VOLUME XXXII NUMBER 101

# BULLETIN

OF THE

# CALIFORNIA INSTITUTE

OF

# TECHNOLOGY

---

## ANNUAL CATALOGUE

---

PASADENA, CALIFORNIA

DECEMBER, 1923

# Contents

# Calendar

## 1924

### JANUARY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| 27 | 28 | 29 | 30 | 31 | | |

### FEBRUARY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | | | 1 | 2 |
| 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 24 | 25 | 26 | 27 | 28 | 29 | |

### MARCH

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | | | | 1 |
| 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| 23 | 24 | 25 | 26 | 27 | 28 | 29 |
| 30 | 31 | | | | | |

### APRIL

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| 27 | 28 | 29 | 30 | | | |

### MAY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 |
| 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 25 | 26 | 27 | 28 | 29 | 30 | 31 |

### JUNE

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 29 | 30 | | | | | |

### JULY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| 27 | 28 | 29 | 30 | 31 | | |

### AUGUST

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | | | 1 | 2 |
| 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 31 | | | | | | |

### SEPTEMBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 | 30 | | | | |

### OCTOBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 |
| 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 26 | 27 | 28 | 29 | 30 | 31 | |

### NOVEMBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | | | | 1 |
| 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| 23 | 24 | 25 | 26 | 27 | 28 | 29 |
| 30 | | | | | | |

### DECEMBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 | 30 | 31 | | | |

## 1925

### JANUARY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 |
| 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 25 | 26 | 27 | 28 | 29 | 30 | 31 |

### FEBRUARY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 |

### MARCH

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 29 | 30 | 31 | | | | |

### APRIL

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 |
| 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 26 | 27 | 28 | 29 | 30 | | |

### MAY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | | | 1 | 2 |
| 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 31 | | | | | | |

### JUNE

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 | 30 | | | | |

### JULY

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 |
| 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 26 | 27 | 28 | 29 | 30 | 31 | |

### AUGUST

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | | | | 1 |
| 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| 23 | 24 | 25 | 26 | 27 | 28 | 29 |
| 30 | 31 | | | | | |

### SEPTEMBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| 27 | 28 | 29 | 30 | | | |

### OCTOBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 |
| 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 25 | 26 | 27 | 28 | 29 | 30 | 31 |

### NOVEMBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 29 | 30 | | | | | |

### DECEMBER

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| 27 | 28 | 29 | 30 | 31 | | |

# Calendar

## 1924

JANUARY 2.....Registration (9 A. M. to 3 P. M.)
JANUARY 14.....Latest Date for Announcing Candidacy for Bachelor's Degree
JANUARY 19.....Examinations for Removal of Conditions
FEBRUARY 22.....Washington's Birthday
MARCH 22.....End of Second Term
MARCH 23-30.....Recess
MARCH 29.....Meetings of Registration Committees
MARCH 31.....Registration (9 A. M. to 3 P. M.)
APRIL 19.....Examinations for Removal of Conditions
MAY 12.....Latest Date for Removing Senior Deficiencies
MAY 30.....Memorial Day
JUNE 7.....End of Senior Examinations
JUNE 10.....Departmental Meetings (9 A. M.)
JUNE 10.....Faculty Meeting (10:30 A. M.)
JUNE 12.....Class Day
JUNE 13.....Commencement
JUNE 13.....Annual Meeting of Alumni Association
JUNE 14.....End of College Year
JUNE 23.....Meetings of Registration Committees
JULY 1, 2.....Entrance Examinations
SEPTEMBER 24, 25.....Entrance Examinations
SEPTEMBER 24.....Examinations for Removal of Conditions
SEPTEMBER 26, 27.....Registration (9 A. M. to 3 P. M.)
SEPTEMBER 29.....Beginning of Instruction
NOVEMBER 27-30.....Thanksgiving Recess
DECEMBER 20.....End of First Term (12 M.)
DECEMBER 29.....Meetings of Registration Committees

## 1925

JANUARY 5.....Registration (9 A. M. to 3 P. M.)
JANUARY 12.....Latest Date for Announcing Candidacy for Bachelor's Degree
JANUARY 24.....Examinations for Removal of Conditions
FEBRUARY 22-23.....Washington's Birthday
MARCH 21.....End of Second Term
MARCH 22-29.....Recess
MARCH 28.....Meetings of Registration Committees
MARCH 30.....Registration 9 A. M. to 3 P. M.
JUNE 13.....End of College Year

# The Board of Trustees

(Arranged in the order of seniority of service.)

