of complex variables. Textbooks: *Hardy, Pure Mathematics; Titchmarsh, Theory of Functions.*

**M90. Mathematical Reading (A).** Designed to give the student an opportunity to read advanced mathematical treatises under the supervision of some member of the department. The treatise chosen and the time allowed will be determined by the needs in each particular case. This course is for graduate students who may find it desirable to do advanced work not provided for in the regular courses. Undergraduates will be allowed to take the subject only under very exceptional circumstances.

The following subjects are offered as General Studies. For description see Division of General Studies.

**G1. History of Science.**

**G76. History of Philosophy.**

## MILITARY SCIENCE AND TACTICS

Subjects MS1 to MS99 (see page 74)

*The prerequisites for each subject will be found in the Tabulation.*

**MS11. Military Science.** (Required in all courses.) Consists of nine weeks of infantry drill, three weeks of instruction in rifle marksmanship, and three weeks of lectures on elementary infantry subjects.

**MS12. Military Science.** (Required in all courses.) Consists of ten weeks of infantry drill and ceremonies and five weeks of lectures on elementary subjects of military training.

**MS21. Military Science.** (Required in all courses.) Consists of six weeks of topography and map reading; six weeks of lectures on field fortification and signal communications; and three weeks devoted to branch instruction. Opportunity is given the student to choose the unit in which he desires to continue his training. Those who do not report their choice of a unit by the beginning of the second term will be arbitrarily assigned to a unit.

**MS221. Military Science. Coast Artillery.** Elements of heavy artillery; fire control instruments; target characteristics; ammunition; aiming and laying of guns; service of the piece.

**MS222. Military Science. Engineer Corps.** Engineer organization and training; military bridges; military explosives and demolitions; scouting and patrolling.

**MS223. Military Science. Signal Corps.** Tactical principles; principles of signal communication; Signal Corps equipment; codes and ciphers.

**MS224. Military Science. Ordnance Department.** Ordnance matériel.

**MS226. Military Science. Chemical Warfare Service.** Weapons; chemical agents; chemical warfare drill and command.

**MS31. Military Science, Advanced.** Drill and command. Students are given instruction in the duties and responsibilities of noncommissioned officers and junior officers in Infantry drill; in the training of recruits; and in saber and command exercises.

**MS311. Military Science. Coast Artillery, Advanced.** Position-finding, fire control, and gunnery for seacoast artillery; determination of firing data; conduct of fire; observation of fire; and analysis of drill and practice.

**MS312. Military Science. Engineer Corps, Advanced.** Organization and duties of engineers; administration and supply; scouting and patrolling; combat principles; field fortifications.

**MS313. Military Science. Signal Corps, Advanced.** Various types of codes and ciphers, their uses, and methods employed to break them down; Signal Corps tactics; message centers; administration and supply; military law; Reserve Corps regulations.

**MS314. Military Science. Ordnance Department, Advanced.** Organization and duties of the Ordnance Department; company administration; tactics.

**MS316. Military Science, Advanced.** Combat Principles of Infantry and Chemical Troops.

**MS32. Military Science, Advanced.** Drill and command. Students are assigned to companies and are given instruction in the duties and responsibilities of company officers and noncommissioned officers.

**MS321. Military Science. Coast Artillery, Advanced.** Position finding, gunnery, and fire control for antiaircraft artillery.

**MS322. Military Science, Engineer Corps, Advanced.** Military roads and bridges; fortifications; engineer combat principles; military law.

## DESCRIPTION OF SUBJECTS

**MS323. Military Science. Signal Corps, Advanced.** Theoretical and applicatory instruction on all telephone and telegraph equipment in use by the Signal Corps; applicatory instruction on Signal Corps field radio sets; instruction in International Morse code; pistol and pistol equipment.

**MS324. Military Science. Ordnance Department, Advanced.** Army organization; industrial mobilization; ordnance problems.

**MS325. Military Science. Air Corps, Advanced.** Airplane instruments; aerial navigation; meteorology; parachutes; pistol marksmanship.

**MS326. Military Science. Chemical Warfare, Advanced.** Tactics and technique of Chemical Warfare Service.

**MS41. Military Science, Advanced.** Drill and command. Students are assigned to companies and are given instruction in the duties and responsibilities of junior officers in Infantry drill and in the training of men in the enlisted grades.

**MS411. Military Science. Coast Artillery, Advanced.** Coast artillery matériel, organization, and employment.

**MS415. Military Science. Air Corps, Advanced.** Administration and supply; duties of squadron officers; special roles of each class of aviation; military law.

**MS416. Military Science. Chemical Warfare, Advanced.** Tactical employment of the Chemical Platoon.

**MS42. Military Science, Advanced.** Drill and command. Students are assigned to companies and are occupied primarily in imparting instruction and in the development of qualities of command and leadership in other students.

**MS421. Military Science. Coast Artillery, Advanced.** Tactical employment of fixed, mobile, and antiaircraft artillery.

The following subject is offered as a General Study. For description, see Division of General Studies.

**G98. Military History and Policy of the United States.**

## MODERN LANGUAGES

Several courses are offered in both French and German; one in Spanish, and one in Italian. Those in French and German are of Elementary, Intermediate and Advanced grade. In the Elementary and Intermediate courses a careful foundation is laid for reading, writing and speaking the foreign language. Great care is taken to secure a good pronunciation, a mastery of the working essentials of grammar, a reasonable vocabulary for the expression of common ideas, training of the ear, and a broad reading vocabulary. The reading texts include scientific matter, fiction, drama, historical or descriptive works of a nature to open up to the student the genius, institutions and social point of view of the country studied. 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 literary art, and a familiarity with architectural literature. The General Study courses offer the student an opportunity to carry his study beyond the Intermediate grade, increasing his practical command of the language, reading ability, and acquaintance with the greatest writers.

The one-year elective courses in Elementary Spanish and Elementary Italian are parallel to the courses in Elementary French and German. They give a training in pronunciation, essentials of grammar, and reading of varied matter. On completion a student should be able to make intelligent contact with the foreign country, be able to read correspondence and translate reading matter of moderate difficulty. In all courses the foreign language is used as much as possible in the classroom.

In the designation of subjects, the grades Elementary and Intermediate correspond to the definitions of the Modern Language Association of America and the College Entrance Examination Board. Elementary French = French Cp. 2; Elementary German = German Cp. 2; Elementary Italian = Italian Cp. 2; Elementary Spanish = Spanish Cp. 2; Intermediate French = French B or French Cp. 3; Intermediate German = German B or German Cp. 3.

**Subjects L1 to L99** (see page 74)

*The prerequisites for each subject will be found in the Tabulation.*

**L11, L12. German, Elementary.** The necessary foundation for the study of the German language and literature, or for scientific studies. It will also enable students to fulfill the entrance requirements in Elementary German. It consists of training in pronunciation, elementary grammar, acquisition of useful vocabulary and reading of easy matter, some of which dealing with science. Textbooks: *Vos, Essentials of German*, Holt; *Wright, German Science Reader*, Holt; *Hillern, Höher als die Kirche*, Heath.

**L13. German, Elementary.** For students in Course XIII-A. Similar to L11 but more extensive. (Not offered 1933-34.)

**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. Textbooks: *Herzog, Die Burgkinder, Heath; Wesselhoeft, German Composition, Heath; Greenfield, Technical and Scientific German, Heath.*

**L23, L24. German (Aeronautical).** For students in Course XVI. Review of grammatical principles. Readings adapted to the needs of aeronautical students. Textbooks: *Pfister, Der Bau des Flugzeuges, Hefte 1, 2, 3, Volckmann Nachfolger, Berlin; Langsdorff, Das Segelflugzeug, published by J. F. Lehmann.*

**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. Textbooks: *Selected texts from the Goetschen Scientific Series.* (Not offered in 1933-34.)

**L51, L52. French, Elementary.** The necessary foundation for the study of the French language and literature, or for scientific studies; it also enables students to fulfill the entrance requirement in elementary French. Consists of training in pronunciation, elementary grammar, acquisition of useful vocabulary and reading of easy matter, part of which deals with French institutions and the history of France. The last term will include the reading of some technical French. Textbooks: *Aldrich, Foster, Roulé, Elementary French; Bovée, Aventures par la Lecture; Les Chemins de Fer and Le Ciel* (both in *L'Encyclopédie par l'image*).

**L61, L62. French, Intermediate.** Designed to enable students to meet the entrance requirements in intermediate French. Recitations partly conducted in French. A continuation of the study of grammar, pronunciation, and useful conversational forms; drill in composition and in translation into French of connected passages; reading of matter dealing with French geography, history and industrial activity; some standard modern authors; reading of scientific French. Textbooks: *Barton and Sirich, New French Review Grammar; Williams, Technical and Scientific French; Buffum, French Short Stories; some selected plays; Kullmer and Gérard, Sketch Maps of France.*

**L63, L64. French, Advanced.** Planned to meet the needs of Course IV. Emphasis is laid upon good pronunciation, and the ability to express in French matters dealing with travel and architecture. Most of the reading matter will deal with architecture and allied subjects. Textbooks: such books as *Coindreau and Lowe, French Composition; L'Art Egyptien, L'Art Grec et l'Art Romain, L'Art Roman, L'Art Gothique (Grammaire des Styles); Hervieu, La Course du Flambeau; George Riat, Paris (Les Villes d'Art Célèbres); Foville, Pise et Lucques; Histoire de France (Encyclopédie par l'image).*

**L65, L66. French, Advanced.** For Course IV, second year. 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. Textbooks: *Coindreau and Lowe, French Composition* (continued); such reading matter as *Guerlin, Ségovie, Avila et Salamanque; Besnard, Le Mont-Saint-Michel; La Renaissance Italienne, La Renaissance Française, Le Style Louis XIII, Le Style Louis XIV, Le Style Louis XV (Grammaire des Styles); Hugo, Notre Dame de Paris; Demaison, La Cathédrale de Reims.*

**L71, L72. French, Aeronautical.** For students in Course XVI. Review of grammatical principles. Reading of scientific matter dealing with aeronautics, engines, electricity, etc. Textbooks: *Barton and Sirich, French Review Grammar and Composition; Williams, Technical and Scientific French; L'Aviation (Encyclopédie par l'image); L'Aéronautique (Revue Mensuelle).*

**L81, L82. Spanish, Elementary.** Pronunciation, elementary grammar, easy reading matter, practice in conversational phrases useful for travel. Text-

books: such books as *Hills and Ford, First Spanish Course*; *Wilkins, Beginner's Spanish Reader*; *Romera-Navarro, Historia de España*; *Carrión and Aza, Zaragozaleta*.

**L91, L92. Italian, Elementary.** Pronunciation, elementary grammar, easy reading matter, practice in conversational phrases useful for travel. Textbooks: *Russo, Elementary Italian Grammar*; *Tutt, Italian Reader*; *Capocelli, L'Italia nel Passato e nel Presente*. (Not offered in 1933-34.)

The following subjects are offered as General Studies. For description see Division of General Studies.

G821.	French.	G831.	French.	G921.	German.	G931.	German.
G822.	French.	G832.	French.	G922.	German.	G932.	German.

### DEPARTMENT OF HYGIENE

The gymnasium of the Institute is located in the Walker Memorial Building and affords ample accommodation for the training of classes in gymnastics.

The gymnasium is open to all students free of charge, and the instruction is especially arranged to fit individual needs. Bronze medals, known as the Cabot Medals for Improvement in Physical Development, are awarded to the five or six men showing the greatest physical improvement for the year. These medals 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. By using this building the Walker Gymnasium is left free for the regular gymnastics for which it was designed.

The Athletic Field gives an opportunity for track-team contests and interclass games. This field is provided with a quarter-mile running track, straightaway tracks for one hundred yard and two hundred twenty yard dashes, tennis courts, etc. It is under the direction of an Advisory Council on Athletics, composed of alumni and undergraduate students.

**PT1, PT2. Physical Training.** All first-year men take two examinations during the first month — one at Walker Memorial by the Physical Director, from which anthropometric charts are plotted, and the other a health examination 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 at the left is the subject number.  
The numbers under the names of subjects indicate the prerequisite subjects (those in parentheses may be taken simultaneously).

To the right of the subjects are noted the Professional Courses, and the year and term in which the subjects are required.

(A) following the year, indicates that the subject is primarily for Graduate students. (B) indicates subjects for Graduate as well as Undergraduate students.

Some "B" subjects will not be credited to graduate students in Courses in which they are required subjects of the undergraduate schedule.

Then follows the time distribution of the subject in units (a unit representing fifteen hours work). The total credit for a subject is the sum of the units allotted to Exercise (Recitation, Lecture, Laboratory, Drawing or Fieldwork); and Preparation.

To the extreme right is given the name of the Instructor in charge of the subject.

### CIVIL AND SANITARY ENGINEERING — 1'00-1'99

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
1'00	Surveying . . . . . I <i>D12</i> (Not open to 1st yr.)		2	1	2	..	2	{ Hosmer Howard
1'01	Surv. & Top. Draw. I <i>D12</i> (Not open to 1st yr.)		2	2	0	4	0	Howard
1'02	Surveying . . . . . III, VI, XVic <i>D12</i>		3	S	1	2	1	{ Hosmer Howard
		VI-A <sub>2,3</sub>	2	S	1	2	1	
		II, IV-A	2	1	1	2	1	
		IX-B	2	2	1	2	1	
		XVib	3	1	1	2	1	
1'04*	Surveying . . . . . (Elective) <i>D12</i> (Not open to 1st and 2d yr.)		3	S	2	20	2	Howard
1'041	Surveying (Not open to 1st and 2d yr.) <i>D12</i>	VII, XI, XV <sub>1a</sub> IV-B	3	S	1	11	1	Howard
			4	S	1	11	1	
1'042	Surveying . . . . . XVII <i>D12</i>		3	S	1	10	1	Howard
1'05	Plane Surveying . . . I <i>1'00, 1'01</i> (Not open to 1st or 2d yr.)		3	S	1	5	1	Howard
1'06	Geod. & Top. Sur. . . I <i>(1'05)</i>		3	S	1	5	0	Hosmer
1'07*	Geodetic Surveying (Elective) <i>1'13, 1'06</i>		4(B)	S	0	10	0	Hosmer
1'10	Surveying . . . . . III, 1 <i>M4, D12</i> (Not open to 1st or 2d yr. except on petition)	XII	3	S	5	18	1	Eberhard
			4	S	5	18	1	
1'12	Astron. & Sph. Trig. I <i>M4, 1'09</i>		2	2	3	..	4	Hosmer
1'13	Geodesy . . . . . I <i>M22, 1'12</i>		3	1	2	..	2	Hosmer
1'131	Geodesy . . . . . I <sub>4</sub> <i>1'13</i>		4(B)	1	2	..	4	Hosmer
1'132	Geod. Astron. & Nav. I <sub>4a</sub> <i>1'131</i>		4(B)	2	3	..	6	Hosmer
1'133	Geodetic Lab. . . . . I <sub>4</sub> <i>1'131, 8'07</i>		4(B)	2	0	2	0	Hosmer
1'134	Adj. of Observations I <sub>4</sub> <i>M26, 1'131</i>		4(B)	2	3	..	6	Hosmer
1'125	Seismom. & Vibra. Meas. . . . . I <sub>4</sub> <i>M22, 8'201</i>		4(B)	1	3	..	2	Ruge

\* Not offered in Summer Session, 1933.

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
1'136	Vibration Problems	(Elective)	G(A)	2	3	..	6	Ruge
1'138	Seismological Lab..	I <sub>1</sub>	4(B)	2	0	4	0	Hosmer
	<i>8'201, 1'135</i>							
1'14	Geodesy Adv.....	(Elective)	G(A)	2	2	..	4	Hosmer
	<i>1'13</i>							
1'15	Navigation.....	(Elective)	3	2	2	..	2	Howard
1'16	Aerial Surveying...	(Elective)	4(B)	2	2	..	2	Hosmer
	<i>1'03</i>							
1'18	Map Read. & Top. Draw.....	XI	2	2	0	2	0	Howard
	<i>D12</i> (Not open to 1st yr.)							
1'181	Map Read. & Top. Draw.....	IV-B	4	S	5	..	0	Howard
	<i>1'041</i>							
1'20	Ry. & Hy. Fieldwk. (I, XV <sub>1a</sub> )	IV-B	3	S	1	4	0	Babcock
	<i>(1'05) or (1'04)</i>		4	S	1	4	0	
1'21	Ry. & Hy. Curves... (I, XI, XV <sub>1a</sub> )	IV-B	3	1	2	..	2	C. B. Breed
	<i>M21; 1'20 or 1'041</i>		4	1	2	..	2	
1'25	Eng. Constr..... (I, VII <sub>1</sub> , XI, XV <sub>1a</sub> )	IV-B, Mil. Eng.	3 (B)	2	4	..	4	C. B. Breed
	<i>1'21, 2'20 for I, XI, XV<sub>1a</sub></i>		4 (B)	2	4	..	4	
	<i>1'21, 2'21 for IV-B</i>							
	<i>2'20 for VII<sub>1</sub>, Mil. Eng.</i>							
1'26	Rail. Signaling... (Elective)		4(B)	2	2	..	3	Babcock
1'271	Transp. Eng..... I <sub>2</sub>		4(B)	1	4	1	5	C. B. Breed
	<i>1'21, 1'25, (1'35)</i>							
1'272	Transp. Eng..... I <sub>2</sub>		4(B)	2	3	..	3	C. B. Breed
	<i>1'271</i>							
1'28	Rail. Design..... (Elective)		4(B)	2	0	5	0	Babcock
	<i>1'271, (1'272)</i>							
1'301	Rail. Trans. Adv... (Elective)		G(A)	1	2	..	4	Babcock
	<i>1'27, 1'28 or 1'281</i>							
1'302	Rail. Trans. Adv... (Elective)		G(A)	2	2	..	4	Babcock
	<i>1'301</i>							
1'31	Rail. Des., Adv... (Elective)		G(A)	1 or 2	2	..	4	Babcock
	<i>1'28 or 1'281</i>							
	<i>1'301 or (1'301)</i>							
1'32	Des. of Harbor Works (Elective)		G(A)	1	3	..	6	C. B. Breed
	<i>1'48</i>							
1'35	Roads & Pave..... I <sub>1,2</sub>		4	1	2	..	1	C. B. Breed
	<i>1'21, 1'25</i>							
1'36	Phys. & Chem. Test. of High. Mater. (Elective)		4(B)	2	1	4	1	C. B. Breed
1'371	Pave. & High. Trans. (Elective)		4(B)	S	3	..	6	C. B. Breed
1'372	High. Trans. Adv... (Elective)		G(A)	1	2	..	4	C. B. Breed
	<i>1'35, 1'37 or 1'371</i>							
1'373	High. Trans. Adv... (Elective)		G(A)	2	2	..	4	C. B. Breed
	<i>1'372</i>							
1'38	Highway Design... (Elective)		4(B)	2	0	5	0	Babcock
	<i>1'271 (1'272)</i>							
1'39	Graphic Statics... I		2	1	1	2	1	Mitsch
	<i>8'02</i> (Not open to 1st yr.)							
1'40	Structures..... (I, IV-A, VII <sub>1</sub> , IX-B, XI, XV <sub>1a</sub> , XVII)		3	2	3	..	5	Fife
	<i>2'20 or 2'211</i>		4	S	3	..	5	
	Mil. Eng.		3	2	3	..	5	Newell
1'401	Structures..... XVI							
	<i>2'20 or 2'211</i>							
1'41	Structures..... (I, IV-A, VII <sub>1</sub> , XI, XV <sub>1a</sub> , XVII)		4(B)	1	4	..	8	Fife
	<i>1'40, 1'43</i>		4(B)	2	4	..	8	Fife
1'42	Structures..... (I <sub>1, 2, 3</sub> , Mil. Eng.)							
	<i>1'41</i>							
1'421	Structures..... (I <sub>1</sub> , VII <sub>1</sub> , XI, XV <sub>1a</sub> )		4	2	2	..	4	Fife
	<i>1'41</i>							
1'422	Structures..... (IV-A, XVII)		4	2	2	..	4	Mitsch
1'43	Materials..... (I, XI)		3	1	1	..	2	Fife
1'44	Stat. Structures... (III <sub>1, 2</sub> )		4	2	2	..	3	Wilbur
	<i>2'20</i>							
1'45	Structures..... (XIII-A)		G	1	3	..	6	Fife
	<i>2'20 or equiv.</i>							
1'46	Structural Design... (XIII-A)		G	2	0	2	0	Fife
	<i>1'45</i>							
1'48	Foundations..... (I, IV-A, XI, XV <sub>1a</sub> , XVII)		4(B)	1	3	..		Gil boy
	<i>2'20</i>							

◆ Time specially arranged.

No.	Subject with Prerequisites	Taken by	Yr. Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge	
1'491	Soil Mechanics. . . . . <i>#20</i>	(Elective)	G(A) 1	3	..	6	Gilbooy	
1'492	Soil Mechanics. . . . . <i>1'491</i>	(Elective)	G(A) 2	3	..	6	Gilbooy	
1'501	Bridge Design. . . . . <i>(1'41)</i>	I, 2	4(B) 1	0	7	0	Mirabelli	
1'502	Bridge Design. . . . . <i>1'501 (1'42)</i>	I, 2	4(B) 2	0	5	0	Mirabelli	
1'511	Bridge Design. . . . . <i>(1'41)</i>	I	4(B) 1	0	4	0	Mirabelli	
1'512	Bridge Design. . . . . <i>1'511 (1'421)</i>	I	4(B) 2	0	6	0	Mirabelli	
1'52	Structural Design. . . . . <i>(1'421)</i>	XI	4	2	0	6	0	Mirabelli
1'54	Structural Design. . . . . <i>(1'421)</i>	XV <sub>1a</sub>	4	2	0	4	0	Mirabelli
1'551	Struct. Des. Adv. . . . . <i>(1'561)</i>	(Elective)	G(A) 1	0	6	0	Wilbur	
1'552	Struct. Des. Adv. . . . . <i>(1'562)</i>	(Elective)	G(A) 2	0	6	0	Wilbur	
1'561	Structures, Adv. . . . . <i>1'42 or 1'421 or 1'422, 1'502 or 1'512 or 4'922</i>	(Elective)	G(A) 1	3	..	9	{ Fife Wilbur	
1'562	Structures, Adv. . . . . <i>1'561</i>	(Elective)	G(A) 2	3	..	9	{ Fife Wilbur	
1'57	Secondary Stresses. (Elective) <i>(1'41 or 16'01)</i>		G(A) 2	2	..	4	Fife	
1'581	Reinf. Con. Design. (Elective) <i>1'42 or 1'421</i>	Mil. Eng.	G(A) 1	0	6	2	Mitsch	
1'582	Reinf. Con. Design. (Elective) <i>1'581</i>		G(A) 2	2	..	4	Mitsch	
1'60	Hydrog. Survey. . . . . <i>M12 (1'05, 1'06)</i>	I, 2, 3, VII, XI, XV <sub>1a</sub>	3	S	1	4	0	Liddell
1'62	Hydraulics. . . . . <i>#15 or equiv.</i>	I, VII, IX-B, XI	3	2	3	..	5	G. E. Russell
1'63	Hydraulics. . . . . <i>#15 or equiv.</i>	IV-A, XV <sub>1b</sub> XIII III, 2, 3, XV <sub>1a</sub> XV <sub>1c</sub> , XVII	4 3 4 3	1 1 2 2	2 .. 2 ..	3 3 3 3	G. E. Russell	
1'64	Hydraulics. . . . . <i>#15 or equiv.</i>	II, VI, VI-A(A)	4	1	3	..	6	G. E. Russell
1'65	Hydraulic Mach. . . . . <i>1'62 or equiv.</i>	I, XI	4	2	2	..	2	Liddell
1'66	Hydraulics, Adv. . . . . <i>1'62 or equiv.</i>	(Elective)	G(A) 2	2	..	6	G. E. Russell	
1'67	Design of Masonry Dams. . . . . <i>1'42 or (42)</i>	(Elective)	G(A) 2	2	3	2	Wilbur	
1'68	Th. of Hydraulic Models. . . . . <i>1'62 or equiv.</i>	(Elective)	G(A) 1	1	..	3	Reynolds	
1'691	River Hyd. Lab. . . . . <i>1'62 (1'68)</i>	(Elective)	G(A) 1	0	9	0	Reynolds	
1'692	River Engineering. (Elective) <i>1'62 or equiv.</i>		G(A) 2	2	..	4	Reynolds	
1'70	Water Power Eng. . . . . <i>1'62</i>	I	4(B) 1	3	3	3	Barrows	
1'71	Water Power Eng. . . . . <i>1'70, 1'41</i>	I	4(B) 2	2	4	3	Barrows	
1'731	Wat. Pr. Eng., Adv. (Elective) <i>1'42, 1'71 (1'851)</i>		G(A) 1	3	..	6	Barrows	
1'732	Wat. Pr. Eng., Adv. (Elective) <i>1'731 (1'852)</i>		G(A) 2	3	..	6	Barrows	
1'75	Hyd. & San. Eng. . . . . <i>1'62</i>	I, VII, XI	4(B) 1	4	..	6	Camp	
1'76	Sanitary Eng. . . . . <i>1'75</i>	I	4(B) 2	2	..	3	Camp	
1'78	Sanitary Eng. . . . . <i>1'75</i>	VII, XI	4(B) 2	3	..	4	Camp	
1'79	Hyd. & San. Des. . . . . <i>1'75</i>	I	4(B) 2	0	2	0	Camp	
1'801	Sanitary Design. . . . . <i>(1'75)</i>	VII, XI	4(B) 1	0	3	0	Camp	
1'802	Sanitary Design. . . . . <i>(1'76 or 1'78)</i>	VII, XI	4(B) 2	0	6	0	Camp	
1'811	San. Eng., Adv. . . . . <i>1'75</i>	(Elective)	G(A) 1	3	..	6	Camp	

## TABULATION OF SUBJECTS

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
1'812	San. Eng., Adv.... <i>1'811, 1'76</i>	(Elective)	G(A)	2	3	..	6	Camp
1'851	Wat. Pr. Des., Adv. <i>(1'751)</i>	(Elective)	G(A)	1	0	8	0	Barrows
1'852	Wat. Pr. Des., Adv. <i>1'851 (1'752)</i>	(Elective)	G(A)	2	0	8	0	Barrows
1'881	San. Des., Adv.... <i>(1'811)</i>	(Elective)	G(A)	1	0	6	0	Camp
1'882	San. Des., Adv.... <i>(1'812)</i>	(Elective)	G(A)	2	0	6	0	Camp

## MECHANICAL ENGINEERING — 2'00-2'99

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2'00	Applied Kinematics <i>D12, M12, 8'01</i>	I, II, IV-A, VI, VI-A IX-B, XIII, XIII-C XVI, XVI, XVII III, 1, 1	2	1	3	2	3	Merrill
2'03	Mechanisms . . . . . <i>2'891</i>	II (A. O.)	2	2	3	2	3	Swett
2'04	Mech. Eng. Equip.. II <i>2'00</i>	II	2	2	3	..	3	Eames
2'05	Mech. of Machines. II <i>2'00</i>	II	3	1	3	..	2	Townsend
2'06	Mech. of Machines. II(T.D.) <i>2'00</i>	II(T.D.)	G(B)	1	2	..	2	Townsend
2'07	Auto. Machinery... II(T.D.) <i>(2'05 or 2'06), 2'20</i>	II(T.D.)	G(A)	1	3	..	3	Swett
2'08	Auto. Machinery... II(T.D.) <i>2'07</i>	II(T.D.)	G(A)	2	1	3	4	Swett
2'09	Des. of Auto. Mach. II, II(T.E.) <i>2'05, 2'20, 2'850</i>	II, II(T.E.)	G(A)	2	0	12	0	Dole
2'10	Mech. Eng. Draw.. II <i>(2'00)</i>	II	2	1	0	5	0	James
2'102	Mech. Eng. Draw.. XVI <i>2'00 (2'15)</i>	XVI	2	2	0	4	0	James
2'12	Machine Drawing.. IX-B, XVI <i>D12</i>	III, 1, 1 III, 1, 1 III, 1, 1	2	1	0	6	0	James
2'13	Machine Drawing.. II <i>D12, 2'15</i>	II	3	S	0	6	0	James
2'15	Applied Mechanics. I, II, IV-A, VI, VI-A <i>(M21) (8'02)</i>	VII, IX-B, X, XI XIII, XIII-C, XVI XVI, XVII III	2	2	3	..	5	Fuller
2'20	Applied Mechanics. I, II, VI <i>2'15</i>	VI-A (B), VI-C VII, IX-B, X, XI XIII, XIII-C, XIII-A, XVI, XVI, XVII III	3	1	3	..	6	Fuller
2'21	Applied Mechanics II, XIII, XIII-A <i>2'20</i>	IV-A, VI-A(A) Mil. Eng. II, XIII, XIII-A Mil. Eng. IV-A	3	S	3	..	6	Fuller
2'22	Applied Mechanics. VI, VI-A(A) <i>2'20</i>	VI-A(B)	3	2	3	..	5	Fuller
2'231	Mechanics . . . . . IV <i>M12 (For 1933-34 only)</i>	IV	2	1	3	..	6	Fuller
2'232	Mechanics . . . . . IV <i>2'231 (For 1933-34 only)</i>	IV	2	2	3	..	6	Fuller
2'232T	El. Struct. Mech... IV <i>M111</i>	IV	1	2	3	..	6	Fuller
2'233	Struct. Mech. . . . . IV <i>2'232T</i>	IV	2	1	2	..	4	Fuller
2'234	Struct. Mech. . . . . IV <i>2'233</i>	IV	2	2	2	..	4	Fuller
2'251	Dyn. of Mach. . . . . II <i>2'20</i>	II, II(T.D.) XVI (Elective)	4(B)	1	2	..	4	Riley
2'254	Dynamics of Eng. . II(A.E.) <i>2'251</i>	II(A.E.) (Elective)	G(B)	1	2	..	4	Riley
2'255	Dyn. of Aircraft Eng. (Elective) <i>2'254 or equiv.</i>	(Elective)	G(A)	1	2	..	2	Riley
2'256	Dynamics of Rota. II(T.D.) <i>2'251</i>	II(T.D.)	G(A)	2	1	..	2	Riley
2'26	Mech. of Eng. . . . . II <i>2'21</i>	II	4(B)	2	3	..	6	Fuller
2'271	Th. of Elasticity... II(A.O.) <i>2'891</i>	II(A.O.)	4	S	5	..	9	Fuller
2'281	Adv. Mech. & Th. Elas. . . . . (Elective) <i>2'26</i>	(Elective)	G(A)	1	3	..	9	Fuller
2'282	Adv. Mech. & Th. Elas. . . . . (Elective) <i>2'281</i>	(Elective)	G(A)	2	3	..	9	Ful

## TABULATION OF SUBJECTS

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2'285	Photoelasticity . . . . <i>2'281 or equiv.</i>	(Elective)	G(A)	2	1	3	2	Maeser
2'291	Theoret. Mech. . . . .	XIII-A	G(A)	1	3	..	6	
2'292	Theoret. Mech. . . . .	XIII-A	G(A)	2	3	..	6	
2'295	Applied Hydrodyn. . . . <i>1'62 or 1'64</i>	(Elective)	G(A)	1	4	..	8	Spannhake
2'296	Gen. Th. of Hyd. Turb. & Pumps <i>2'295</i>	(Elective)	G(A)	2	4	..	8	Spannhake
2'297	Laminar & Turbulent Flow <i>2'295</i>	(Elective)	G(A)	2	1	..	2	Spannhake
2'30	Materials of Eng. . . . <i>(2'20)</i>	XIII-C, XV <sub>1</sub> XIII, Mil. Eng.	3	2	2	..	2	Zimmerman
			4	1	2	..	2	
			3	1	2	..	2	
2'301	Materials of Eng. . . .	II(T,D), II, IV-A, XIII-A, XVI	G	1	1	..	2	Zimmerman
2'32	App. of Photoelas. . . <i>2'20 or equiv.</i>	II (T,D.)	G	2	1	2	1	Maeser
2'331	Engineering Metals <i>2'35, 2'712</i>	(Elective)	4(B)	2	2	..	2	Zimmerman
2'332	Engineering Metals Problems <i>2'35, 2'712</i>	(Elective)	G(A)	2	2	6	4	Zimmerman
2'35	Testing Mat. Lab. . . . <i>2'20</i>	II	4(B)	1	1	3	2	Holmes
		XVI	3	2	1	3	2	
2'36	Testing Mat. Lab. . . . <i>2'20</i>	I, VI-A(A), XI, XIII-A, XV <sub>1c</sub> VI-A(B) III, IV-A, XV <sub>1b</sub> , XVII, Mil. Eng. XIII	3	2	0	2	1	Holmes
			4	S	0	2	1	
			4	1	0	2	1	
			4	2	0	2	1	
2'362	Testing Mat. Lab. Conc. . . . . <i>2'30</i>	IV-A	4	1	0	3	2	Holmes
2'363	Testing Mat. Lab. Conc. Mil. Eng., XVII		4	1	0	2	0	Adams
2'38	Phys. Test. of Met. (Elective)		S	0	2	0	0	Cowdrey
2'391	Reinf. Con. Des. . . . <i>2'21</i>	II, IV-A	4(B)	1	2	5	0	Peabody
2'392	Reinf. Con. Des. . . . <i>2'391</i>	II, IV-A	4(B)	2	2	4	0	Peabody
2'393	Reinf. Con. Des. . . . Adv. <i>2'392</i>	(Elective)	G(A)	1 or 2	+			Peabody
2'394	Concrete Research. . . <i>2'362</i>	(Elective)	G(A)	1 or 2	+			Peabody
2'395	Conc. Bldgs. Des. & Spec. . . . . <i>2'20</i>	Mil. Eng.	4	2	2	..	4	Peabody
2'40	Eng. Thermodyn. . . . <i>(M21), 2'02</i>	II, III, VI, VI-A(B) IX-B, XIII, XIII-C XV <sub>2</sub> , XVI II(T,D.) VI-A(A) (Elective)	3	1	4	..	5	Berry
			G	1	4	..	5	
			3	S	4	..	5	
			3	2	4	..	5	
2'41	Boilers & Engines. . . <i>2'02</i>	II	3	1	2	..	2	Holt
2'42	Eng. Thermodyn. . . . <i>2'40</i>	II, VI, VI-A(A), IX-B XIII, XIII-C, XV <sub>2</sub> , XVI II(T,D.) VI-A(B) (Elective)	3	2	4	..	5	Berry
			G	2	4	..	5	
			4	S	4	..	5	
			3	1	4	..	5	
2'43	Refrigeration . . . . . <i>2'40</i>	II	4(B)	1	2	..	4	Berry
2'46	Heat Engineering. . . <i>(M21), 2'02</i>	XVI, XVII I, 1, 1, XI Mil. Eng.	3	1	4	..	7	Taft
			4	1	4	..	7	
			4	S	4	..	7	
2'461	Thermodynamics. . .	II(A.O.)	3	1	3	..	6	Taft
2'47	Heat Engineering. . . <i>2'46</i>	XVI, XVII I, 1, 1, XI Mil. Eng.	3	2	2	..	3	Taft
			4	2	2	..	3	
			4	S	2	..	3	
2'49	Refrigeration . . . . . <i>2'43</i>	(Elective)	4(B)	2	3	..	5	Berry
2'491	Refrigeration . . . . . <i>2'02</i>	VII <sub>2</sub>	4	1	1	..	2	W. H. Jones
2'501	Refrigeration, Adv. (Elective)		G(A)	1	3	..	9	Berry
2'502	Heat Trans., Adv. (Elective)		G(A)	2	3	..	9	Berry

† Time specially arranged.

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
2504	Refrigeration Eng. <sup>240</sup>	(Elective)	G(A)	2	3	..	3	Svenson
2505	Storage & Trans. of Foodstuffs. . . . . <sup>243</sup>	(Elective)	G(A)	1	3	..	6	W. H. Jones
2506	Des. of Refrig. Pl. . . . . <sup>243</sup>	(Elective)	G(A)	2	2	..	4	W. H. Jones
251	Torpedoes. . . . . <sup>2505</sup>	II(T.D.)	G(A)	2	2	..	4	Taft
258	Power Plant Design II <sup>240</sup>		4(B)	2	0	4	0	Holt
2581	Power Plants, Adv. (Elective) <sup>241, 242</sup>		G(A)	1	3	..	6	Holt
259	Mech. Eq. Bldg., H. & V. . . . . <sup>258 or equip.</sup>	IV-A, VII, XVII	4	2	3	1	3	Eames
2591	Adv. Heat & Vent. (Elective) <sup>802</sup>		G(A)	1	3	..	6	Holt
2592	Heat. & Vent. Des. (Elective) <sup>243, 2854</sup>		G(A)	2	4	..	4	Holt
2593	Air Conditioning . . (Elective) <sup>2781, 2854</sup>		G(A)	1	2	..	4	Holt
2594	Refrig. & Air. Con. Lab. . . . . <sup>243, 2854</sup>	(Elective)	G(A)	2	0	4	2	{ Jones Holt Holt
2595	Mech. Eq. Bldg. . . . . <sup>2593</sup>	IV	4	1	2	..	2	Holt
2601	Engineering Lab. . . . . <sup>240 or 243</sup>	II	4	1	0	4	4	Eames
2602	Engineering Lab. . . . . <sup>2601</sup>	II	4(B)	2	0	3	3	Eames
2603	Engineering Lab. . . . . (Elective) <sup>2601 (2602)</sup>		4	2	0	3	3	Eames
2611	Engineering Lab. . . . . <sup>240 or 243</sup>	III, XIII, XVI	3	2	0	2	1	Eames
2612	Engineering Lab. . . . . <sup>2611</sup>	XIII, XIII-C	4	1	0	2	2	Eames
2614	Engineering Lab. . . . . <sup>240 or 243</sup>	XV <sub>1b</sub>	4	1	0	4	3	Eames
2615	Engineering Lab. . . . . <sup>2601 or 2614</sup>	XIII, XV <sub>1b</sub>	4	2	0	2	2	Eames
262	Engineering Lab. . . . . <sup>240 or 243</sup>	IX-B	4	1	0	4	2	Eames
2621	Engineering Lab. . . . . <sup>240 or 243</sup>	XV <sub>2</sub>	4	2	0	4	2	Eames
2622	Engineering Lab. . . . . <sup>240 or 1029</sup>	VI, VI-A(A) <sub>1,2</sub> , Mil.Eng.	4	1	0	3	2	Eames
263	Eng. & Hyd. Lab. . . . . <sup>240 or 243</sup>	I, 2, XI	4	2	0	2	2	Eames
2631	Eng. & Hyd. Lab. . . . . <sup>240 or 243</sup>	I <sub>1</sub>	4	2	0	3	3	Eames
264	Refrigeration Lab. (Elective) <sup>243 &amp; 2601</sup>		4(B)	2	0	2	2	Jones
266	Automobile Lab. . . . . (Elective) <sup>2601 (279)</sup>		4(B)	2	0	2	2	Fales
2661	Main. & Op. of Auto. Eq. . . . . . <sup>279</sup>	II, II(A.E.)	G(B)	1	2	..	2	Fales
2671	Engine Testing. . . . . <sup>266</sup>	II, II(A.E.)	G(B)	1	0	4	2	Fales
2672	Motor Veh. Test. . . . . <sup>2801 &amp; 2671</sup>	II, II(A.E.)	G(A)	2	1	4	3	Fales
2681	Auto. Engine Lab. . . . . (Elective)		4(B)	1	0	4	4	Fales
2691	Auto. Engine Lab. . . . . (Elective) <sup>2601</sup>	II(T.D.)	G(B)	2	0	2	0	Fales
270	Machine Design. . . . . <sup>D12, 220</sup>	II	3	2	1	3	0	Townsend
271	Machine Design. . . . . <sup>270</sup>	II	4(B)	1	2	3	0	Swett
2721	Machine Design. . . . . <sup>220</sup>	XV <sub>1b</sub>	4	1	2	2	0	Swett
2722	Machine Design. . . . . (Elective) <sup>2721</sup>		4	2	2	..	2	Swett
2741	Machine Des., Adv. II <sup>271</sup>		G(A)	1	3	5	2	Haven
2742	Machine Des., Adv. II <sup>271</sup>		G(A)	2	3	5	2	Haven
2761	Machine Design. . . . . (Elective) <sup>271</sup>	II(T.D.)	G(A)	1	2	4	2	Haven
2762	Machine Design. . . . . (Elective) <sup>2761</sup>	II(T.D.)	G(A)	2	2	4	2	Haven