| | Term Expires |
|---|---|
| Hiram W. Wadsworth<br>716 South El Molino Avenue. | 1927 |
| Arthur H. Fleming<br>1003 South Orange Grove Avenue. | 1925 |
| George E. Hale<br>South Pasadena. | 1927 |
| Charles W. Gates<br>Fordyce, Arkansas. | 1928 |
| Henry M. Robinson<br>195 South Grand Avenue. | 1926 |
| John Wadsworth<br>90 South Grand Avenue. | 1924 |
| Tod Ford<br>257 South Grand Avenue. | 1926 |
| R. C. Gillis<br>Los Angeles. | 1927 |
| John D. Spreckels<br>San Diego. | 1926 |
| J. H. Henry<br>1199 Oak Knoll Avenue. | 1923 |
| R. R. Blacker<br>1177 Hillcrest Avenue. | 1924 |
| Harry Chandler<br>Los Angeles. | 1924 |
| Henry W. O'Melveny<br>Los Angeles. | 1925 |
| George S. Patton<br>San Marino. | 1928 |

# Officers of the Board of Trustees

ARTHUR H. FLEMING.....President
HENRY M. ROBINSON.....First Vice-President
———.....Second Vice-President
JOHN WADSWORTH.....Third Vice-President and Auditor
EDWARD C. BARRETT.....Secretary and Assistant Treasurer
———.....Treasurer

FINANCE COMMITTEE

ARTHUR H. FLEMING  CHARLES W. GATES
HENRY M. ROBINSON

# Administrative Officers of the Institute

EXECUTIVE COUNCIL

ROBERT A. MILLIKAN, Chairman
ARTHUR H. FLEMING  HENRY M. ROBINSON
GEORGE E. HALE  ARTHUR A. NOYES
EDWARD C. BARRETT

FREDERIC W. HINRICHS, JR.....Dean of Upper Classmen
JOHN R. MACARTHUR.....Dean of Freshmen
EDWARD C. BARRETT.....Executive and Financial Secretary
HARRY C. VAN BUSKIRK.....Registrar

# Advisory Council

JOHN J. CARTY, Vice-President, American Telephone and Telegraph Company.

GANO DUNN, President, J. G. White Corporation.

FRANK B. JEWETT, Vice-President, Western Electric Company.

JOHN C. MERRIAM, President, Carnegie Institution of Washington.

CHARLES L. REESE, Chemical Director, E. I. du Pont de Nemours and Company.

# Associates, 1923-1924

SAMUEL JACKSON BARNETT, PH.D.
Research Associate in Physics
Research Associate of the Carnegie Institution of Washington

PAUL EHRENFEST, PH.D.
Associate in Physics
Professor of Mathematical Physics, University of Leiden, Leiden, Holland

ROSWELL CLIFTON GIBBS, PH.D.
Research Associate in Physics
Professor of Physics, Cornell University

STANISLAW LORIA, PH.D.
Research Associate in Physics
Professor of Physics, John Casimir University, Poland

ALBERT ABRAHAM MICHELSON, PH.D., LL.D., Sc.D.
Research Associate in Physics
Professor of Physics, University of Chicago

# Staff of Instruction and Research

## Robert Andrews Millikan, Ph.D., Sc.D.

Director of the Norman Bridge Laboratory of Physics and Chairman of the Executive Council

A.B., Oberlin College, 1891; A.M., 1893; Ph.D., Columbia University, 1895. Assistant in Physics, University of Chicago, 1896-1897; Associate, 1897-1899; Instructor, 1899-1902; Assistant Professor, 1902-1907; Associate Professor, 1907-1910; Professor, 1910-1921; Director, Norman Bridge Laboratory of Physics, California Institute of Technology, 1921. Vice-President, American Association for the Advancement of Science, 1911; Sc.D., (hon.) Oberlin College, 1911; Comstock Prize, National Academy of Sciences, 1913; Sc.D., (hon.) Northwestern University, 1913; Member, American Philosophical Society, 1914; Member, National Academy of Sciences, 1915; Member, American Academy of Arts and Sciences, 1915; Sc.D., (hon.) University of Pennsylvania, 1915; Sc.D., (hon.) Amherst College, 1917; Sc.D., (hon.) Columbia University, 1917; President, American Physical Society, 1916-1918; Vice-Chairman, National Research Council, 1916-; Lieutenant-Colonel, U. S. A., and Chief, Science and Research Division of Signal Corps, 1917-1919; Corresponding Member, Société Batave de Philosophie Expérimentale à Rotterdam, 1919; Hon. Member, Royal Institution of Great Britain, 1920; American Representative, Troisième Conseil de Physique Solvay, Brussels, 1921; Exchange Professor, Belgium, 1922; American Representative, Committee on Intellectual Co-operation, League of Nations; Recipient of Edison Medal of the American Institute of Electrical Engineers, 1923, of the Nobel Prize in Physics, 1923, and of the Hughes Medal of the Royal Society of Great Britain, 1923.