## TABULATION OF SUBJECTS

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
277	Engine Design . . . . <i>2'251, 2'71</i>	(Elective)	4(B)	2	2	4	2	Riley
2781	Industrial Plants . . . <i>(2'26)</i>	II	4(B)	2	3	..	3	Peabody
2782	Industrial Plants . . . <i>(2'781)</i>	(Elective)	4(B)	2	0	4	0	Peabody
279	Gasoline Auto . . . . . <i>2'40 or 2'47</i>	(Elective)	4(B)	2	4	..	4	Park
2801	Automotive Eng. . . . . <i>2'79, 2'251</i>	II, II(A.E.)	G(A)	1	3	..	6	Park
2802	Automotive Eng. . . . . <i>2'801</i>	II, II(A.E.)	G(A)	2	3	..	6	Park
2811	Automotive Design <i>(2'801)</i>	II, II(A.E.)	G(A)	1	0	8	0	Park
2812	Automotive Design <i>(2'802)</i>	II, II(A.E.)	G(A)	2	0	10	0	Park
2850	Automatic Mach. . . . . <i>2'70</i>	(Elective)	4(B)	2	2	..	2	Swett
2851	Fire Protec. Eng. . . . . <i>2'00</i>	(Elective)	4(B)	2	2	..	2	Schwarz
2853	Locomotive Eng. . . . . <i>2'251</i>	(Elective)	4(B)	2	2	..	2	Dole
2854	Mech. Eq. of Bldgs. . . . . <i>2'40 or 2'46</i>	(Elective)	4(B)	2	2	..	2	Holt
2855	Steam Tur. Eng. . . . . <i>2'42</i>	(Elective)	4(B)	2	2	..	2	Taft
2858	Inspection Meth. . . . . <i>2'951</i>	(Elective)	4(B)	2	2	..	2	Buckingham
287	Textile Eng. . . . . . . . . <i>2'00</i>	(Elective)	4(B)	2	2	4	2	Haven
2871	Textile Laboratory <i>2'251, 2'71, or 2'711</i>	IIa (Elective)	G(A)	any	0	6	0	Haven
2872	Des. of Cot. Mach. . . . . <i>2'251, 2'71, or 2'711</i>	II(T.E.)	G(A)	1	3	..	6	Haven
2873	Des. of Wool Work. Mach. . . . . . . . . . . . <i>2'251, 2'71 or 2'711</i>	II(T.E.)	G(A)	2	3	..	6	Schwarz
2874	Dyn. of Tex. Mach. II(T.E.) <i>2'251</i>	II(T.E.)	G(A)	1	2	..	2	Haven
2875	Tex. Tech. Anal. . . . . <i>2'87</i>	II(T.E.)	G(A)	1	2	..	3	Haven
2876	Prin. of Fabric. St. . . . . <i>2'87</i>	II(T.E.)	G(A)	1	2	..	4	Schwarz
2877	Tex. Microscopy . . . . . <i>8'04</i>	(Elective)	4(B)	any	2	3	2	Schwarz
288	Ordinance Eng. . . . . <i>2'21</i>	II Ord.	4(B)	2	3	2	3	Fuller
2891	Mechanics . . . . . . . . . . <i>M72</i>	II(A.O.)	4	S	3	..	0	Fuller
290	Forge Shop . . . . . . . . . .	II	2	2	0	3	0	Sheppard
2901	Forging . . . . . . . . . . . .	XIII	2	1	0	2	0	Sheppard
		XIII-C	2	2	0	2	0	
		IIIa	3	2	0	2	0	
291	Foundry . . . . . . . . . . . .	II	2	1	0	3	0	O'Neill
		III, XIII	2	2	0	3	0	
2911	Foundry . . . . . . . . . . . .	XIII-A	4	S	0	2	0	O'Neill
2912	Structural Castings	IV-A	3	2	0	1	0	
292	Pattern Making . . . . . <i>2'91</i>	II	2	2	0	3	0	O'Neill
2922	Pattern Making . . . . .	XIII-A	4	S	0	2	0	
2941	Mach. Tool Lab. . . . . . . . .	VI, VI-A	2	1	1	3	0	O'Neill
2951	Mach. Tool Lab. . . . . . . . .	II, XIII	3	1	2	4	0	Littlefield
		XVc	3	2	2	4	0	English
2952	Mach. Tool Lab. . . . . . . . . <i>2'951</i>	II, XIII	3	2	1	5	0	English
2953	Weld. Eng. & Prac. . . . . <i>6'85 or 6'86 or 6'89</i>	(Elective)	4(B)	2	1	2	1	
296	Mach. Tool Lab. . . . . . . . .	III, IX-B	2	2	1	2	0	English
		XIV	2	1	1	2	0	
2961	Mach. Tool Lab. . . . . . . . .	XIII-C	4	2	1	1	0	English
2971	Mach. Tool Lab. . . . . . . . .	XVb	3	1	1	2	0	English
2972	Mach. Tool Lab. . . . . . . . .	XVb	3	2	1	2	0	English
298	Production Meth. . . . . <i>2'952</i>	II	4	2	1	..	1	Littlefield
2981	Manuf. Proc. . . . . . . . . . . <i>2'952</i>	II, II(A.E.)	G(A)	1	3	..	3	Littlefield
2982	Prep. for Manuf. . . . . (Elective) <i>2'71 or 2'721, or 6'03</i>	(Elective)	4(B)	2	3	..	3	Buckingham
2983	Production Des. . . . . (Elective)	(Elective)	4(B)	2	2	..	2	Buckingham
299	Met. & Dim. Eng. St. . . . . <i>2'951</i>	(Elective)	G(A)	1	3	..	6	Buckingham

## MINING AND METALLURGY — 3'00-3'99

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
3'00	Int. to Min. & Met. III		2	1	2	..	0	Hutchinson
3'01	Mining Methods... III <sub>1</sub> <i>1'10, 3'04, 12'01</i>		3	1	5	..	4	Foster
3'02	Mining Methods... III <sub>1</sub> <i>3'01</i>		3	2	5	..	5	Foster
3'03	Econ. of Mining... III <sub>1</sub> <i>3'02, or 3'05; 3'08; 3'21 or 3'23</i>		4(B)	1	4	..	4	Hutchinson
3'031	Econ. of Mining... III <sub>2</sub> <i>3'02, or 3'05; 3'21 or 3'23</i>		4(B)	1	2	..	2	Hutchinson
3'04	Mining, Prin. of... III <sub>1, 2</sub> <i>3'03 or 3'031</i>		4(B)	2	3	..	4	Hutchinson
3'05	Mining, Elem. of... III <sub>2, 3, XIIa</sub>		3	1	2	..	2	Hutchinson
3'061	Mining Eng., Adv. (Elective) <i>3'04</i>		G(A)	1	4			Hutchinson
3'062	Mining Eng., Adv. (Elective) <i>3'04</i>		G(A)	2	4			Hutchinson
3'08	Mining Practice... III <sub>1, 2</sub> <i>1'10</i>		3	S	0	3	0	Hutchinson
3'101	Mine Valuation... (Elective) <i>3'04, 3'08</i>		G(A)	1	3	..	8	Hutchinson
3'102	Mine Valuation... (Elective) <i>3'101</i>		G(A)	2	3	..	8	Hutchinson
3'12	Econ. of Min., Adv. (Elective) <i>3'04</i>		G(A)	2	4			Hutchinson
3'13	Geophys. Pros. El. III <sub>1, 2</sub> <i>M21, 3'04</i>		4(B)	1	2	2	0	Foster
3'21	Ore Dressing... III <sub>1</sub> <i>12'01 (3'22)</i>		3(B)	2	3	..	2	Locke
3'22	Ore Dressing Lab... III <sub>1</sub> <i>3'21, 5'13 (3'21)</i>		3(B)	2	1	4	2	Locke
3'23	Ore Dressing... III <sub>2, 3, XIIa</sub> <i>12'01</i>		3	2	1	2	2	Locke
3'241	Ore Dressing, Adv. (Elective) <i>3'21, 3'22; or 3'23</i>		G(A)	2	4			Locke
3'242	Ore Dressing, Adv. (Elective) <i>3'21, 3'22; or 3'23</i>		G(A)	1	4			Locke
3'251	Th. & Prac. of Plot. (Elective) <i>3'21, 3'22; or 3'23</i>		G(A)	1	4			Locke
3'252	Th. & Prac. of Plot. (Elective) <i>3'21, 3'22; or 3'23</i>		G(A)	2	4			Locke
3'26	Ore Dress. Econ... (Elective) <i>3'21, 3'22; or 3'23</i>		G(A)	1 or 2	4			Locke
3'271	Ore Dressing Des... (Elective) <i>3'21, 3'22; or 3'23</i>		G(A)	1	4			Locke
3'272	Ore Dressing Des... (Elective) <i>3'21, 3'22; or 3'23</i>		G(A)	2	4			Locke
3'31	Fire Assaying... III <sub>1, 2</sub> <i>5'12, 12'01</i>		3	1	2	4	2	Bugbee
3'331	Fire Assaying, Adv. (Elective) <i>3'31, 5'12</i>		G(A)	1	4			Bugbee
3'332	Fire Assaying, Adv. (Elective) <i>3'31, 5'12</i>		G(A)	2	4			Bugbee
3'41	Met.; Copper, Lead III <sub>1a, 4b</sub> <i>3'00, 5'13, 12'01</i>		4(B)	1	5	5	3	Hayward
3'411	Met.; Copper, Lead III <sub>1a, 4a</sub> <i>3'00, 5'13, 12'01</i>		4(B)	1	4	2	3	Hayward
3'412	Met.; Copper, Lead III <sub>1</sub> <i>5'13, 12'01</i>		4(B)	1	3	2	3	Hayward
3'42	Met.; Gold & Silver III <sub>1</sub> <i>3'31, 3'23</i>		4(B)	2	2	3	2	Bugbee
3'421	Met.; Gold & Silver III <sub>1</sub> <i>3'31, 3'23</i>		4(B)	2	2	1	1	Bugbee
3'422	Met.; Gold & Silver. III <sub>1</sub> <i>5'02</i>		4(B)	2	2	..	2	Bugbee
3'43	Met.; Iron & Steel. III <sub>1a, 4a</sub> <i>3'00, 5'02</i>		4(B)	1	7	..	3	Waterhouse
3'431	Met.; Iron & Steel. III <sub>1a, 4b</sub> <i>3'00, 5'02</i>		4(B)	1	3	..	3	Waterhouse
3'432	Met.; Iron & Steel. III <sub>1</sub> <i>5'02</i>		4	1	2	..	1	Waterhouse
			3	1	2	..	1	

♦Time specially arranged.

## TABULATION OF SUBJECTS

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
3'44	Met.; Gen. Zinc & Min. Met. . . . . <i>3'41, 3'43</i>	III, 4	4(B)	2	4	..	3	Hayward
3'45	Met.; Heat Tr. Steel <i>3'41, 3'61, 3'12</i>	III, 4	4(B)	2	2	..	1	Waterhouse
3'46	Met. of Com. Met. <i>3'02</i>	XII	4	2	3	..	3	Hayward
3'501	Met.; Iron & Steel, Adv. . . . . <i>3'43</i>	(Elective)	G(A)	1	+			Waterhouse
3'502	Met.; Iron & Steel, Adv. . . . . <i>3'43</i>	(Elective)	G(A)	2	+			Waterhouse
3'511	Metal. Plant Design <i>3'41, 3'42, 3'43</i>	(Elective)	G(A)	1	13	..	0	Waterhouse
3'512	Met. Plant. Design. (Elective) <i>3'41, 3'42, 3'43</i>	(Elective)	G(A)	2	13	..	0	Waterhouse
3'52	Gen. Metal., Adv. . . . . <i>3'44</i>	(Elective)	G(A)	2	+			Hayward
3'53	Non-Fer. Met. Adv. (Elective) <i>3'41, 3'23, 3'44</i>	(Elective)	G(A)	1	+			Hayward
3'54	Gold & Silver Met., Adv. . . . . <i>3'42 or 3'421</i>	(Elective)	G(A)	1	+			Bugbee
3'55	Metal. Calc., Adv. (Elective) <i>3'44</i>	(Elective)	G(A)	2	2	..	6	Hayward
3'56	Metal. Plants. . . . . (Elective) <i>3'41, 3'42, 3'43</i>	(Elective)	4(B)	2	3	..	3	Waterhouse
3'60	Metal. Pl. Visits. . . . . <i>3'44</i>	III, 4	4(B)	S	0	3	1	Hayward
3'61	Metallography. . . . . <i>5'12, 3'04</i>	III, V, XIV, XVI (Elective)	3	2	2	2	1	R. S. Williams
3'615	Metallography. . . . . <i>(3'713)</i>	II(T.D.)	G	1	2	2	2	R. S. Williams
3'621	Metallography. . . . . <i>5'12, 3'04</i>	III, 4	3	1	3	6	3	R. S. Williams
3'622	Metallography. . . . . <i>3'621</i>	III, 4	3	2	3	6	3	R. S. Williams
3'641	Phys. Metal. (Non-Fer.) . . . . . <i>3'62</i>	III, 4	4(B)	1	2	3	2	R. S. Williams
3'642	Phys. Metal. (Fer.) . . . . . <i>3'641</i>	III, 4	4(B)	2	2	3	2	Homerberg
3'643	Light Alloys (Elective) <i>3'61 or 3'62</i>	(Elective)	4(B)	2	2	0	4	R. S. Williams
3'651	Phys. Metal., Adv. (Elective) <i>3'61 or 3'62</i>	(Elective)	G(A)	1	+			R. S. Williams
3'652	Phys. Metal., Adv. (Elective) <i>3'61 or 3'62</i>	(Elective)	G(A)	2	+			R. S. Williams
3'653	X-Ray Metal. . . . . <i>M22, 3'04, 3'61</i>	III, XIV	3	2	2	1	3	J. T. Norton
	<i>or 3'62</i>		4	2	2	1	3	
3'657	X-Ray Met. Adv. (Elective) <i>3'656, 3'27</i>	(Elective)	4(B)	2	+			J. T. Norton
3'66	App. of Metallog. . . . . (Elective) <i>3'61 or 3'62</i>	(Elective)	G(A)	1 or 2	0	5	0	Homerberg
3'67	Physics of Metals. . . . . <i>3'61, 3'62, 3'04, M22</i>	III, 4	4(B)	2	2	..	4	J. T. Norton
3'673	Physics of Metals. . . . . Adv. (Elective) <i>3'656, 3'67</i>	(Elective)	G(A)	1	+			J. T. Norton
3'68	Metall. of Welding. (Elective) <i>3'61 or 3'62</i>	(Elective)	4(B)	2	2	2	2	Walsted
3'69	Corrosion & Heat Resisting Alloys. (Elective) <i>3'61 or 3'62</i>	(Elective)	4(B)	2	2	0	4	R. S. Williams
3'71	Heat Treatment. . . . . II Ord., Mil. Eng. <i>2'30, 2'36 or (2'36)</i>	II Ord., Mil. Eng.	4	2	1	3	2	Pratt Zavarine
3'712	Eng. Heat Treat. . . . . II <i>2'30</i>	II	4	1	0	2	0	Zavarine
3'713	Heat Treatment. . . . . II(T.D.) <i>(3'615)</i>	II(T.D.)	G	1	1	2	2	Zavarine
3'714	Heat Treatment. . . . . II(A.E.) (Elective) <i>3'71 or 3'712</i>	II(A.E.) (Elective)	G	1	1	3	2	Zavarine
3'731	Phys. Metallurgy. . . . . II(T.D.)	II(T.D.)	4	2	1	3	2	
			G	1	1	..	2	R. S. Williams

◆ Time specially arranged.

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
3-732	Phys. Metallurgy . . . <i>3-731</i>	II(T.D.)	G	2	1	7	2	R. S. Williams
3-74	Th. of Metal Hard. (Elective) <i>3-62</i>		G(A)	2	2	..	4	Zavarine
3-81	Petrol. Eng., El. . . . <i>1-10, 8-04, 12-30</i>	III <sub>2</sub>	3	1	5	..	4	Mann
3-82	Petrol. Eng., El. . . . <i>3-81</i>	III <sub>2</sub>	3	2	5	..	4	Mann
3-84	Outline of Petrol. (Elective) Production . . . . .		4	2	3	..	1	Mann
3-85	Petroleum Product. III <sub>2</sub> <i>3-82</i>		4(B)	1	4	..	2	Mann
3-86	Petroleum Product. III <sub>2</sub> <i>3-85</i>		4(B)	2	3	..	2	Mann
3-89	Oil Field Visits . . . . <i>1-10</i>	III <sub>2</sub>	3	S	0	3	0	Mann
3-901	Oil & Gas Land Val. (Elective) <i>3-86, 3-89</i>		G(A)	1	3	..	8	Mann
3-902	Oil & Gas Land Val. (Elective) <i>3-901</i>		G(A)	2	3	..	8	Mann
3-911	Petrol. Eng., Adv. (Elective) <i>3-86</i>		G(A)	1	◆			Mann
3-912	Petrol. Eng., Adv. (Elective) <i>3-86</i>		G(A)	2	◆			Mann
3-921	Oil & Gas Law . . . . (Elective) <i>3-86</i>		G(A)	1	2	..	4	Mann
3-922	Oil & Gas Law . . . . (Elective) <i>3-86</i>		G(A)	2	2	..	4	Mann
3-93	Ceramics . . . . . (Elective) <i>5-02, 8-04</i>		4(B)	2	2	2	5	F. H. Norton
3-94	Optical Ceramics . . (Elective) <i>3-04</i>		4(B)	1	0	6	2	C.L. Norton, Jr.
3-95	Fund. Ceramic Proc. (Elective) <i>3-93, 5-62, 8-10 or 8-11</i>		G(A)	1	3	4	4	F. H. Norton
3-96	Physical Prop. of Ceramic Products (Elective) <i>3-95</i>		G(A)	2	2	3	4	F. H. Norton

◆ Time specially arranged.

## ARCHITECTURE

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
4'021	Freehand Drawing. IV, IV-B		2	1	0	4	0	Reid
4'022	Freehand Drawing. IV, IV-B		2	2	0	4	0	Reid
	4'021							
4'031	Freehand Drawing. IV, IV-B		3	1	0	4	0	Reid
	4'022							
4'032	Freehand Drawing. IV, IV-B		3	2	0	4	0	Reid
	4'031							
4'041	Freehand Drawing. IV		4	1	0	4	0	Reid
	4'032							
4'042	Freehand Drawing. IV		4	2	0	4	0	Reid
	4'041							
4'051	Free Dr. & Fig. Comp. . . . . . IV		5(B)	1	0	6	0	Reid
	4'042							
4'052	Free Dr. & Fig. Comp. . . . . . IV		5(B)	2	0	6	0	Reid
	4'051							
4'053	Freehand Drawing. IV		G(A)	1	0	6	0	Reid
	4'052							
4'054	Freehand Drawing. IV		G(A)	2	0	6	0	Reid
	4'053							
4'06	Graphics. . . . . IV, IV-B		1	1	2	4	0	Zisman
4'071	Modeling. . . . . IV, IV-B		3	1	0	3	0	Selmar-Larsen
	4'722							
4'072	Modeling. . . . . IV, IV-B		3	2	0	3	0	Selmar-Larsen
	4'071							
4'081	Color, Comp. Th. & App. . . . . IV, IV-B		4	1	1	..	3	Beckwith
	4'732							
4'082	Color, Comp. Th. & App. . . . . IV, IV-B		4	2	1	..	3	Beckwith
	4'081							
4'091	Color, Comp. Th. & App. . . . . IV		5(B)	1	1	..	4	H. W. Gardner
	4'082							
4'092	Color, Comp. Th. & App. . . . . IV		5(B)	2	1	..	4	H. W. Gardner
	4'091							
4'11	Shades & Shadows. IV, IV-B		1	1	0	3	0	H. W. Gardner
	4'06							
4'12	Perspective. . . . . IV, IV-B		1	1	1	2	0	Zisman
	4'06 or (D12)							
4'13	Perspective. . . . . IV-A		2	1	2	..	2	W.H. Lawrence
	D12							
4'211	Office Practice . . . IV, IV-B		2	1	0	5	0	Bridge
	4'712, 4'20							
4'212	Office Practice. . . IV, IV-B		2	2	0	5	0	Bridge
	4'211							
4'22	Office Practice. . . IV-A		3	S	0	6	0	Bridge
	D12							
4'24	Prof. Relations. . . IV		5(B)	2	1	..	1	
4'25	Estimating. . . . . IV-A		4	2	1	..	3	Jenrick
	4'212 or 4'22 and 4'212 or 4'212 (Not offered to students below the 4th year.)							
4'311	Theory of Arch. . . IV, IV-B		1	1	2	..	2	Zisman
4'312	Theory of Arch. . . IV, IV-B		1	2	2	..	2	Zisman
	4'311							
4'321	Theory of Arch. . . IV, IV-B		2	1	1	..	1	Beckwith
	4'312							
4'322	Theory of Arch. . . IV, IV-B		2	2	1	..	1	Beckwith
	4'321							
4'331	Theory of Arch. . . IV, IV-B		3	1	2	..	0	H.W.Gardner
	4'322							
4'332	Theory of Arch. . . IV, IV-B		3	2	2	..	0	H.W.Gardner
	4'331							
4'341	Theory of Arch. . . IV		4	1	1	..	1	Cash
	4'332							
4'342	Theory of Arch. . . IV		4	2	1	..	1	Cash
	4'341							
4'411	Architectural Hist. IV, IV-B		1	1	2	..	3	Putnam
	IV-A		2	1	2	..	3	
4'412	Architectural Hist. IV, IV-B		1	2	2	..	3	Putnam
	IV-A		2	2	2	..	3	
	4'411							

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
4'421	Architectural Hist..	IV, IV-B	2	1	2	..	2	Putnam
	<i>4'412</i>	IV-A	3	1	2	..	2	
4'422	Architectural Hist..	IV, IV-B	2	2	2	..	2	Putnam
	<i>4'421</i>	IV-A	3	2	2	..	2	
4'461	Euro. Civilization..	IV, IV-A	3	1	3	..	4	Seaver
	<i>4'422</i>							
4'462	Euro. Civilization..	IV, IV-A	3	2	3	..	4	Seaver
	<i>4'461</i>							
4'471	Euro. Civilization..	IV	4	1	2	..	3	Seaver
	<i>4'462</i>							
4'472	Euro. Civilization..	IV	4	2	2	..	3	Seaver
	<i>4'471</i>							
4'481	Euro. Civilization..	IV	5(B)	1	2	..	3	Seaver
	<i>4'472</i>							
4'482	Euro. Civilization..	IV	5(B)	2	2	..	3	Seaver
	<i>4'481</i>							
4'491	Euro. Civilization..	IV	G(A)	1	2	..	4	Seaver
	<i>4'482</i>							
4'492	Euro. Civilization..	IV	G(A)	2	2	..	4	Seaver
	<i>4'491</i>							
4'53	Arch. Humanities.	IV, IV-B	5(B)	1	1	..	1	Emerson
	<i>4'241</i>							
4'61	City Planning.....	IV, IV-B	3	1	2	..	3	T. Adams
4'641	Th. & Prac. City Pl.	IV-B	4(B)	1	3	..	6	F. J. Adams
	<i>4'61</i>							
4'642	Th. & Prac. City Pl.	IV-B	4(B)	2	3	..	6	F. J. Adams
	<i>4'641</i>							
4'651	Th. & Prac. City Pl.	IV-B	5(B)	1	3	..	6	F. J. Adams
	<i>4'642</i>							
4'652	Th. & Prac. City Pl.	IV-B	5(B)	2	3	..	6	F. J. Adams
	<i>4'651</i>							
4'671	City Plan. Design.	IV-B	4(B)	1	20	..	0	F. J. Adams
	<i>4'732, 1'20, 1'81</i>							
4'672	City Plan. Design.	IV-B	4(B)	2	20	..	0	F. J. Adams
	<i>4'671</i>							
4'681	City Plan. Design.	IV-B	5(B)	1	28	..	0	F. J. Adams
	<i>4'672</i>							
	(Not offered 1933-34)							
4'682	City Plan. Design.	IV-B	5(B)	2	16	..	0	F. J. Adams
	<i>4'681</i>							
	(Not offered 1933-34)							
4'712	Design I.....	IV, IV-B	1	2	0	12	0	Zisman
4'721	Design II.....	IV, IV-B	2	1	0	10	0	Beckwith
	<i>4'712</i>							
4'722	Design II.....	IV, IV-B	2	2	0	10	0	Beckwith
	<i>4'721</i>							
4'731	Design III.....	IV, IV-B	3	1	0	12	0	H. W. Gardner
	<i>4'722</i>							
4'732	Design III.....	IV, IV-B	3	2	0	17	0	H. W. Gardner
	<i>4'731</i>							
4'741	Design IV.....	IV	4	1	0	21	0	Gunther
	<i>4'732</i>							
4'742	Design IV.....	IV	4	2	0	29	0	Gunther
	<i>4'741</i>							
4'751	Design V.....	IV	5(B)	1	0	30	0	Anderson
	<i>4'742</i>							
4'752	Design V.....	IV	5(B)	2	0	12	0	Anderson
	<i>4'751</i>							
4'761	Design.....	IV	G(A)	1	0	36	0	Anderson
	<i>4'752</i>							
4'762	Design.....	IV	G(A)	2	0	36	0	Anderson
	<i>4'761</i>							
4'78	Planning Principles	IV-A	3	2	1	3	8	Clapp
	<i>4'413, 4'414</i>							
4'80	Building Construct.	IV-A	3	1	1	..	1	P. W. Norton
4'811	Construction.....	IV, IV-B	3	1	2	5	0	P. W. Norton
	<i>2'232</i>							
4'812	Construction.....	IV, IV-B	3	2	2	5	0	P. W. Norton
	<i>4'811</i>							
4'90	Structural Drawing	IV-A						
	<i>D12</i>							
4'911	Structural Anal....	IV-A	3	1	4	8	0	W. H. Lawrence
	<i>2'20</i>							
4'912	Structural Anal....	IV-A	3	2	2	6	0	W. H. Lawrence
	<i>4'911</i>							
4'921	Structural Design.	IV-A	4	1	2	7	0	W. H. Lawrence
	<i>4'912, 1'40, 4'90</i>							
4'922	Structural Design..	IV-A	4	2	2	7	0	W. H. Lawrence
	<i>4'921</i>							

## TABULATION OF SUBJECTS

## CHEMISTRY — 5'00-5'99

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
5'00	Chem., Entrance...			S				
5'01	Chemistry, Gen.... 5'00	All courses except IV and IV-B	1	1	3	3	5	Blanchard Phelan
5'02	Chemistry, Gen.... 5'01	All courses except IV and IV-B	1	2	4	3	4	Phelan
5'04	Chemistry, Gen....	IIA.O.	4	S	3	..	3	Wareham
5'05	Atom. St., Elem....	(Elective)		2	1	..	1	Blanchard
5'061	Inorg. Chemistry... 5'13	V	4(B)	1	2	..	3	Schumb
5'062	Inorg. Chemistry... 5'061	V	4(B)	2	2	..	3	Schumb
5'07	Inorg. Chem., Adv. 5'062	(Elective)	G(A)	1	2	..	3	Schumb
5'08	Inorg. Lab. Adv.... 5'13	(Elective)	G(A)	1 or 2	6	..	0	Schumb
5'10	Qualitative Anal... 5'02	V, X, XIV, XV <sub>1</sub> (Elective)	2	S	3	11	4	Hamilton
5'11	Qualitative Anal... 5'02	III, VII, VIII, IX-A XI, XII	2	1	3	11	4	
5'12	Quantitative Anal... 5'10 or 5'11	V, X, XIV, XV <sub>2</sub> III, VII, IX-A, XI, XII	2	1	2	5	2	Hamilton Hamilton
5'13	Quantitative Anal... 5'12	III, V, X, XII	3	1	2	5	2	Hamilton
5'141	Anal. Chemistry... 5'13	V	3	1	3	..	2	
5'142	Anal. Chemistry... 5'141	V	3	2	3	..	1	Gill Woodman Hamilton
5'16	Anal. Chemistry... 5'13	X-A	4	2	1	3	1	Hamilton
5'18	Qual. Anal., Adv... 5'10	(Elective)	G(A)	1	1	8	1	W. T. Hall
5'20	Chem. of Wat. Sew. 5'12	VII	3	1	1	3	1	Woodman
5'23	Sanitary Chem.... 5'12	XI	3	2	1	6	1	Woodman
5'25	Chemistry of Foods 5'12	VII, 2	3	2	1	4	1	Woodman
5'251	Chemistry of Foods 5'12	(Elective)	4(B)	1 or 2	1	2	1	Woodman
5'26	Food Analysis..... 5'12	(Elective)	4(B)	1 or 2	0	5	0	Woodman
5'30	Proximate Anal.... 5'12, (5'41)	(Elective)	4(B)	1 or 2	1	5	2	Gill
5'31	Gas Analysis..... 5'12	XIV III <sub>1</sub>	2	2	1	0	1	Gill
5'33	Study of War Gases	V.C.W.S.	3	1	1	0	1	Gill
5'35	Applied Chemistry. 5'02	XIII, XIII-C XIII-A	4	2	1	..	2	Gill
5'37	Chem. of Road Mat. 5'02	(Elective)	4(B)	1	1	..	2	Gill
5'38	Lub. & Fuel Oil Test 5'02	(Elective)	4	1 or 2	1	2	1	Gill
5'381	Oil Test.&Pet.Refin 5'02	III <sub>1</sub>	3	1	2	3	2	Gill
5'39	Special Methods... 5'12, 5'02	(Elective)	3	1	0	2	1	Gill
5'41	Organic Chem. I... 5'12, 5'04	V, VII <sub>2</sub> , VIII, IX-A, XI X, XIV, XV <sub>2</sub>	3	1	4	..	3	Mulliken
5'412	Organic Chemistry. 5'04	VII <sub>1,2</sub> IIA.O.	3	S	4	..	3	Mulliken
5'413	Organic Chemistry. 5'412	IIA.O.	4	1	3	3	0	Mulliken
5'414	Organic Chem. Lab V 5'12 (5'41)	V	3	1	0	9	0	Mulliken
5'416	Organic Chem. Lab. X, XV <sub>1</sub> 5'12 (5'41)	X, XV <sub>1</sub>	3	1	0	9	0	Mulliken
5'418	Organic Chem. Lab. IX-A, XIV 5'12 (5'41)	IX-A, XIV	3	1	0	6	0	Mulliken
5'42	Organic Chem. I... 5'41	V, X	3	2	3	..	2	Mulliken
5'424	Organic Chem. Lab. V 5'414	V	3	2	0	11	0	Mulliken
5'425	Organic Chem. Lab. Chem. War. 5'414	Chem. War.	3	2	0	9	0	Mulliken

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
5'426	Organic Chem. Lab. X <i>5'416</i>		3	2	0	5	0	Mulliken
5'427	Quant. Org. Anal. (Elective) <i>5'41</i>		4	1	0	3	0	Underwood
5'428	Organic Chem. Lab. VII, 1 <i>(5'41)</i>		3	S	0	10	0	Mulliken
5'43	Powder & Explosive <i>5'48</i>	VC.W.S., X Ord., X.C.W.S. (Elective)	4	2	2	..	2	Underwood
		(Elective)	4(B)	2	2	..	2	
		Chem. War. (Elective)	4(B)	2	2	..	2	
5'51	Organic Chem. II. (Elective) <i>5'42</i>		G(A)	1	2	..	2	Norris
5'52	Organic Chem. II. (Elective) <i>5'42</i>		G(A)	2	2	..	2	Norris
5'53	Organic Chem. III. (Elective) <i>5'42</i>		G(A)	1	3	..	6	Mulliken
5'541	Organic Chem. IV. (Elective) <i>5'42</i>		G(A)	1	2	..	4	T. L. Davis
5'542	Organic Chem. IV. (Elective) <i>5'541</i>		G(A)	2	2	..	4	T. L. Davis
5'55	Organic Qual. Anal. (Elective) <i>5'42, 5'414</i>		G(A)	1	0	10	0	Mulliken
5'56	Tech.Org.Chem.... (Elective) <i>5'41</i>		G(A)	2	2	..	2	Underwood
5'57	Chemistry of Dyes. (Elective) <i>5'42</i>		G(A)	2	2	..	2	Mulliken
5'572	Stereochemistry.... (Elective) <i>5'42</i>		G(A)	2	2	0	4	Euntress
5'574	Free Rad. & Org.-Met. Comp..... (Elective) <i>5'42</i>		G(A)	2	2	0	4	Morton
5'576	Sem. Recent Hist. of Org. Chem..... (Elective) <i>5'42</i>		G(A)	2	2	0	4	T. L. Davis
5'581	Org. Lab., Adv.... (Elective) <i>5'42, 5'424</i>		G(A)	1	1	5	1	Morton
5'582	Org. Lab., Adv.... (Elective) <i>5'42, 5'424</i>		G(A)	2	0	5	1	Morton
5'584	Mol. Str. of Org. Chem. Comp.... (Elective) <i>5'42</i>		G(A)	2	2	..	4	Ashdown
5'591	Recent Adv. in Org. Chem..... (Elective) <i>5'42</i>		G(A)	1	1	..	1	Norris
5'592	Recent Adv. in Org. Chem..... (Elective) <i>5'42</i>		G(A)	2	1	..	1	Norris
5'61	Phys. Chem. I. .... V, X <i>M21, 8'03, 5'13</i>		3	1	4	1	5	Sherrill
5'611	Physical Chem. I. .... III, XII(b) <i>M21, 8'03, 5'13</i>		4	1	4	..	4	Millard
		III, XV <sub>2</sub>	3	1	4	..	4	
5'62	Phys. Chem. II. .... V, X <i>5'61</i>		3	2	3	1	5	Sherrill
5'63	Phys. Chem. III. .... V <i>5'62</i>		4(B)	1	3	1	4	Sherrill
5'64	Phys. Chem. IV. .... V <i>5'63</i>		4(B)	2	3	..	4	Sherrill
5'683	Phys. Chem., Elem., XVI <i>5'02, 8'04</i>	II. Mil. Eng. II (T.D.)	3	1	2	..	2	Millard
			4	1	2	..	2	
			G(A)	1	2	..	2	
5'684	Phys. Chem., Elem. VII, 2, XI <i>M21, 5'12, 8'04</i>		3	1	3	..	3	Gillespie
5'71	Physical Chem.... (Elective) <i>M21, 8'03, 5'13</i>		G(A)	1	4	..	6	Sherrill
5'72	Physical Chem.... (Elective) <i>5'71</i>		G(A)	2	4	..	6	Sherrill
5'73	Free Energy. .... (Elective) <i>5'63 or 5'72</i>		G(A)	1	2	..	4	Sherrill
5'741	Kin. Th. of Matter I (Elective) <i>5'64 or 5'72</i>		G(A)	1	2	..	4	Harris
5'742	Kin. Th. of Matter II (Elective) <i>5'741</i>		G(A)	2	2	..	4	Kirkwood
5'75	Thermodynamics. . (Elective) II (T.D.)		G(A)	2	2	..	2	Keys
			G(A)	2	2	..	2	
5'76	Thermodyn.&Chem. (Elective) <i>5'62</i>		G(A)	1	3	..	6	Gillespie

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
5'77	Thermodyn.&Chem. (Elective) <i>5'76</i>		G(A)	2	2	..	4	Beattie
5'79	Th. of Solutions... (Elective) <i>5'76</i>		G(A)	2	2	..	4	Scatchard
5'81	Chem. Literature I. V <i>L12 and L52 or L22</i>		3	1	3	..	2	W. T. Hall
5'82	Chem. Literature II V <i>5'81, 5'41, 5'61</i>		3	2	1	..	1	Huntress
5'83	History of Chem... V <i>5'41</i>		4(B)	2	2	..	2	T. L. Davis
5'842	Optical Methods... (Elective) <i>5'12, 5'02</i>		4(B)	1 or 2	0	2	1	Woodman
5'843	Eng. Chemistry... (Elective) <i>5'02</i>		4	1 or 2	2	..	2	Gill
5'844	Eng. Chemistry... XVII		2	1	5	..	1	Gill
5'851	Meth. of Electrochem. Anal. .... (Elective) <i>5'12</i>		G(A)	2	1	3	2	W. T. Hall
5'852	Org. Phys. Chem... (Elective) <i>5'64, 5'42</i>		G(A)	2	2	..	4	Morton
5'855	Th. & App. of Cat. (Elective) <i>5'41</i>		G(A)	2	2	..	2	Underwood
5'89	Chemistry ..... V, X <i>(5'42, 5'62, 10'203 or 10'19, 5'424 or 5'426)</i>		3	2	0	0	6	Millard
5'90	Logic of Sci. Inq... (Elective)		G(A)	1	1	..	2	T. L. Davis
5'911	Journal Meet. in Inorg. Chem.... (Elective)		G(A)	1	1	..	1	Schumb
5'912	Journal Meet. in Inorg. Chem.... (Elective)		G(A)	2	1	..	1	Schumb
5'921	Journal Meet. in Org. Chem. .... (Elective) <i>5'42</i>		G(A)	1	1	..	1	Norris
5'922	Journal Meet. in Org. Chem. .... (Elective) <i>5'42</i>		G(A)	2	1	..	1	Norris
5'931	Journal Meet. in Phys. Chem. .... (Elective)		G(A)	1	1	..	1	Scatchard
5'932	Journal Meet. in Phys. Chem. .... (Elective)		G(A)	2	1	..	1	Scatchard
5'941	Research Conf., Inorg. and Org. Chem.. (Elective) <i>5'42, 5'63</i>		G(A)	1	1	..	1	Norris
5'942	Research Conf., Inorg. and Org. Chem... (Elective) <i>5'42, 5'63</i>		G(A)	2	1	..	1	Norris
5'943	Research Conf. Phys. Chem. .... (Elective)		G(A)	1	1	..	1	Scatchard
5'944	Research Conf. Phys. Chem. .... (Elective)		G(A)	1	1	..	1	Scatchard
5'96	Thesis Conference. V		4	2	1	..	1	Keyes
5'961	Thesis..... V		4	1	0	15	0	Keyes
5'962	Thesis..... V		4	2	0	15	0	Keyes
5'98	Research..... (Elective)		G(A)	◆				Norris

◆ Time specially arranged.

## ELECTRICAL ENGINEERING — 6'00-6'99

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6'00	Elec. Eng. Prin. . . . (M22) 8'03	VI, VI-A, XIV	2	2	4	..	4	Lansil
6'01	Elec. Eng. Prin. . . . 6'00	VI, VI-C, XIV VI-A(A) VI-A(B)	3 3 3	1 S S	3 3 2	.. .. ..	4 4 5	Lansil
6'02	Elec. Eng., Prin. . . . 6'00, M22	VI, VI-C, XIV VI-A(B)	3 3	2	5	..	6	R.R.Lawrence
6'021	Elec. Eng., Prin. . . . 6'00, M22	VI-A(A)	3	1	5	..	6	R.R.Lawrence
6'023	Elec. Eng. Prin. . . . 6'021	VI-A(A)	3	2	5	..	6	R.R.Lawrence
6'03	Elec. Eng. Prin. . . . 6'02	VI, VI-C	4	1	6	..	8	R.R.Lawrence
6'031	Elec. Eng. Prin. . . . 6'02	VI-A(B)	3	2	2	..	5	R.R.Lawrence
6'032	Elec. Eng. Prin. . . . 6'023 or 6'031	VI-A(A) VI-A(B) VI-A(B) <sub>1</sub>	4 4 4	S 1 S	2 2 3	.. .. ..	5 5 4	R.R.Lawrence
6'04	Elec. Eng. Prin. . . . 6'03	VI 4(B)	4 4	2 2	6	..	9	Woodruff
6'041	Elec. Eng. Prin. . . . 6'032	VI-A(A) <sub>1</sub> , VI-A(B) <sub>1</sub>	4 4	1 1	3	..	5	Woodruff
6'042	Elec. Eng. Prin. . . . 6'041	VI-A(A) <sub>1</sub> , VI-A(B) <sub>1</sub>	4 4	2 2	2 3	.. ..	6 5	Woodruff
6'09	Elec. Eng. Prin. . . . 6'02	XIV	4	1	3	..	6	R.R.Lawrence
6'20	Power Trans. Equip. (Elective) 5'04		4(B)	2	3	..	6	Woodruff
6'21	Ind. App. El. Power (Elective) 6'03	Mil. Eng.	4(B)	2	3	..	6	Dawes
6'221	Central Stations . . . (Elective) 2'42		4(B)	1	3	..	6	Mulligan
6'222	Central Stations . . . (Elective) 6'03		4(B)	2	3	..	6	Mulligan
6'241	Electric Railways . . (Elective) 6'01 (6'03)		4(B)	1	3	..	6	Entwistle
6'242	Electric Railways . . (Elective) 6'241		4(B)	2	3	..	6	Entwistle
6'251	Elec. Mach. Design (Elective) 6'03		4(B)	1	3	..	6	Dwight
6'252	Elec. Mach. Design (Elective) 6'03		4(B)	2	3	..	6	Dwight
6'26	Elec. Insulation and its Behavior . . . . (Elective) M31		4(B)	1	2	3	4	Moon
6'27	Illumination . . . . . (Elective) 8'02		4(B)	1	2	3	4	Moon
6'281	Prin. Wire Com. . . (Elective) 6'02		4(B)	1	3	..	6	C. E. Tucker
6'282	Prin. Radio Com. . . (Elective) 6'02		4(B)	2	3	..	6	Gager
6'29	Storage Batteries . . (Elective) 6'00		3 or 4	1, 2	1	..	1	R.R.Lawrence
6'301	Elec. Com., Prin. . . VI-C 6'00		3	1	3	..	6	E. A. Guillemain
6'302	Elec. Com., Prin. . . VI-C 6'301 (6'02)		3	2	3	..	6	E. A. Guillemain
6'311	Elec. Com., Prin. . . VI-C 6'302, 6'02		4(B)	1	3	..	5	Bowles
6'312	Elec. Com., Prin. . . VI-A(B) <sub>1</sub> , VI-C 6'302 and 6'02		4(B)	2	3	..	5	E. A. Guillemain
6'330	Elec. Com. Lab. . . . VI-A(A) <sub>1</sub> 6'32T		4	2	2	..	6	Gager
6'331	Elec. Com. Lab. . . . VI-A(B) <sub>1</sub> 6'311		4	2	0	4	4	Gager
6'332	Elec. Com. Lab. . . . VI-C 6'311		4	1	0	5	6	Gager
6'39	Eng. Electronics . . . VI-A(A) VI-A(B) <sub>1</sub> , XIV VI, VI-C VI-A(B) <sub>1</sub>		4 4 3 3 4	1 2 2 1 S	2 2 2 2 2	3 3 3 3 3	4 4 4 4 4	Gray