300 Palmetto Drive.

## Arthur Amos Noyes, Ph.D., LL.D., Sc.D.

Director of the Gates Chemical Laboratory

S.B., Massachusetts Institute of Technology, 1886; S.M., 1887; Ph.D., University of Leipzig, 1890; LL.D., (hon.) University of Maine, 1908; Clark University, 1909; University of Pittsburgh, 1915; Sc.D., (hon.) Harvard University, 1909; Yale University, 1913. Assistant and Instructor in Analytical Chemistry, Massachusetts Institute of Technology, 1887-1892, Instructor in Organic Chemistry, 1892-1894; Assistant and Associate Professor of Organic Chemistry, 1894-1899; Professor of Theoretical Chemistry, 1899-1919; Director of the Research Laboratory of Physical Chemistry, 1903-1919. Acting President, Massachusetts Institute of Technology, 1907-1909; President, American Chemical Society, 1904. Foreign Associate, Royal Society of Edinburgh; Member, National Academy of Sciences, American Philosophical Society, and American Academy of Arts and Sciences; Willard Gibbs Medal, American Chemical Society, 1915.

1025 San Pasqual Street.

## Edward Cecil Barrett, B.A.

Executive and Financial Secretary

B.A., State University of Iowa, 1906. Assistant Secretary, Board of Regents, 1906-1907; Registrar and Secretary to the President, State University of Iowa, 1907-1911.

942 North Chester Avenue

### HARRY BATEMAN, PH.D.

**Professor of Mathematics, Theoretical Physics, and Aeronautics**

B.A., Cambridge University, 1903; Smith Prize, 1905; Fellowship, Trinity College, Cambridge, 1905-1911; Universities of Göttingen and Paris, 1905-1906; M.A., Cambridge University, 1906; Ph.D., Johns Hopkins University, 1913. Lecturer in Mathematics, University of Liverpool, 1906-1907; Reader in Mathematical Physics, University of Manchester, 1907-1910; Lecturer in Mathematics, Bryn Mawr College, 1910-1912; Lecturer in Applied Mathematics, Johns Hopkins University, 1915-1917.

310 Commonwealth Avenue, La Canada.

Mail Address: Box 163, Route 4, Pasadena.

### STUART JEFFERY BATES, PH.D.

**Professor of Physical Chemistry**

B.A., McMaster University, Toronto, 1907; M.A., 1909; Ph.D., University of Illinois, 1912. Chemist, Comfort Soap Works, Toronto, 1907-1908; Research Assistant, McMaster University, 1909-1910; Fellow in Chemistry, University of Illinois, 1910-1912; Research Associate in Physical Chemistry, 1912-1913. Instructor in Analytical Chemistry, University of Illinois, 1913-1914.

124 Berkeley Avenue.

### JAMES EDGAR BELL, PH.D.

**Professor of Chemistry**

S.B., University of Chicago, 1905; Ph.D., University of Illinois, 1913. Graduate student, University of Chicago, 1908-1910; Graduate student and assistant, University of Illinois, 1911-1913; Instructor in Chemistry, University of Washington, 1910-1911, 1913-1916.

Sierra Madre Villa.

R. D. 3, Box 279.

### W. HOWARD CLAPP, E.M.

**Professor of Mechanism and Machine Design**

E.M., University of Minnesota, 1901. Instructor in Mathematics, Macalester College, 1897-1898. Superintendent and Designing Engineer, Sherman Engineering Company, Salt Lake City, 1905-1909; Superintendent, Nevada-Goldfield Reduction Company, Goldfield, Nevada, 1909-1910.

95 South Mentor Avenue.

### ROBERT L. DAUGHERTY, M.E.

**Professor of Mechanical and Hydraulic Engineering**

A.B. in Mechanical Engineering, Leland Stanford Junior University, 1909; M.E., 1914; Assistant in Mechanics, Leland Stanford Junior University, 1907-1908; Assistant in Hydraulics, 1908-1909; Instructor in Mechanical Engineering, 1909-1910; Assistant Professor of Hydraulics, Sibley College, Cornell University, 1910-1916; Professor of Hydraulic Engineering, Rensselaer Polytechnic Institute, 1916-1919.

373 South Euclid Avenue.

PAUL SOPHUS EPSTEIN, Ph.D.

Professor of Theoretical Physics

C.Sc., Moscow University, 1906; M.Sc., 1909; Ph.D., University of Munich, 1914. Assistant in Physics, Moscow Institute of Agriculture, 1906-1907; Assistant in Physics, Moscow University, 1907-1909; Privat docent, Moscow University, 1909-1913; Privat docent, University of Zurich, 1919-1922.

676 South El Molino Avenue.

LUCIEN HOWARD GILMORE, A.B.