## TABULATION OF SUBJECTS

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lab.			Instructor in Charge
					Lec.	Draw.	Prep.	
6'40	Elec. Eng. Elem.... (8'04)	I, XI, XV <sub>1</sub> , a, c, XVII	3	1	4	..	6	Hudson
			4	3	4	..	6	
6'42	Elec. Eng. Elem....	II, IX-B, XV <sub>1</sub> , b, 2, XIII-C	4	1	4	..	6	Hudson
6'43	Gen. & Dist. Elec. Energy..... 6'40	II(A.O.) XV <sub>1</sub> b	4	2	4	..	6	Balsbaugh
6'44	Elec. Trans. & Con. I <sub>3</sub> 6'40	I <sub>3</sub>	3	2	2	..	4	Balsbaugh
6'48	Elec. Eq. of Bldgs.. 8'04	XVII (Elective)	3	2	1	..	2	Hudson
			3, 4	2	1	..	2	
6'501	Elec. Eng. Seminar	(Elective)	G(A)	1	2	..	6	Woodruff
6'502	Elec. Eng. Seminar	(Elective)	G(A)	2	2	..	6	Woodruff
6'511	Elec. Circuits..... 6'04, M31	(Elective)	G(A)	1	3	..	7	Wildes
6'512	Elec. Circuits..... 6'04, M31	(Elective)	G(A)	2	3	..	7	Wildes
6'513	Elec. Circuits..... 6'511	(Elective)	G(A)	2	3	..	7	Hazen
6'521	Alt. Cur. Machinery 6'04, M31	(Elective)	G(A)	1	2	3	5	Lyon
6'522	Alt. Cur. Machinery 6'04, M31	(Elective)	G(A)	2	2	3	5	Lyon
6'531	Org. & Adm. Pub. Service Co..... 6'04, Ec32	(Elective)	G(A)	1	3	..	7	Jackson
6'532	Org. & Adm. Pub. Service Co..... 6'04, Ec32	(Elective)	G(A)	2	3	..	7	Jackson
6'541	Power Gen. Stations 6'03, Ec32	(Elective)	G(A)	1	3	..	6	Mulligan
6'542	Power Gen. Stations 6'03, Ec32	(Elective)	G(A)	2	3	..	6	Mulligan
6'551	Railroad Elec. Trac. 6'03, Ec32	(Elective)	G(A)	1	3	..	6	Entwistle
6'552	Railroad Elec. Trac. 6'551	(Elective)	G(A)	2	3	..	6	Entwistle
6'561	Adv. Network Th.. 6'312	(Elective)	G(A)	1	3	2	5	E. Guillemin
6'562	Adv. Network Th.. 6'561	(Elective)	G(A)	2	2	..	5	E. Guillemin
6'571	Illumination..... 8'02	(Elective)	G(A)	1	2	3	4	Brune Moon
6'572	Illumination..... 6'571	(Elective)	G(A)	2	2	3	4	Moon
6'58	Op. Circuit Anal.. 6'04 or 6'312, M31	(Elective)	G(A)	1 or 2	3	..	7	M.F. Gardner
6'59	Communications Laboratory..... 6'332 or equiv.	(Elective)	G(A)	1 or 2	2	3	5	Bowles
6'62	Elec. Com. Prin.... 6'312	(Elective)	G(A)	2	2	3	5	Bowles
6'651	Elec. Power Distri. 6'04	(Elective)	G(A)	1	3	..	6	Balsbaugh
6'652	Elec. Power Distri. 6'04	(Elective)	G(A)	2	3	..	6	Balsbaugh
6'661	Elec. Mach. Dev. Prin..... 6'03	(Elective)	G(A)	1	3	1	6	Dwight
6'662	Elec. Mach. Dev. Prin..... 6'03	(Elective)	G(A)	2	3	1	6	Dwight
6'68	Transmission-Line Trans..... 6'04, M31	(Elective)	G(A)	1 or 2	3	..	7	Dahl
6'69	Sound in Elec. Com. M31, 6'04 or 6'312	(Elective)	G(A)	2	2	3	5	Fay
6'71	Elec. Eng. Lab.... 6'75, 6'76 (6'02)	VI, VI-C, XIV	3	2	2	3	5	C.E. Tucke Bennett
6'72	Elec. Eng. Lab.... 6'71 (6'03)	VI	4	1	1	3	4	C. E. Tucker
6'73	Elec. Meas. Lab. Adv. 6'71, 6'04	(Elective)	G(A)	1 or 2	2	..	..	Bennett

↔ Time specially arranged.

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
6'74	Elec. Eng. Lab. Adv. 6'03, 6'72	(Elective)	G(A)	1 or 2				{ C. E. Tucker Hazen
6'75	Elec. Eng. Lab. (6'00) or 6'40	VI, VI-A III, I	2	2	1	1	2	Bennett
6'76	Elec. Eng. Lab. 6'75 (6'01)	VI, VI-C, VI-A(B)	3	S	1	1	2	C. E. Tucker
6'77	Elec. Eng. Lab. (6'023) or 6'02	VI-A(A) VI-A(B)	3	2	1	2	2	Bennett
6'78	Elec. Eng. Lab. 6'76, 6'032	VI-A(A) <sub>1,2</sub> VI-A(B) <sub>1,2</sub>	4	1	1	3	6	C. E. Tucker
6'781	Elec. Eng. Lab. 6'76, 6'032	VI-A(A) <sub>1</sub> VI-A(B) <sub>1</sub>	4	2	1	3	6	C. E. Tucker
6'80	Elec. Eng. Lab. (Elective)		4(B)	1 or 2				
6'81	Elec. Eng. Lab. (6'01)	XIV	3	1	1	2	2	{ C. E. Tucker Bennett
6'83	Elec. Eng. Lab. 6'71, (6'03)	VI-C	4	1	1	2	3	C. E. Tucker
6'85	Elec. Eng. Lab. 6'40	X, Mil. Eng. XVI III, 1, 2, 3, IX-B	4	2	0	2	3	C. E. Tucker
6'88	Elec. Eng. Lab. (6'42)	A.O.	4	1	1	3	6	C. E. Tucker
6'89	Elec. Eng. Lab. (6'40)	I, II, XVIa, XVII XIII, XIII-C	3	2	0	2	2	C. E. Tucker
6'901	Man. Practice	VI-A(A) <sub>1</sub> VI-A(B) <sub>1</sub>	3	1		h. p. w. 0 48	0	Timbie
6'902	Man. Practice	VI-A(A) <sub>1</sub> VI-A(B) <sub>1</sub>	3	S	0	48	0	Timbie
6'903	Man. Practice	VI-A(A) <sub>1</sub> VI-A(B) <sub>1</sub>	4	S	0	48	0	Timbie
6'904	Man. Practice	VI-A(A) <sub>1</sub> VI-A(B) <sub>1</sub>	3	2	0	48	0	Timbie
6'911	Pub. Util. Practice	VI-A(A) <sub>1</sub> VI-A(B) <sub>1</sub>	4	1	0	48	0	Timbie
6'912	Pub. Util. Practice	VI-A(A) <sub>1</sub> VI-A(B) <sub>1</sub>	G	1	0	48	0	Timbie
6'913	Pub. Util. Practice	VI-A(A) <sub>1</sub> VI-A(B) <sub>1</sub>	3	S	0	48	0	Timbie
6'914	Pub. Util. Practice	VI-A(A) <sub>1</sub> VI-A(B) <sub>1</sub>	4	S	0	48	0	Timbie
6'921	Pub. Util. Practice	VI-A(A) <sub>1</sub> VI-A(B) <sub>1</sub>	3	2	0	48	0	Timbie
6'922	Pub. Util. Practice	VI-A(A) <sub>1</sub> VI-A(B) <sub>1</sub>	4	1	0	48	0	Timbie
6'923	Pub. Util. Practice	VI-A(A) <sub>1</sub> VI-A(B) <sub>1</sub>	G	1	0	48	0	Timbie
6'924	Pub. Util. Practice	VI-A(A) <sub>1</sub> VI-A(B) <sub>1</sub>	3	S	0	48	0	Timbie
6'941	Com. Practice	VI-A(A) <sub>1</sub> VI-A(B) <sub>1</sub>	3	1	0	48	0	Timbie
6'942	Com. Practice	VI-A(A) <sub>1</sub> VI-A(B) <sub>1</sub>	4	S	0	48	0	Timbie
6'943	Com. Practice	VI-A(A) <sub>1</sub> VI-A(B) <sub>1</sub>	3	2	0	48	0	Timbie
6'944	Com. Practice	VI-A(A) <sub>1</sub> VI-A(B) <sub>1</sub>	4	1	0	48	0	Timbie
			G	S	0	48	0	Timbie

◆ Time specially arranged

## BIOLOGY AND PUBLIC HEALTH

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
7-01	General Biology...	VII, XI V, IX-A, XIIb	2	1	2	3	2	Turner
			3	1	2	3	2	
7-03	Theoret. Biology...	VII, 1	4(B)	2	2	..	3	Blake
	7-01, 7-10							
7-06	Botany.....	VII, 1	2	2	2	5	3	Jennison
	(7-01)							
7-07	Mycology.....	VII, 1	3	1	1	2	2	Proctor
	7-06							
7-08	Parasitology.....	VII, 1	4	2	2	..	4	Blake
	7-01							
7-09	Parasitology, Adv..	(Elective)	G(A)	2	0	4	4	Bigelow
	7-08							
7-10	Zoology.....	VII, 1 XIIb	2	2	1	4	3	Blake
	7-01		3	2	1	4	3	
7-11	Anatomy & Histol.	VII, 1	3	1	2	6	4	Blake
	7-01							
7-12	Anatomy & Histol.	VII, 1	3	2	2	5	4	Blake
	7-11							
7-131	Adv. Histology....	(Elective)	4(B)	1	4	..	3	Blake
7-132	Adv. Histology....	(Elective)	G(A)	2	4	..	2	Blake
7-14	Hist. of Biology....	(Elective)	G(A)	1	1	..	4	Bigelow
	7-01							
7-15	Essent. of Anatomy	VII, 1	3	1	3	..	3	Blake
	7-10							
7-18	Tech.Asp.of Entom.	(Elective)	G(A)	1	2	..	3	Blake
	7-10							
7-20	Physiology.....	VII, 1	3	2	3	3	5	Bunker
	5-501, 7-11 or 7-15							
7-22	Pers. Hyg. & Nut.	VII, 1	4(B)	1	2	..	2	Bunker
7-23	App. Nutrition....	(Elective)	G(A)	2	1	..	2	Turner
7-24	Limnology.....	(Elective)	3	1	3	4	3	Jennison
7-29	Bacteriology.....	XI	3	2	1	4	2	Jennison
	7-01							
7-301	Bacteriology.....	VII	3	1	2	4	4	Horwood
	7-01							
7-302	Bacteriology.....	VII	3, 4(B)	2	2	4	3	Horwood
	7-501							
7-31	Bacteriology.....	Mil.Eng.	4	1	2	..	2	Prescott
7-321	Bacteriology, Adv..	(Elective)	G(A)	1	3	..	4	Jennison
	7-301, 7-80							
7-322	Bacteriology, Adv..	(Elective)	G(A)	2	1	4	2	Jennison
	7-321							
7-33	Plant Diseases....	VII, 1	3	2	1	..	2	Prescott
	7-301							
7-34	Limnological Field.	VII, XI	3	S	0	5	0	Jennison
	7-01, 5-122							
7-35	Planktonology....	(Elective)	G(A)	1	2	..	3	Blake
	7-06, 7-10							
7-36	Microbiology.....	VII, 1	4	1	1	2	2	Prescott
	7-301							
7-361	Indust. Microbiology	VII, 1	4(B)	1	1	4	2	Prescott
7-362	Indust. Microbiology	VII, 1	4(B)	2	1	3	4	Proctor
	7-361							
7-371	Indust. Microbiology	(Elective)	G(A)	1	1	4	4	Prescott
	7-361							
7-372	Indust. Microbiology	(Elective)	G(A)	2	1	3	4	Prescott
7-421	Food Fishes.....	(Elective)	3	1	2	6	5	Blake
	7-10							
7-422	Food Fishes.....	(Elective)	3	2	2	4	2	Blake
	7-421							
7-43	Fish Culture.....	(Elective)	3	2	1	..	2	Blake
	7-10							
7-441	Tech. of Fish. Prod.	(Elective)	4(B)	1	1	3	4	Proctor
	7-302, 7-422							
7-442	Tech. of Fish Prod.	(Elective)	4(B)	2	1	4	4	Proctor
	7-441							
7-50	Commun. Diseases.	VII, 1	3(B)	1	3	..	3	J. W. Williams
	7-301							
7-52	Industrial Hygiene.	VII	4(B)	2	3	1	4	Turner
	7-50							
7-53	Air Examination...	II(Elective)	4(B)	1	1	2	1	Jennison
	VII, 1		3	1	1	2	1	
7-541	Pub. Health Adm..	VII, 1	4(B)	1	2	..	3	Turner
	7-302							

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
7 542	Pub. Health Adm. VII, 1 <i>7 302</i>	VII, 1	4(B)	2	2	..	3	Turner
7 551	Public Health Lab. Meth. .... <i>7 301</i>	VII, 1	4(B)	1	2	6	3	Williams
7 552	Serological Meth. .... <i>7 301</i>	VII, 1	4(B)	2	1	5	1	Williams
7 553	Public Health Lab. Meth. .... (Elective) (Not offered summer 1933)	(Elective)		S	1	3	1	
7 560	Pub. Health Surveys (Elective) <i>7 67</i>	(Elective)	G(A)	2	2	..	3	Horwood
7 57	Municipal Sanita. Mil. Eng. <i>7 301</i>	VII	3(B)	2	4	..	4	Horwood
7 58	Vital Statistics. .... VII, 1 <i>7 301, 7 60</i>	VII, 1	4(B)	1	2	..	3	Horwood
7 59	Sanitation. .... VII, 1 <i>7 302, 7 57</i>	VII, 1	4(B)	1	2	2	4	Horwood
7 601	Health Education. (Elective) <i>7 01</i>	(Elective)	G(A)	1	2	..	4	Turner
7 602	Health Education. (Elective) <i>7 601</i>	(Elective)	G(A)	2	1	3	6	Turner
7 603	Health Edu. Meth. (Elective)	(Elective)		S	2	1	4	Turner
7 604	School Health Adm. (Elective)	(Elective)	G(A)	2	1	..	1	Turner
7 605	Health Ed. Subj Matter (Not offered summer 1933) (Elective)	(Elective)		S	3	..	4	Proctor
7 63	Pub. Health Field. (Elective) <i>7 542</i>	(Elective)	G(A)	2	2	..	4	Turner
7 64	Public Health Prob. (Elective) <i>7 542</i>	(Elective)	G(A)	2	2	..	4	Turner
7 65	Health Hazards in Spec. Industries. (Elective) <i>7 52</i>	(Elective)	G(A)	2	1	..	5	{ Prescott Turner
7 66	Epidemiology. .... (Elective) <i>7 302, 7 50</i>	(Elective)	G(A)	1	2	..	6	Horwood
7 67	Func. Pathology. .... (Elective) <i>7 12, 7 301, 7 20, 7 80</i>	(Elective)	G(A)		3	..	4	
7 68	Pathology. .... (Elective) <i>7 12, 7 551, 7 552</i>	(Elective)	G(A)	2	2	4	2	
7 701	Tech. of Food Sup. VII, 1 <i>(7 301)</i>	VII, 1	3	1	2	2	2	Proctor
7 702	Tech. of Food Sup. VII, 2 <i>(7 302)</i>	VII, 2	3	2	2	2	4	Proctor
7 711	Tech. of Food Prod. VII, 1 <i>7 701, 7 702</i>	VII, 1	4(B)	1	2	2	4	{ Prescott Proctor
7 712	Tech. of Food Prod. VII, 2 <i>7 701, 7 702</i>	VII, 2	4(B)	2	2	3	4	{ Prescott Proctor
7 722	Adv. Food Tech. .... (Elective) <i>7 711, 7 712</i>	(Elective)	G(A)		1	2	3	Proctor
7 80	Biochemistry. .... VII, 1 <i>8 41, 7 301</i>	VII, 1	4(B)	1	3	5	5	{ Bunker Tobie
7 81	Enzyme Chemistry. (Elective) <i>7 80</i>	(Elective)	G(A)	2	2	4	3	{ Bunker Tobie
7 91	Biological Colloq. .... VII	VII	4	1	1	..	1	{ Prescott and Staff
7 92	Biological Colloq. .... VII	VII	4	2	1	..	1	{ Prescott and Staff
7 931	Biological Seminar. (Elective)	(Elective)	G(A)	1	1	..	3	Prescott
7 932	Biological Seminar. (Elective)	(Elective)	G(A)	2	1	..	3	and Staff

## PHYSICS — 8'00-8'99

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
8'00	Physics Entrance . . .			S	2	..	5	Bennett
8'01	Physics (Mech.) . . .	All courses except IV and IV-B	1	1	4	2	5	Frank Bennett
8'012	Physics (College Transfer)		1	1	4	..	6	Bennett
8'02	Phys. (Mech. and Heat) . . . . .	All courses except IV and IV-B	1	2	4	2	5	Frank
8'03	Physics (Elec.) . . .	All courses except IV and IV-B	2	1	4	1	5	Page
8'034	Physics (College Transfer)		2	2	4	..	6	Bennett
8'04	Physics (Elec. Optics, & Modern Phys.)	All courses except IV and IV-B	2	2	4	2	4	Page Morse
8'05	Sound, Sp. & Aud. . .	VI-C	4	2	3	..	6	Morse
8'06	Accoust., Ill. & Col.	IV-A	3	1	1	..	2	Drisko
8'07	Precision of Meas. . .	XIII-A	G	1	1	..	1	Goodwin
	<i>M22</i>	XIV	4	1	1	..	1	
		XIII-A	3	2	1	..	1	
8'091	Physical Meas. . . . .	VIII	2	2	0	3	2	Müller
8'092	Physical Meas. . . . .	VIII	3	1	0	3	2	Sears
8'10	Heat Measurements (Elective)		4	1	1	3	2	Wilkes
8'11	Heat Measurements (Elective)	IX-A	3	1	0	2	1	Wilkes
8'12	Heat Measurements (Elective)	III, XIV	3	1	1	2	1	Wilkes
8'13	Heat Measurements (Elective)	III	4	1	1	2	1	Wilkes
8'14	Heat Measurements (Elective)	II . . . . .	G(A)	1	1	..	1	Wilkes
		<i>8'10, 8'11, 8'12 or 8'13</i>						
8'15	Photography . . . . .	(Elective)		2	2	..	1	Hardy
8'152	Adv. Photography . . .	(Elective)		2	0	3	2	Hardy
8'161	Optics . . . . .	I, VIII	4	1	3	..	6	Hardy
8'162	Optical Meas. . . . .	I, VIII	4	1	0	3	2	Hardy
8'171	Advanced Optics . . .	(Elective)	4(B)	1	2	..	3	Hardy
8'173	Color Measurements (Elective)		4(B)	2	0	3	2	Hardy
8'174	Motion Picture Photography . . .	(Elective)	4(B)	1	1	..	3	Hardy
	(Not offered in 1933-34)							
	Offered in alternate years							
8'181	Optics, Seminar . . . .	(Elective)	G(A)	2	2	..	2	Hardy
8'191	Microscopy and Photomicrography (Elective)		G(A)	1	2	..	0	Hardy
8'193	Geom. Optic. Adv. . . .	(Elective)	G(A)	1	2	..	4	Hardy
	<i>8'161</i> (Not offered 1933-34)							
8'194	Phys. Optics, Adv. . . .	(Elective)	G(A)	2	2	..	4	Hardy
	<i>8'161</i> (Not offered 1933-34)							
8'201	Elec. & Magnetism . . .	VIII	3	2	3	..	5	Nottingham
8'202	Electronic Lab. . . . .	VIII	3	2	0	3	2	Nottingham
8'21	Electronic Phen. . . . .	(Elective)	G(A)	1	2	..	4	Nottingham
8'212	Experimental Electronics . . . . .	(Elective)	G(A)	1 and 2	1	3	3	Nottingham
	<i>8'201 (8'21) or (8'213)</i>							
8'213	Adv. Electronics . . . .	(Elective)	G(A)	1	3	..	9	Nottingham
	<i>M22, 8'04, 8'201, 8'512</i>							
	(Offered in alternate years)							
8'214	Adv. Electronics . . . .	(Elective)	G(A)	2	3	..	9	Nottingham
	<i>8'213</i>							
	(Offered in alternate years)							

◆ Time specially arranged.

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
8'215	Special problems in Electronics. . . . . (Elective) <i>8'201</i>		G(A)	<b>1 or 2</b>	◆			Nottingham
8'26	Polar Molecules. . . . . (Elective) <i>8'311</i> (Offered in alternate years)		G(A)	<b>1</b>		3	1 3	Müller
8'27	X-Rays & Crystal Physics. . . . . (Elective) <i>8'04, M22</i>		4(B)	<b>1</b>		2	1 5	Warren
8'28	X-Ray Diffraction. (Elective) <i>8'27</i> (Not offered in 1933-34. Offered in alternate years)		G(A)	<b>2</b>		2	.. 4	Warren
8'29	Lattice Th. of the Solid State. . . . . (Elective) <i>8'27, 8'311</i> (Offered in alternate years)		G(A)	<b>2</b>		2	.. 4	Warren
8'30	Special Problems in Crystal Physics. . . (Elective) <i>8'27</i>		G(A)	<b>2</b>	◆			Warren
8'311	Atomic Structure. . VIII <i>8'04</i>		3	<b>2</b>		3	.. 5	Harrison
8'312	Atomic Struct. Lab. VIII <i>8'04 (8'311)</i>		3	<b>2</b>		0	3 2	Harrison
8'32	Line Spectra. . . . . (Elective) <i>8'311</i>		G(A)	<b>1</b>		3	.. 6	Harrison
8'341	Spectroscopy Seminar. . . . . (Elective) <i>8'32</i>		G(A)	<b>1</b>		1	.. 1	Harrison
8'342	Spectroscopy Seminar. . . . . (Elective) <i>8'32</i>		G(A)	<b>2</b>		1	.. 1	Harrison
8'343	Sp. Problems in Spectroscopy . . . (Elective) <i>8'32</i>		G(A)	<b>1 or 2</b>	◆			Harrison
8'35	Excitation of Spectra. . . . . (Elective) <i>8'32, 8'36</i>		G(A)	<b>2</b>		2	3 4	Stockbarger
8'36	Radiation Meas. . . . (Elective) <i>8'04</i>		4(B)	<b>1</b>		2	3 4	Stockbarger
8'361	Radiation Meas. . . . (Elective) <i>8'36</i>		G(A)	<b>1 or 2</b>		0	5 0	Stockbarger
8'45	Int. to Phys. Sci. . . VIII		4(B)	<b>2</b>		3	.. 2	Müller Slater
8'461	Int. to Theor. Phys. I, VIII, XVIII <i>8'04, M22</i>		4(B)	<b>1</b>		4	.. 8	Slater
8'462	Int. to Theor. Phys. II, VIII, XVIII <i>8'461</i>		4(B)	<b>2</b>		4	.. 8	Slater
8'463	Int. to Theor. Phys. III. . . . . (Elective) <i>8'461</i>		G(A)	<b>2</b>		3	.. 9	Slater
8'471	Hist. Dev. of Phys. VIII <i>(8'461)</i>		4(B)	<b>1</b>		3	.. 6	Allis
8'472	Rec. Dev. of Phys. VIII <i>8'311</i>		4(B)	<b>2</b>		3	.. 6	Allis
8'481	Advanced Mechan. I (Elective) <i>8'462 or 8'471</i> (Offered in alternate years)		G(A)	<b>1</b>		3	.. 9	Stratton
8'482	Adv. Mechanics. II (Elective) <i>8'462 or 8'471</i>		G(A)	<b>2</b>		3	.. 9	
8'49	Elasticity and Fluid Dynamics. . . . . (Elective) <i>8'462 or 8'471</i> (Not offered in 1933-34. Offered in alternate years)		G(A)	<b>2</b>		3	.. 9	Stratton
8'491	Bound. Value Prob. in Th. Phys. . . . . (Elective) <i>8'461, 8'462</i> (Offered in alternate years)		G(A)	<b>2</b>		3	.. 9	Morse
8'50	Heat & Thermodyn VIII <i>8'02, M22</i>		3	<b>1</b>		3	.. 4	Scars
8'512	Statistical Mech. . . . (Elective) <i>8'50</i> (Not offered in 1933-34. Offered in alternate years)		G(A)	<b>2</b>		3	.. 9	Frank

◆ Time specially arranged.

## TABULATION OF SUBJECTS

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
8'521	Quantum Mech. . . . . <i>8'311, 8'402 or 8'472, 8'481, or M652</i> (Not offered in 1933-34. Offered in alternate years)	(Elective)	G(A)	1	3	..	9	Morse
8'522	Theory of Spectra. . . . . <i>8'521</i> (Not offered in 1933-34. Offered in alternate years)	(Elective)	G(A)	2	3	..	9	Morse
8'541	Electromag. Theory VI-C <i>M77 or 8'402</i>		4(B)	1	2	..	4	Stratton
8'542	Electromag. Wave Propagation. . . . . <i>8'541</i>	VI-C	4(B)	2	2	..	4	Stratton
8'56	Electromag. Wave Theory I. . . . . <i>8'491</i> (Not offered in 1933-34. Offered in alternate years)	(Elective)	G(A)	1	3	..	6	Vallarta
8'57	Electromag. Wave Theory II. . . . . <i>8'56</i> (Not offered in 1933-34. Offered in alternate years)	(Elective)	G(A)	2	3	..	6	Vallarta
8'58	Th. of Relativity. . . . . <i>8'462, M631</i> (Offered in alternate years)	(Elective)	G(A)	1	3	..	6	Vallarta
8'591	Theoretical Seminar. . . . .	(Elective)	G(A)	1	1	..	1	Morse
8'592	Theoretical Seminar. . . . .	(Elective)	G(A)	2	1	..	1	Morse
8'801	Electrochem. Prin. . . . . <i>8'04, M22</i>	XIV XIIa	3 4	1 1	3 3	.. ..	6 6	Goodwin
8'802	Electrochem. Prin. . . . . <i>8'801</i>	XIV XIIa	3 4	2 2	3 3	.. ..	6 6	Goodwin
8'82	Electrochemistry. . . . . <i>8'802</i>	XIV	4(B)	1	3	..	6	Goodwin
8'83	Electrochem., Adv. . . . . <i>8'82</i>	(Elective)	G(A)	1	3	..	6	Thompson
8'85	App. Electrochem. . . . . <i>8'851, 8'82</i>	XIV	4(B)	2	3	..	6	Thompson
8'86	Electrochem. Lab. . . . . <i>(8'82)</i>	XIV	4(B)	1	0	9	3	Thompson
8'87	Electric Furnace Lab. . . . . <i>8'85</i>	XIV	4(B)	2	0	2	2	Thompson
8'89	Electric Furnaces. . . . . <i>8'04, 8'02</i>	(Elective)	4(B)	1	1	2	2	Thompson
8'90	Electroch. Elem. . . . . <i>8'04 and 8'02</i>	III	4	2	2	2	2	Thompson
8'93	Electroch. Colloq. . . . . <i>8'82</i>	XIV	4(B)	2	1	..	1	Goodwin
8'98	Glass Blowing. . . . .	(Elective)	4	1	0	1	0	Thompson

## CHEMICAL ENGINEERING — 10'00-10'99

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
10'11	Prob. of Chem. Eng. <i>5'02</i>	X	2	1	1	..	0	Lewis
10'15	Thesis Reports. . . . . <i>10'26</i>	X	4	2	2	..	2	C. S. Robinson
10'17	Indust. Chemistry. <i>(5'41, 5'61)</i>	X	3	1	3	..	2	Sherwood
10'18	Indust. Chemistry. <i>10'17, (5'42, 5'62)</i>	X	3	2	3	..	4	Lewis
10'191	Chem. Eng. Lit. . . . . <i>L12, L62</i>	X(Elective)	2	1	3	..	5	C. S. Robinson
10'192	Chem. Eng. Lit. . . . . <i>10'191</i>	X(Elective)	2	2	3	..	5	C. S. Robinson
10'201	Indust. Chemistry. <i>5'41, 5'611</i>	XV <sub>2</sub>	3	2	4	..	4	Lewis
10'203	Indust. Chemistry. <i>(5'42), (5'62)</i>	V	3	2	3	..	4	Lewis
10'21	Indust. Chemistry. <i>10'18 or 10'201 or 10'203</i>	V, X, XV <sub>2</sub>	4(B)	1	2	..	2	Lewis
10'25	Indust. Stoichiom. <i>5'42, 5'62</i>	Chem. War. Chem. War.	G G(A)	1 1	2 2	.. ..	2 4	Lewis Weber
10'26	Indust. Chem. Lab. <i>(10'21)</i>	X, XV <sub>2</sub>	4(B)	1	2	3	1	Weber
10'28	Chemical Eng. . . . . <i>5'61, 10'17</i>	X Chem. War.	3 G	2 1	3 3	.. ..	6 6	Lewis
10'29	Chemical Eng. . . . . <i>10'28</i>	X Chem. War.	4 G	1 2	3 3	.. ..	6 6	Lewis
10'30	Eng. Equipment. . . . . <i>(10'32)</i>	X-B	4	2	4	..	1	Lewis
10'31	Chemical Eng. . . . . <i>10'18, 10'28</i>	X, XV <sub>2</sub> Chem. War.	4(B) G	1 1	5 5	.. ..	4 4	C. S. Robinson
10'32	Chemical Eng. . . . . <i>10'31</i>	X, X-B, XV <sub>2</sub> Chem. War.	4(B) G	2 2	5 5	.. ..	4 4	C. S. Robinson
10'38	Chemical Eng. . . . .	II(A.O.)	4	1	5	..	2	C. S. Robinson
10'41	Distillation. . . . . <i>10'32</i>	(Elective)	G(A)	2	2	..	6	McAdams
10'42	Drying. . . . . <i>10'32</i>	(Elective)	G(A)	1	2	..	4	Sherwood
10'43	Evaporation. . . . . <i>10'31</i>	(Elective)	G(A)	1	2	..	4	C. S. Robinson
10'46	Absorption and Ext. <i>10'32</i>	(Elective)	G(A)	2	2	..	4	Sherwood
10'50	Heat Transmission. <i>10'31</i>	(Elective)	G(A)	2	2	..	4	McAdams
10'52	Chemical Eng. II. . . . . <i>10'32</i>	(Elective)	G(A)	1	2	..	4	McAdams
10'53	Chem. Eng. Des. . . . . <i>10'81, 10'82, 10'83</i>	X-A	G(A)	1	3	..	9	Sherwood
10'54	Economic Balance. <i>(10'32)</i>	(Elective)	G(A)	1	5	..	7	McAdams
10'55	Economic Balance. <i>10'32</i>	(Elective)	G(A)	2	3	..	6	Sherwood
10'62	App. Chem. Therm. <i>5'62, 10'29</i>	(Elective)	G(A)	2	3	..	6	Weber
10'63	App. Colloid Chem. <i>5'62</i>	(Elective)	G(A)	2	3	..	6	Lewis
10'65	High Pres. Proc. . . . . <i>(10'32)</i>	(Elective)	G(A)	2	2	..	4	Marek
10'68	Corrosion. . . . . <i>5'62</i>	(Elective)	G(A)	1	2	..	4	Brugmann
10'70	Prin. of Combust. . . . . <i>Gen. Inorg. Chem.</i>	(Elective)	G(A)	1	4	..	6	Hottel
10'71	Fuel Engineering. . . . . <i>10'70</i>	(Elective)	G(A)	2	3	..	6	Hottel
10'72	Fuel Eng. Practice. <i>10'71, 10'72</i>	(Elective)	G(A)	1	0	20	0	Lewis
10'73	Fuel Eng. Design. . . . . <i>10'72</i>	(Elective)	G(A)	1	3	..	6	Hottel
10'74	Furnace Design. . . . . <i>10'31</i>	(Elective)	G(A)	2	3	..	6	Hottel
10'76	Sem. in Radiant Heat Transmiss. <i>10'31</i>	(Elective)	G(A)	2	2	..	4	Hottel
10'78	Fuel Eng. Lab. . . . . <i>10'70</i>	(Elective)	4	2	0	4	2	V. C. Smith

## TABULATION OF SUBJECTS

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
10'79	Automotive Fuels. <i>5'42, 5'62, 2'42 or 10'29</i>	(Elective)	G(A)	1	2	..	4	Hottel
10'81	Sch. Ch. Eng. Prac. (Bangor Station). <i>10'32</i>	X-A	G(A)	1, 2	..	12	..	Lewis
10'82	Sch. Ch. Eng. Prac. (Boston Station). <i>10'31</i>	X-A	G(A)	1, 2	..	12	..	Lewis
10'83	Sch. Ch. Eng. Prac. (Buffalo Station). <i>10'31</i>	X-A	G(A)	1 2	..	12	..	Lewis
10'84	Sch. Ch. Eng. Prac. (Bangor Station). <i>10'31</i>	X-B	4	2	..	12	..	Lewis
10'85	Sch. Ch. Eng. Prac. (Boston Station). <i>10'31</i>	X-B	4	2	..	12	..	Lewis
10'86	Sch. Ch. Eng. Prac. (Buffalo Station). <i>10'31</i>	X-B	4	2	..	12	..	Lewis
10'90	Exp. Research Problem <i>5'42, 5'62</i>	X(Elective)	G(A)	✦				McAdams
10'911	Research Conf..... <i>5'42, 5'62</i>	(Elective)	G(A)	1	1	..	2	McAdams
10'912	Research Conf..... <i>10'911</i>	(Elective)	G(A)	2	1	..	2	McAdams
10'941	Org. & Meth. of Ind. Research..... <i>5'42, 5'62</i>	(Elective) Chem. War.	G(A) G	1 1	1 1	.. ..	2 2	Brugmann
10'942	Org. & Meth. of Ind. Research..... <i>10'941</i>	(Elective) Chem. War.	G(A) G	2 2	1 1	.. ..	2 2	Brugmann
10'991	Sem. in Chem. Eng. <i>10'52</i>	(Elective)	G(A)	1	2	..	4	Lewis
10'992	Sem. in Chem. Eng. <i>10'52</i>	(Elective)	G(A)	2	2	..	4	McAdams

✦ Time specially arranged.

## GEOLOGY — 12'00—12'99

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lab.			Instructor in Charge
					Lec.	Draw.	Prep.	
12'01	Mineralogy . . . . . <i>5'02</i>	III, 1, 2, XII IX-A	2	1	2	6	2	Buerger
12'02	Mineralogy . . . . . <i>12'01</i>	XII	3	1	2	6	2	Buerger
12'05	Mineralogy, Adv. . . . . <i>12'16</i>	(Elective)	G(A)	1	1	4	1	Buerger
12'15	Petrography . . . . . <i>12'02, 12'211</i>	XII	3	2	1	7	2	Buerger
12'17	Petrographic Res. . . . . <i>12'16</i>	(Elective)	G(A)	2	1	7	2	Buerger
12'211	Optical Crystallog. . . . . <i>8'02</i>	XII	3(B)	1	1	3	1	Buerger
12'212	Optical Crystallog. . . . . <i>12'211</i>	(Elective)	G(A)	2	1	2	1	Buerger
12'25	Physical Crystallog. . . . . <i>8'04</i>	III, 1	3(B)	1	1	2	2	Buerger
12'30	Geology . . . . . <i>12'01</i>	III, 1, XII IX-A	2	2	3	1	2	Morris
12'31	Geology . . . . . <i>12'30</i>	III, 1, XII IX-A	3	1	3	2	3	Shimer
12'321	Geology . . . . . <i>12'322</i>	I XI	3	1	2	..	1	Morris
12'322	Geology . . . . . <i>12'321</i>	I	3	2	1	3	4	Morris
12'33	Field Geology . . . . . <i>1'08, 12'01, 12'31</i>	III, 1, XII	4	1	0	3	2	Morris
12'351	Geol. Survey., Adv. . . . . <i>12'32</i>	(Elective)	G(A)	1	0	4	4	Morris
12'352	Geol. Survey., Adv. . . . . <i>12'351</i>	(Elective)	G(A)	2	0	4	4	Morris
12'36	Geology, Field. . . . . <i>12'30</i>	XII	4	S	0	8	0	Newhouse
12'38	Physiography . . . . . <i>12'31 or G60</i>	XII	4	1	1	2	1	Shimer
12'39	Field Geol. Meth. . . . . <i>12'31</i>	(Elective)	3	2	0	3	1	Morris
12'40	Geology, Economic. . . . . <i>12'01, 12'31</i>	III, 1, XII	3	2	4	..	3	Newhouse
12'41	Econ. Geol. Lab. . . . . <i>12'40</i>	XII	4(B)	1	0	6	2	Newhouse
12'42	App. Econ. Geol. . . . . <i>12'40</i>	XII	4(B)	2	2	..	1	Newhouse
12'431	Ec. Geol. Lab., Adv. (Elective) <i>12'41</i>	(Elective)	G(A)	1	0	4	1	Newhouse
12'432	Ec. Geol. Lab., Adv. (Elective) <i>12'41</i>	(Elective)	G(A)	2	0	4	1	Newhouse
12'433	Ec. Geol. Sem., Adv. (Elective) <i>12'40</i>	(Elective)	G(A)	1	2	..	2	Newhouse
12'434	Ec. Geol. Sem., Adv. (Elective) <i>12'40</i>	(Elective)	G(A)	2	2	..	2	Newhouse
12'44	Ec. Geol. of Fuels. . . . . <i>G60</i>	(Elective)	4(B)	2	1	..	1	Whitehead
12'46	Econ. Geol. of Non-Metallic Deposits <i>12'40</i>	XII	4(B)	1	2	1	3	Newhouse
12'47	Microstruct. of Ores and Metals . . . . . <i>5'12, 8'02</i>	III, 1	4(B)	1	0	3	0	Newhouse
12'48	Eng. Geol. & Hyd. . . . . <i>12'31</i>	XII	4(B)	1	3	..	2	Morris
12'49	Geol. of Materials. . . . . <i>XVII</i>	IV-A	2	2	2	..	2	Morris
12'50	Historical Geology. . . . . <i>12'31 or G60</i>	XII	3	2	2	1	2	Shimer
12'511	Paleontology . . . . . <i>12'31 or G60</i>	XII	3	1	1	2	2	Shimer
12'512	Paleontology . . . . . <i>12'511</i>	XII	3	2	0	1	1	Shimer
12'521	Paleontology, Adv. (Elective) <i>12'512</i>	(Elective)	G(A)	1	1	3	5	Shimer
12'522	Paleontology, Adv. (Elective) <i>12'521</i>	(Elective)	G(A)	2	1	3	3	Shimer
12'53	Index Fossils . . . . . <i>12'511</i>	(Elective)	G(A)	2	2	4	1	Shimer

## TABULATION OF SUBJECTS

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
12'54	Micropaleontology. (Elective) <i>12'512</i>		G(A)	1	1	2	2	Shimer
12'55	Organic Evol., Adv. (Elective) <i>664</i>		G(A)	2	2	..	3	Shimer
12'581	Stratigraphy, Adv.. (Elective) <i>12'50</i>		G(A)	1	2	..	4	Shimer
12'582	Stratigraphy, Adv.. (Elective) <i>12'15, 12'581</i>		G(A)	2	2	..	4	Shimer
12'60	Struct. Geology.... XII <i>12'31</i>		4(B)	1	2	..	3	Morris
12'61	Diastro. & Vulcan.. XII <i>12'15, 12'31</i>		4(B)	2	2	..	3	Morris
12'631	Geol. Seminar, Adv. (Elective) <i>12'31</i>		G(A)	1	2	..	5	Shimer
12'632	Geol. Seminar, Adv. (Elective) <i>12'31</i>		G(A)	2	2	..	5	Shimer and Staff
12'64	Geol. of N. America. (Elective) <i>12'60</i>		G(A)	1	2	..	4	
12'65	Geology of Europe. (Elective) <i>12'64</i>		G(A)	2	2	..	4	Shimer
12'80	Geol. Coal & Petrol. XII <i>12'31 or 660</i>		4(B)	2	4	..	3	Whitehead
12'81	Geol. of Petroleum. (Elective) <i>12'80</i>		3	2	4	..	3	Whitehead
12'851	Theoret. Geophysics Adv., <i>8'461</i>	(Elective)	G(A)	1	3	..	4	Slichter
12'852	Theoret. Geophysics, Adv., <i>8'461, 12'851</i>	(Elective)	G(A)	2	3	..	4	Slichter
12'86	Seismology, Elem... I <i>12'222</i>		4(B)	1	2	..	2	Slichter
12'87	Intro. Geophysics Prospect ..... I <sub>4</sub> (b) <i>12'322</i>		4(B)	2	2	..	2	Slichter

NAVAL ARCHITECTURE  
AND MARINE ENGINEERING — 13'00-13'99

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge		
13'01	Naval Architecture, XIII, XIII-A, XIII-C <i>M12, 8'01</i>	XIII, XIII-A, XIII-C	3(B)	1	2	..	2	Jack		
13'02	Naval Architecture, XIII, XIII-A <i>13'01</i>	XIII, XIII-A	3(B)	2	2	..	2	Jack		
13'021	Naval Architecture, XIII-C <i>13'01</i>	XIII-C	3	2	2	..	2	Chapman		
13'03	Naval Architecture, XIII, XIII-A <i>13'02</i>	XIII, XIII-A	4(B)	1	3	..	3	Jack		
13'11	Th. of Warship Des. XIII-A	XIII-A	3	1	4	..	13	Rossell		
13'12	Th. of Warship Des. XIII-A	XIII-A	3	2	4	..	10			
13'13	Th. of Warship Des. XIII-A	XIII-A	G	1	6	..	9			
13'13T	Th. of Warship Des. XIII-A	XIII-A	4	1	3	..	6			
13'14	Th. of Warship Des. XIII-A	XIII-A	G	2	5	..	6			
13'14T	Th. of Warship Des. XIII-A	XIII-A	4	2	3	..	8			
13'21	Warship Design. . . . XIII-A	XIII-A	3	1	0	5	0		Keith	
13'22	Warship Design. . . . XIII-A	XIII-A	3	2	0	5	0			
13'23	Warship Design. . . . XIII-A	XIII-A	G	1	0	8	0			
13'23T	Warship Design. . . . XIII-A	XIII-A	4	1	5	..	0			
13'24	Warship Design. . . . XIII-A	XIII-A	G	2	0	10	0			
13'24T	Warship Design. . . . XIII-A	XIII-A	4	2	5	..	0			
13'31	Ship Construction. XIII	XIII	2	1	2	..	2			Owen
13'32	Ship Construction. XIII, XIII-C	XIII, XIII-C	2	2	2	..	2			Jack
13'33	Ship Construction. XIII, XIII-C <i>13'32</i>	XIII, XIII-C	3	1	2	..	2	Jack		
13'37	Merchant Shipbuild. XIII-A	XIII-A	4	2	2	..	2	Jack		
13'38	Shipyard Organ. . . . XIII <i>13'02, 13'32</i>	XIII	4(B)	2	2	..	1	Jack		
13'41	Ship Drawing . . . . . XIII	XIII	2	2	0	5	0	Owen		
13'42	Ship Design. . . . . XIII, XIII-C	XIII, XIII-C	3	1	0	3	0	Owen		
13'43	Ship Design. . . . . XIII <i>13'42</i>	XIII	3	2	6	6	0	Owen		
13'45	Ship Design. . . . . XIII <i>13'43</i>	XIII	4(B)	1	0	8	0	Owen		
13'471	Ship Design. . . . . XIII-C <i>13'021, 13'51</i>	XIII-C	4	1	0	6	0	Owen		
13'472	Ship Design. . . . . XIII-C	XIII-C	4	2	0	6	0	Owen		
13'48	Model Making . . . . XIII-A	XIII-A	4	2	0	1	0	Owen		
13'50	Marine Engineering XIII, XIII-C	XIII, XIII-C	2	1	2	..	1	Jack		
13'51	Marine Engineering XIII, XIII-C <i>2'40</i>	XIII, XIII-C	3	2	2	..	3	Burtner		
13'54	Marine Engineering XIII <i>2'21, 2'40, 13'51</i>	XIII	4(B)	1	2	..	3	Burtner		
13'56	Marine Engineering XIII-C <i>13'51, 13'72</i>	XIII-C	4	1	3	..	3	Chapman		
13'58	Marine Engineering XIII-A	XIII-A	4	1	3	..	4	Chapman		
13'61	Marine Eng. Design XIII <i>2'20, 2'40, 13'51</i>	XIII	4(B)	1	0	5	0	Burtner		
13'62	Marine Eng. Design XIII <i>13'61</i>	XIII	4(B)	2	1	4	0	Burtner		
13'64	Marine Eng. Design XIII-A <i>13'58</i>	XIII-A	4	2	0	4	0	Chapman		
13'66	Marine Eng. Design XIII-C <i>2'42, 13'51</i>	XIII-C	4	2	0	3	0	Burtner		
13'70	Steam Turbines. . . . XIII <i>2'42, 13'51</i>	XIII	4(B)	2	2	..	3	Burtner		
13'72	Marine Diesel Eng. XIII <i>2'40</i>	XIII	4	2	2	..	2	Chapman		
13'81	Ship Operation . . . . XIII-C <i>13'021, 13'51, 13'83</i>	XIII-C	4(B)	1	2	..	3	Chapman		
13'82	Ship Operation . . . . XIII-C <i>13'81</i>	XIII-C	4(B)	2	3	..	4	Chapman		
13'83	Terminal Facilities. XIII-C	XIII-C	3	1	3	..	3	Chapman		

## AERONAUTICAL ENGINEERING — 16'00-16'99

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
16'00	Aerody. of Airp. Des. XVI <i>2'20, 8'04, M43, 16'52</i>		3	2	3	..	3	Ober
16'01	Aerodyn. Airplane Des. XVI <i>M44, 16'00</i>		4(B)	1	4	..	4	Koppen
16'02	Aircraft Structures. XVI <i>1'401</i>		4(B)	1	2	..	2	Newell
16'05	Airplane Structures. XVI (Elective) <i>16'02</i>		4(B)	2	3	..	3	Newell
16'06	Airplane St., Adv.. (Elective) <i>16'02, 16'13</i>		G(A)	1	3	..	6	Newell
16'08	Airplane Des. Prob. XVI (Elective) <i>16'01, 16'13</i>		4(B)	2	2	4	6	Koppen
16'13	Airplane Des. Prac. XVI <i>16'00, (16'01)</i>		4(B)	1	0	8	0	Koppen
16'14	Airplane Des. Prac., Adv. .... (Elective) <i>(16'08)</i>		G(A)	2	0	6	0	Koppen
16'21	Airship Theory .... (Elective) <i>M44, 16'00</i>		G(A)	1	2	..	3	R. H. Smith
16'22	Airship Structures. (Elective) <i>M22, 16'21</i>		G(A)	2	2	..	4	R. H. Smith
16'26	Adv. Aeronautical Problems. .... XVI (Elective) <i>16'01 or 16'06 or 16'21 or 16'63 or 16'83</i>		G(A)	1 or 2	◆			C. F. Taylor or R. H. Smith
16'30	Aircraft Propeller Design ..... (Elective) <i>16'01</i>		G(A)	2	2	2	4	Ober
16'35	Aircraft Instrum. . . (Elective) <i>8'04</i>		G(A)	1	3	..	3	Draper
16'52	Airplane Shopwork. XVI		3	S	0	8	2	Markham
16'53	Aircraft Prod. Meth. XVI		3	S	0	7	2	Markham
16'55	Airplane Design. . . XVI <i>16'01</i>		4(B)	2	3	4	2	Koppen
16'62	Aeronautical Lab. . . XVI <i>16'01 or (16'01)</i>		4(B)	1	2	2	3	Ober
16'63	Aero. Lab. & Res. Methods. .... XVI (Elective) <i>16'62</i>		4(B)	2	2	2	2	Ober
16'69	Aeronaut. Seminar. (Elective) <i>16'01</i>		G(A)	2	2	..	2	R. H. Smith
16'73	Adv. Wing Theory. (Elective) <i>M44</i>		G(A)	1	3	..	6	R. H. Smith
16'74	Adv. Wing Theory. (Elective) <i>16'73</i>		G(A)	2	3	..	6	R. H. Smith
16'76	Aeronautics. .... (Elective) <i>M21, 2'20</i>		4(B)	1	3	..	1	Markham
16'78	Aeronautics. .... XIII-A <i>16'76</i>		G	1	3	..	2	Markham
16'82	Aeronautics. .... XIII-A <i>16'76</i>		G(B)	2	3	..	5	Ober
16'82	Int. Comb. Eng. . . . XVI (Elective) <i>2'42, 2'611</i>		4	1	4	..	3	C. F. Taylor
16'84	Int. Comb. Eng. . . . XVI (Elective) <i>16'82</i>		4	2	4	..	5	C. F. Taylor
16'85	Airp. Eng. Des. Prac.. (Elective) <i>16'84</i>		4(B)	1	2	6	0	E. S. Taylor
16'86	Airplane Eng. Des. Prac. .... (Elective) <i>16'85</i>		4(B)	2	2	6	0	E. S. Taylor
16'901	Int. Meteor. .... XVI (Elective) <i>M22</i>		4(B)	1	2	..	2	Willett
16'902	Aero. Meteorology. XVI (Elective)		4(B)	2	2	..	2	Lange
16'911	Synoptic Meteor. . . VIII (Elective) <i>8'04, L12 (16'901) (16'921)</i>		4	1	2	..	2	Willett
16'912	Synoptic Meteorol. (Elective) <i>16'911, (16'922)</i>		G(A)	2	2	..	4	Willett
16'921	Synoptic Meteorol. (Elective) <i>16'901 (16'911)</i>		4(A)	2	2	..	2	Willett
16'922	Synoptic Meteorol. (Elective) <i>16'921, (16'912)</i>		G	1	2	..	4	Willett
			4	1	0	10	0	
			G(A)	2	2	..	4	Willett
			4	2	0	8	0	

◆ Time specially arranged.

## AERONAUTICAL ENGINEERING

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No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
16'931	Dyn. Meteorology <i>16'912, 16'922, 8'461, 8'462, 8'50, (M36)</i>	(Elective)	G(A)	1	5	..	10	Rossby
16'932	Dyn. Meteorology. <i>16'931</i>	(Elective)	G(A)	2	5	..	10	Rossby
16'941	Meteorol. Seminar. <i>(16'931)</i>	(Elective)	G(A)	1	2	..	4	Rossby
16'942	Meteorol. Seminar. <i>16'941, (16'932)</i>	(Elective)	G(A)	2	2	..	4	Rossby
16'95	Meteor. Instruments & Meth. of Obser. <i>16'901</i>	(Elective)	4(B)	2	0	4	0	Lange

## BUILDING ENGINEERING AND CONSTRUCTION

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
17-20	Hist. of Construction	XVII	2	2	3	..	0	Voss
17-21	Building Const. . . . <i>D12</i>	XVII	2	1	5	..	1	R. F. Tucker
17-22	Building Const. . . . <i>17-21</i>	XVII	2	2	5	..	1	R. F. Tucker
17-31	Building Const. . . . <i>17-22</i>	XVII	3	1	5	..	1	R. F. Tucker
17-32	Building Const. . . . <i>17-31</i>	XVII	3	2	5	..	1	R. F. Tucker
17-41	Building Const. . . . <i>17-32</i>	XVII	4	1	8	..	2	R. F. Tucker
17-42	Building Const. . . . <i>17-41</i>	XVII	4	2	3	..	1	R. F. Tucker
17-46	Building Const. . . .	III, 2	4	2	4	4	0	R. F. Tucker
17-50	Job Management. . .	IV-A, XVII	4	2	1	0	1	R. F. Tucker
17-51	Structural Analysis. . <i>2-15</i>	XVII	3	1	2	2	2	Voss
17-52	Structural Analysis. . <i>17-51</i>	XVII	3	2	4	..	2	Voss
17-53	Structural Analysis. . <i>17-52</i>	XVII	4	1	3	..	1	Voss
17-54	Structural Analysis. . <i>17-53</i>	XVII	4	2	3	..	2	Voss
17-65	Quant. Surv. & Est.	XVII	3	S	0	11	0	
17-73	Materials. . . . .	XVII	2	2	2	..	1	Peskin
17-74	Materials. . . . .	XVII	3	2	2	..	1	Voss
17-75	Materials. . . . .	XVII	4	2	2	..	1	Peskin
17-81	Seminar. . . . .	XVII	4	1	1	..	1	Staff
17-82	Seminar. . . . .	XVII	4	2	1	..	1	Staff

## DRAWING

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
D11	Draw. & Desc. Geometry. <i>M2, M3</i>	All courses except IV and IV-B	1	1	0	6	1	W.H.Lawrence
D12	Draw. & Desc. Geometry. <i>D11</i>	All courses except IV and IV-B	1	2	0	6	1	W.H.Lawrence
D13	Desc. Geometry .. (College Class) <i>M3</i>		1	1	3	..	4	Watts
D23	Desc. Geometry... (College Class) <i>M3</i>		1	1	3	..	4	Watts

## BUSINESS AND ENGINEERING ADMINISTRATION AND ECONOMICS

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
Ec31	Political Economy. <i>E12</i>	VI, VI-C, VI-A, XIII-C,	2	1	3	..	3	Doten D. S. Tucker
		XV						
		I, II, III, IV, IV-A, V, VII, VIII, IX-A, IX-B, X, XI, XII, XIII, XIV,	3	1	3	..	3	
		XVII, XVIII XVI	4	1	3	..	3	
Ec32	Political Economy. <i>Ec31</i>	XIII-C, XV	2	2	3	..	3	Doten D. S. Tucker
		I, II, III, IV, IV-A, V, VII, VIII, IX-A, IX-B, X, XI, XII, XIII, XIV,						
		XVIII XVI	3	2	3	..	3	
			4	2	3	..	3	
Ec33	Current Economic Problems..... <i>Ec32, Ec37</i>	(Elective)	4(B)	2	2	..	4	Ingraham
Ec35	Political Economy. <i>E12</i>	XIII-A	4	1	3	..	5	Freeman
Ec37	Banking..... <i>Ec31, Ec65</i>	XIII-C, XV	2	2	3	..	3	Freeman
Ec39	Internat. Finance.. <i>Ec32, Ec33 or Ec56</i>		G(A)	1	2	..	6	Freeman
Ec46	Indust. Relations.. <i>Ec31, Ec32</i>	XIII-A, XIII-C, XV	4(B)	2	3	..	5	Doten
Ec471	Personnel Manage. (Elective) <i>Ec32, Ec46</i>		G(A)	1	3	..	5	Doten
Ec472	Personnel Manage. (Elective) <i>Ec471</i>		G(A)	2	3	..	5	Doten
Ec50	Accounting..... Not open to 1st yr.	I	3	1	4	..	2	Porter Fiske
		III	3	2	4	..	2	
		XV	2	2	4	..	2	
		XIII	4	2	4	..	2	
		XVI (Elective)	4	1	4	..	2	
Ec51	Industrial Account. <i>Ec50</i>	XIII-C, XV	4(B)	1	4	..	4	{ Porter Fiske Fiske
Ec521	Anal. of Bus. State. (Elective) <i>Ec51, Ec57</i>		G(A)	1	3	..	5	
Ec522	Control through Bus. Records..... <i>Ec71T, Ec82</i>	(Elective)	G(A)	2	3	..	5	Fiske
Ec53	Building Finance.. <i>Ec32</i>	XVII	4(B)	2	3	..	5	Armstrong
Ec56	Corporations..... <i>Ec32, Ec50</i>	XV	4	1	3	..	6	Armstrong
		VI-A(B)	3	1	3	..	3	
Ec56T	Econ. of Corp..... Not offered in 1933-34	VI, VI-C, VI-A (A)	3	2	3	..	3	Thresher
Ec57	Corp. Fin. & Invest. <i>Ec56</i>	XV	4	2	3	..	6	Armstrong
Ec581	Fin. Adm. of Indust. (Elective) <i>Ec32, Ec50</i>		G(A)	1	3	..	5	Armstrong
Ec582	Fin. Adm. of Indust. (Elective) <i>Ec581 or Ec57</i>		G(A)	2	3	..	5	Freeman
Ec591	Pub. Util. Org. Fin. (Elective) <i>Ec32</i>		G(A)	1	2	..	4	Armstrong
Ec592	Pub. Util. Reg. Rates (Elective) <i>Ec591</i>		G(A)	2	2	..	4	Armstrong
Ec61	Business Law..... <i>Ec37, Ec57</i>	XIII-C	3	1	3	..	3	Schaefer
		XIII-C, XV	4(B)	1	3	..	3	
Ec62	Business Law..... <i>Ec61</i>	XIII-C	3	2	3	..	2	Schaefer
		XV	3	2	3	..	2	
Ec63	Bus. Law & Org.... <i>Ec31</i>	XIII-C, XV	4(B)	2	3	..	3	Schaefer
		VI-A	4(B)	2	3	..	5	
Ec64	Business Law..... (Elective)		S		3	..	3	Schaefer
Ec65	Statistics..... <i>M12</i>	XV	2	1	2	..	3	MacKinnon
		XIII-C	3	1	2	..	3	
		XVI (Elective)	4	1	2	..	2	
Ec661	Statistical Methods (Elective) <i>Ec65, M21</i>		G(A)	1	2	..	6	MacKinnon
Ec662	Statistical Methods (Elective) <i>Ec65, M21</i>		G(A)	2	2	..	6	MacKinnon

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
Ec681	Business Cycles... <i>Ec37, Ec57, Ec65</i>	(Elective)	G(A)	1	3	..	5	Ingraham
Ec682	Business Cycles... <i>Ec681</i>	(Elective)	G(A)	2	3	..	5	Ingraham
Ec70T	Production... <i>Ec32, Ec81</i>	XV	3	2	3	..	3	Fernstrom
Ec71	Production... <i>Ec70T</i>	XV	4(B)	1	3	..	3	Schell
Ec72	Business Manage... <i>Ec71</i>	XV	4(B)	2	4	..	6	Schell
Ec73	Management Lab... <i>Ec70T</i>	XV <sub>1,2</sub>	4	1	3	..	1	Fernstrom
Ec74	Contracting Mgt... <i>Ec72</i>	XVII	4	1	2	..	4	Schell
Ec751	Manufact. Anal... <i>Ec72</i>	(Elective)	G(A)	1	3	..	5	Schell
Ec761	Industrial Market... <i>Ec82</i>	(Elective)	G(A)	1	3	..	5	Elder
Ec762	Retail Marketing... <i>Ec82</i>	(Elective)	G(A)	2	3	..	5	Elder
Ec766	Advertising... <i>Ec82</i>	(Elective)	G(A)	2	3	..	5	
Ec781	Stand. Meas. in Indust. Man... <i>Ec51, Ec71T, Ec82</i>	(Elective)	G(A)	1	3	..	5	Raymond
Ec782	The Business Audit... <i>Ec781</i>	(Elective)	G(A)	2	3	..	5	Raymond
Ec80	Ocean Ship. Adm... <i>Ec31</i>	XIII-C	3	2	2	..	4	Fernstrom
Ec81	Marketing... <i>Ec32, Ec65</i>	XV	3	1	3	..	3	Elder
Ec82	Marketing... <i>Ec81</i>	XV	3	2	3	..	3	Elder
Ec85	Gov't Control of Industry... <i>Ec32, Ec33 or Ec56</i>	(Elective)	G(A)	2	2	..	6	Thresher
Ec90	Investments... <i>Ec57 or (Ec581)</i>	(Elective)	G(A)	1	2	..	6	D. S. Tucker
Ec91	Investment Anal... <i>Ec90</i>	(Elective)	G(A)	2	2	..	6	D. S. Tucker
Ec95	Indust. Traf. Man... <i>Ec70</i>	(Elective)	G(A)	1	3	..	5	Fernstrom
Ec98	Ind. Res. Methods... <i>Ec70, Ec50</i>	XV	4	1	1	..	1	Raymond
Ec99	Ind. Problems... <i>Ec51, Ec57, Ec61, Ec71T, Ec82</i>	XV <sub>ic</sub>	4(B)	2	2	..	4	Schell

## TABULATION OF SUBJECTS

## ENGLISH AND HISTORY

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
E1	English (entrance)			S	2	..	5	Copithorne
E11	English.....	All courses	1	1	2	0	4	Pearson
E12	English.....	All courses	1	2	2	0	4	Pearson
E15	English Comp . . . .	(Elective)		1 or 2	2	..	2	Copithorne
E21	English & History..	All courses	2	1	3	..	5	A. T. Robinson
E22	English & History..	All courses	2	2	3	..	5	Rogers
E33	Report Writing....	XIII-C, XV	3	1	2	..	2	Crosby
E22		IV-A	3	1	2	..	2	
E41	Problem Analysis..	IV	3	1	2	..	2	D. M. Fuller
E42	Problems Analysis..	IV	3	2	2	..	2	W. A. Crosby
E44	Committee Work..	VI-A (A)	3	1	2	..	4	D. M. Fuller
		VI-A(B)	4	1	2	..	4	
E45	Business English...	VI-A(A)	4	S	1	..	3	A.T.Robinson
		VI-A(B)	3	S	1	..	3	
E46	Mod. Forms of Lit..	VI-A(A)	4	2	2	..	4	Watson
		VI-A(B)	3	2	2	..	4	

## GENERAL STUDIES — G1-G99

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
G1	History of Science..		3, 4	1	2	..	2	Woodbury
G2	History of Science.. <i>M12, 8'02</i>		3, 4	2	2	..	2	Woodbury
G3	Int. Law & Amer...		3, 4	1	2	..	2	Vestal
G5	Foreign Policy... Psychology.....		3, 4	1	2	..	2	Whittemore
G6	Psychology of Social Adjustment.....		3, 4	2	2	..	2	Whittemore
G10	Dev. of Trans.....		3, 4 4(B)	2	2	..	2	C. B. Breed
G25	Invest. Finance....		3, 4	1	2	..	2	D. S. Tucker
G27	Int. to Business <i>Ec31</i> Management....	(Not open to XV, XIII-C).....	3, 4	1	2	..	2	Fernstrom
G28	Int. to Business Management....	(Not open to XV, XIII-C).....	3, 4	2	2	..	2	Fernstrom
G31	Humanics.....		3, 4	1	2	..	2	Magoun
G32	Humanics.....		3, 4	2	2	..	2	Magoun
G41	Contemp. Eng. Lit.		3, 4	2	2	..	2	Rogers
G42	Contemp. Eur. Lit.		3, 4	1	2	..	2	Rogers
G43	American Literature		3, 4	2	2	..	2	Eaton
G44	Philosophic Dramas of Literature....		3, 4	2	2	..	2	Rogers
G45	(Not offered in 1933-34) The Bible as Literature (Not offered in 1933-34).....		3, 4	2	2	..	2	Rogers
G46	Public Speaking...		3, 4	1	2	..	2	Copithorne
G47	Committee Reports		3, 4	1, 2	2	..	2	Bartlett
G48	Appreciation of Music.....		3, 4	2	2	..	2	Roberts
G49	Literature and the Fine Arts.....		3, 4	1	2	..	2	Greene
G50	Fine Arts in Modern Life.....		3, 4	2	2	..	2	H. L. Seaver
G51	Biography in Science		4	2	3	..	5	Pearson
		VI, VI-C, VI-A(B) (Req.)	4	1	3	..	5	
G54	Science & Civiliza- tion.....	X(Req.)	2	2	2	..	2	Woodbury
G55	French Rev. and Napoleon.....		3, 4	1	2	..	2	Crosby
G56	(Not offered in 1933-34) Beethoven and Wagner (Not offered in 1933-34)		3, 4	2	2	..	2	Roberts
G591	Prob. of Modern Phi- losophy		3, 4	1	2	..	2	A. T. Robinson
G502	Prob. of Modern Phi- losophy.....		3, 4	2	2	..	2	A. T. Robinson
G60	Geology.....	(Not open to I, III, IX-A, XI, XVII) V (Req.)	3, 4	1	2	..	2	Shimer
G62	Mineral Resources in Rel. to Civ.		2	1	2	..	2	
G63	Economic Geography		3, 4	2	2	0	2	Morris
G64	Organic Evolution.		3, 4	2	2	..	2	Newhouse
		IX-A, XII (Req.)	3	2	2	..	2	Prescott
G651	General Science....	IV (Req.)	4	1	2	..	2	Shimer
G652	General Science....	IV (Req.)	4	2	2	..	2	F. K. Morris
G66	Desc. Astronomy..	(Not open to I) <i>8'04</i>	3, 4	2	2	..	2	F. K. Morris
G71	Prin. of Biology & Heredity.....	IX-A (Req.)	4	2	2	..	2	Goodwin
G75	Biol. Reproduction.		3, 4	1	2	..	2	Blake
			3, 4	2	2	..	2	Bunker

## TABULATION OF SUBJECTS

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lab.			Instructor in Charge
					Lec.	Draw.	Prep.	
G76	Hist. of Philosophy. <i>Mis</i>		3, 4	2	2	..	2	Wiener
G821	French..... <i>L62 or equiv.</i>		3, 4	1	2	..	2	
G822	French..... <i>L62 or equiv.</i>		3, 4	2	2	..	2	
G831	French..... <i>L62 or equiv.</i>		3, 4	1	2	..	2	Langley
G832	French..... <i>L62 or equiv.</i>		3, 4	2	2	..	2	Langley
G921	German..... <i>L22 or equiv.</i>		3, 4	1	2	..	2	Kurrelmeyer
G922	German..... <i>L22 or equiv.</i>		3, 4	2	2	..	2	Kurrelmeyer
G931	German..... <i>L22 or equiv.</i>		3, 4	1	2	..	2	Currier
G932	German..... <i>L22 or equiv.</i>		3, 4	2	2	..	2	Currier
G98	Military History & Policy of U. S.		3, 4	2	2	..	2	Vestal

## HYGIENE — PT1-PT99

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lab.			Instructor in Charge
					Lec.	Draw.	Prep.	
PT1	Physical Training..	All courses	1	1 (last 10w.)	0	1	0	McCarthy
PT2	Physical Training..	All courses	1	2 (1st 10w.)	0	1	0	McCarthy

## MATHEMATICS — M1-M99

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
M1	Algebra (Ent.)....			S	2	..	5	
M3	Solid Geom. (Ent.)			S	2	..	5	
M4	Trigonometry (Ent.)			S	2	..	5	
M11	Calculus.....	All courses except IV and IV-B						
	<i>M1, M3, M4</i>		1	1	3	..	6	R. D. Douglass
M111	Calculus.....	IV, IV-B	1	1	3	..	6	Woods
M12	Calculus.....	All courses except IV and IV-B						
	<i>M11</i>		1	2	3	..	6	Rutledge
M21	Calculus.....	All courses except IV and IV-B						
	<i>M12</i>		1	1	3	..	6	Struik
M22	Dif. Equations....	All except III <sub>1</sub> , 2, IV, IV-B						
	<i>M21</i>	VIII, 2, X, XIII-C, XV <sub>2</sub>	2	2	3	..	6	Phillips
M23	Algebra & Geometry	XVIII	2	1	3	..	6	Franklin
M24	Algebra & Geometry	XVIII	2	2	3	..	6	Franklin
M26	Least Squares.....	(Elective)	4(B)	1	2	..	2	R. D. Douglass
M31	Dif. Equ. of Elec...	VI, VI-C, VI-A (B)	3	1	2	..	4	Franklin
	<i>M22</i>	VI-A (A)	3	2	2	..	4	
M36	Calculus, Adv.....	(Elective)	G(A)	1	3	..	6	Woods
	<i>M22</i>	XIII-A	3	2	3	..	6	
M37	Calculus, Adv.....	(Elective)	G(A)	2	3	..	6	Woods
	<i>M30</i>	XIII-A	3	2	3	..	6	
M41	Dif. Equations....	X, Chem. Wa..	4	1	3	..	6	Hitchcock
	<i>M21</i>		4	1	3	..	6	
M43	Theoret. Aeronaut..	(Elective)	4(B)	1	4	2	4	Rauscher
	<i>M22</i>	XVI	3	1	4	2	4	
M44	Theoret. Aeronaut..	(Elective)	4(B)	2	4	2	4	Rauscher
	<i>M43</i>	XVI	3	2	4	2	4	
M441	Geometry.....	XVIII	4	1	3	..	6	Woods
M442	Geometry.....	XVIII	4	2	3	..	6	Woods
M451	Fourier's Series & Int. Equa.....	(Elective)	G(A)	1	3	..	9	Wiener
M452	Fourier's Series & Int. Equa.....	(Elective)	G(A)	2	3	..	9	Wiener
M461	Theory of Numbers	(Elective)	G(A)	1	3	..	9	Hopf
	<i>M22</i>							
M462	Theory of Numbers	(Elective)	G(A)	2	3	..	9	Hopf
M54	Mathematical Lab..	XVIII	3	2	3	..	6	R. D. Douglass
	<i>M22</i>							
M551	Funct. of Real Vari. (Elective)		G(A)	1	3	..	9	Franklin
	<i>M22</i> (Not offered 1933-34)							
M552	Funct. of Real Vari. (Elective)		G(A)	2	3	..	9	Franklin
	<i>M22</i> (Not offered 1933-34)							
M561	Funct. of Comp. Vari. (Elective)		G(A)	1	3	..	9	Rutledge
	<i>M22</i>							
M562	Funct. of Comp. Vari. (Elective)		G(A)	2	3	..	9	Rutledge
	<i>M61</i>							
M571	Dif. Equations....	(Elective)	G(A)	1	3	..	9	J. Douglas
	<i>M22</i>							
M572	Dif. Equations....	(Elective)	G(A)	2	3	..	9	J. Douglas
	<i>M571</i>							
M581	Continuous Groups. (Elective)		G(A)	1	3	..	9	Zeldin
	<i>M22</i>							
M582	Continuous Groups. (Elective)		G(A)	2	3	..	9	Zeldin
	<i>M58</i>							
M62	Modern Algebra....	XVIII	3	1	3	..	6	Hitchcock
	<i>M22</i>							
M631	Dif. Geometry....	(Elective)	G(A)	1	3	..	9	Struik
	<i>M22</i> (Not offered 1933-34)							
M632	Dif. Geometry....	(Elective)	G(A)	2	3	..	9	Struik
	<i>M631</i> (Not offered 1933-34)							
M641	Adv. Dif. Geometry (Elective)		G(A)	1	3	..	9	Struik
	<i>M632</i>							
M642	Adv. Dif. Geometry (Elective)		G(A)	2	3	..	9	Struik
	<i>M641</i>							

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
M651	Anal. Mechanics... (Elective) <i>M22</i> (Not offered 1933-34)		G(A)	1	3	..	9	Franklin
M652	Anal. Mechanics... (Elective) <i>M651</i> (Not offered 1933-34)		G(A)	2	3	..	9	Franklin
M661	Alg. of Quan. Th. . . (Elective) <i>M62</i>		G(A)	1	3	..	9	Hitchcock
M662	Algeb. of Quan. Th.. (Elective) <i>M661</i>		G(A)	2	3	..	9	Hitchcock
M671	Potential Theory.. (Elective) <i>M22</i> (Not offered 1933-34)		G(A)	1	3	..	9	Hopf
M672	Potential Theory... (Elective) (Not offered 1933-34)		G(A)	2	3	..	9	Hopf
M681	Calc. of Var. . . . . (Elective) <i>M22</i> (Not offered 1933-34)		G(A)	1	2	..	6	J. Douglas
M682	Calc. of Var. . . . . (Elective) <i>M681</i> (Not offered 1933-34)		G(A)	1	2	..	6	J. Douglas
M70	Hist. (Math.) Science (Elective) <i>M12</i> (Not offered in 1933-34)		4(B)	1	2	..	4	
M731	Mechanics . . . . . XVIII <i>M22</i>		3	1	3	..	6	Phillips
M732	Mechanics . . . . . XVIII <i>M731</i>		3	2	3	..	6	Phillips
M76	Th. of Probability.. (Elective) <i>M21</i>		G(A)	2	3	..	9	Struik
M77	Vector Analysis... VI-C, VIII <i>M22</i>		3(B)	2	3	..	5	Phillips
			4(B)	1	3	..	5	
			4(B)	2	3	..	5	
M781	Geometry, Adv. . . . (Elective) <i>M22</i>		G(A)	1	3	..	9	Woods
M782	Geometry, Adv. . . . (Elective) <i>M781</i>		G(A)	2	3	..	9	Woods
M791	Th. & App. Elast... (Elective)		G(A)	1	2	..	6	Phillips
M792	Th. & App. Elast... (Elective)		G(A)	2	2	..	6	Phillips
M831	Analysis . . . . . XVIII <i>M22</i>		3	1	3	..	6	Franklin
M832	Analysis . . . . . XVIII <i>M831</i>		3	2	3	..	6	Franklin
M841	Analysis . . . . . XVIII <i>M832</i>		4	1	3	..	6	Franklin
M842	Analysis . . . . . XVIII <i>M841</i>		4	2	3	..	6	Franklin
M90	Math. Reading . . . . (Elective)		G(A)	1 & 2				Woods

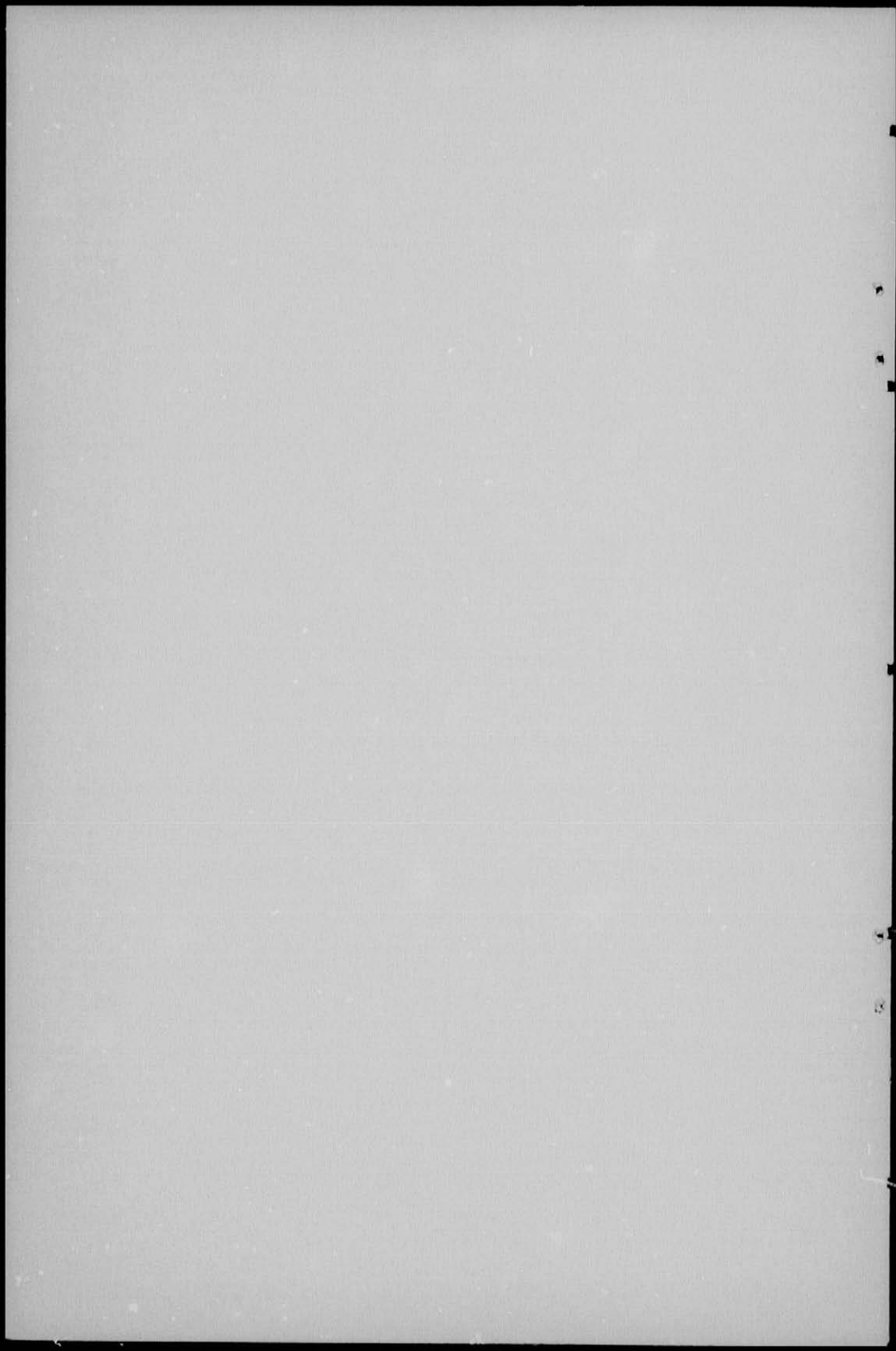
◆ Time specially arranged.

## MILITARY SCIENCE — MS1-MS99

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
MS11	Military Science....	All courses	1	1	0	3	0	Atkinson
MS12	Military Science....	All courses	1	2	0	3	0	Atkinson
MS21	Military Science....	All courses	2	1	3	..	0	Hyde
MS221	Coast Artillery....	All courses	2	2	3	..	0	Arthur
MS222	Engineer Corps....	I, II, III, IV, IV-A, VI, VI-A, VII, IX-B, XI, XII, XIII-C, XVI, XVI, XVII, XVIII	2	2	3	..	0	Harwood
MS223	Signal Corps....	VI, VI-A, VI-C, VIII, IX-B, XIV, XV <sub>b</sub>	2	2	3	..	0	Biche
MS224	Ordnance Dept....	II, III <sub>1</sub> , 4, V, IX-A, X, X-B, XIV, XV <sub>b</sub> , XV <sub>2</sub> , XVIII, XV	2	2	3	..	0	Gatchell
MS226	Chem. War. Ser....	V, X, X-B, XIV, XV <sub>2</sub>	2	2	3	..	0	Johnston
MS31	Military Science, Adv.	All courses	3	1	0	1	0	Gatchell
MS311	Coast Art., Adv. ....	All courses	3	1	2	1	2	Atkinson
MS312	Eng. Corps, Adv....	I, II, III, IV, IV-A, VI, VI-A, VII, IX-B, XI, XII, XIII-C, XVI, XVI, XVII, XVIII	3	1	3	..	3	Harwood
MS313	Signal Corps, Adv.	VI, VI-A, VI-C, VIII, IX-B, XIV, XV <sub>b</sub>	3	1	3	..	3	Bicher
MS314	Ord. Dept., Adv....	II, III <sub>1</sub> , 4, V, VIII, IX-A, X, X-B, XIII, XIV, XV, XVIII	3	1	1	..	1	Gatchell
MS316	Chem. War. Ser....	V, X, X-B, XIV, XV <sub>2</sub>	3	1	2	..	2	Johnston
MS32	Military Science, Adv.	All courses	3	1 & 2	0	1	0	Gatchell
MS321	Coast Art., Adv....	All courses	3	2	2	1	2	Atkinson
MS322	Eng. Corps, Adv....	I, II, III, IV, IV-A, VI, VI-A, VII, IX-B, XI, XII, XIII-C, XVI, XVI, XVII	3	2	3	..	3	Hyde
MS323	Signal Corps, Adv....	VI, VI-A, VI-C, VIII, IX-B, XIV, XV <sub>b</sub>	3	2	3	..	3	Bicher
MS324	Ord. Dept., Adv....	II, III <sub>1</sub> , 4, V, VIII, IX-A, X, X-B, XIV, XV, XV <sub>b</sub> , XV <sub>2</sub> , XVIII	3	2	1	..	1	Gatchell
MS325	Air Corps, Adv....	XVI only	3	2	3	..	3	Johnson
MS326	Chem. Warfare Service, Adv....	V, X, X-B, XIV, XV <sub>2</sub>	3	2	2	..	2	Johnston
MS41	Military Science, Adv. (MS31)	All courses	4	1 & 2	0	1	0	Gatchell
MS411	Coast Art., Adv.... (MS311)	All courses	4	1	1	1	1	Arthur
MS415	Air Corps, Adv....	XVI only	4	1	3	..	3	Johnson
MS416	Chemical Warfare Service, Adv....	V, X, X-B, XIV, XV <sub>2</sub>	4	1	2	0	2	Johnston
MS42	Military Science, Adv. (MS31), (MS32)	All courses	4	2	0	1	0	Gatchell
MS421	Coast Art., Adv.... (MS321)	All courses	4	2	1	1	1	Arthur

## MODERN LANGUAGES — L1-L99

No.	Subject with Prerequisites	Taken by	Yr.	Tm.	Rec. Lec.	Lab. Draw.	Prep.	Instructor in Charge
L11	German, Elem. ....	(Elective)		1	3	..	5	Currier
L12	German, Elem. ....	(Elective)		2	3	..	5	Currier
	<i>L11</i>							
L13	German, Elem. ....		4	1	4	..	8	Currier
	(Not offered 1933-34)							
L21	German, Int. ....	(Elective)		1	3	..	5	Kurrelmeyer
	<i>L12, or Elem. Ent. German</i>							
L22	German, Int. ....	(Elective)		2	3	..	5	Kurrelmeyer
	<i>L21</i>							
L23	German Int. ....	XVI (Elective)		1	2	..	4	Kurrelmeyer
	<i>L12 or Elem. Ent. German</i>							
L24	German, Int. ....	XVI (Elective)		2	2	..	4	Kurrelmeyer
	<i>L23</i>							
L31	German, Adv. ....	(Elective)		1	3	..	5	Kurrelmeyer
	<i>L22, or Int. Ent. German</i>							
	(Not offered in 1933-34)							
L32	German, Adv. ....	(Elective)		2	3	..	5	Kurrelmeyer
	<i>L31 (Not offered in 1933-34)</i>							
L51	French, Elem. ....	(Elective)		1	3	..	5	Koch
L52	French, Elem. ....	(Elective)		2	3	..	5	Koch
	<i>L51</i>							
L61	French, Int. ....	(Elective)		1	3	..	5	Koch
	<i>L52 or Elem. Ent. French</i>							
L62	French, Int. ....	(Elective)		2	3	..	5	Koch
	<i>L61</i>							
L63	French, Adv. ....	IV	1	1	3	..	6	Langley
	<i>L62 or Int. Ent. French</i>							
L64	French, Adv. ....	IV	1	2	3	..	6	Langley
	<i>L63</i>							
L65	French, Adv. ....	IV	2	1	2	..	3	Langley
	<i>L64</i>							
L66	French, Adv. ....	IV	2	2	2	..	3	Langley
	<i>L65</i>							
L71	French. ....	XVI (Elective)	3	1	2	..	4	Langley
	<i>L52 or equiv.</i>							
L72	French. ....	XVI (Elective)	3	2	2	..	4	Langley
	<i>L71</i>							
L81	Spanish, Elem. ....	(Elective)		1	3	..	5	Koch
L82	Spanish, Elem. ....	(Elective)		2	3	..	5	Koch
	<i>L81</i>							
L91	Italian, Elem. ....	(Elective)		1	3	..	5	Langley
	(Not offered 1933-34)							
L92	Italian, Elem. ....	(Elective)		2	3	..	5	Langley
	<i>L91 (Not offered 1933-34)</i>							



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