Professor of Physics

A.B., Leland Stanford Junior University, 1894. Acting Assistant, Department of Physics, Leland Stanford Junior University, 1894-1895.

649 Galena Avenue.

FREDERIC W. HINRICHS, JR., A.B.

Professor of Mechanics

Dean of Upper Classmen

A.B., Columbia University, as of 1902. Graduate of the United States Military Academy, West Point, 1902. Served as an officer of the U. S. Army in the Artillery Corps, Coast Artillery Corps, and Ordnance Department, 1902-1910; retired in 1910 with rank of Captain. Assistant Professor, Professor of Applied Mechanics, University of Rochester, 1910-1919. Captain, Major, Lieutenant-Colonel, Ordnance Department, U. S. A., 1917-1919. Retired to permanent grade of Captain, U. S. A., Retired, 1919.

1071 Garfield Avenue.

CLINTON KELLY JUDY, M.A.

Professor of English Language and Literature

A.B., University of California, 1903; M.A., 1907; B.A., Oxford University, 1909; M.A., 1913; M.A., Harvard University, 1917.

55 North Euclid Avenue.

HANS KRAMER, FIRST LIEUTENANT

Corps of Engineers, U. S. Army

Professor of Military Science and Tactics

Graduate, U. S. Military Academy, West Point, with rank of Second Lieutenant, Corps of Engineers, 1918. Camp Adjutant, Camp Leach, D. C., 1918. Student, The Engineer School, Camp A. A. Humphreys, Virginia, 1919-1920. With American Expeditionary Forces and American Forces in Germany, 1919. Adjutant, Engineer R. O. T. C. Camp, Camp A. A. Humphreys, Virginia, 1920.

2046 Meridian Avenue, South Pasadena.

GRAHAM ALLAN LAING, M.A.

Professor of Business Administration

B.A., University of Liverpool, 1908; M.A., 1909; Gladstone Prize in History and Political Science, Rathbone Prize in Economics, Liverpool University, 1907; Workers' Educational Association Lecturer in Economic History for Liverpool University, 1909-1913; Secretary, Department of Education, Government of British Columbia, 1913-1914; Director of Technical Education, Vancouver, B.C., 1914-1917; Instructor in Economics and History, University of California, 1917-1918; Assistant Statistician, United States Shipping Board, 1918-1919; Assistant Professor of Social Science, University of Arizona, 1919-1921.

1081 Elizabeth Street.

JOHN ROBERTSON MACARTHUR, PH.D.

Professor of Modern Languages

Dean of Freshmen

B.A., University of Manitoba, 1892; Ph.D., University of Chicago, 1903. Lecturer in Modern Languages, Manitoba College, 1893-1898; Professor of English, New Mexico Agricultural College, 1903-1910, 1911-1913; Professor of English, Kansas State Agricultural College, 1914-1920. Agent of International Committee of Young Men's Christian Association, Ellis Island, 1910-1911; National President, Pi Kappa Delta, honorary forensic society, 1918-.

866 South Pasadena Avenue.

PAUL PERIGORD, PH.D.

Professor of Economics and European History

B.A., University of France, 1901; B.Ph., 1902; M.A., University of Chicago, 1911; M.A., Columbia University, 1913; Ph.D., University of Minnesota, 1923. French Army, 1914-1917. Military Instructor as Captain of Infantry, for the New England Division, Camp Devens, Massachusetts, 1917. Member of French High Commission to the United States, 1918-1919.

2001 Oak Knoll Avenue.

ROYAL WASSON SORENSEN, B.S. in E.E.

Professor of Electrical Engineering

B.S. in Electrical Engineering, University of Colorado, 1905. Associated with General Electric Co., Schenectady, N. Y., and Pittsfield, Mass., 1905-1910; Consulting Engineer, Pacific Light and Power Corporation, 1913-1917. Fellow, American Institute of Electrical Engineers; Consulting Engineer, U. S. Electrical Manufacturing Company, 1917-1919, and 1922.

589 North Madison Avenue.

FRANKLIN THOMAS, C.E.

Professor of Civil Engineering

B.E., University of Iowa, 1908; C.E., 1913. Graduate work at McGill University, Montreal. Instructor in Descriptive Geometry and Drawing, University of Michigan, 1910-1912. Construction Foreman, Mines Power Company, Cobalt, Ontario, 1909-1910; Designer, Alabama Power Company, Birmingham, Alabama, 1912-1913. Assistant Engineer, U. S. Reclamation Service, 1919.

685 South El Molino Avenue.

RICHARD CHACE TOLMAN, PH.D.

Professor of Physical Chemistry and Mathematical Physics

S.B. in Chemical Engineering, Massachusetts Institute of Technology, 1903; Ph.D., 1910; Student, Universities of Berlin and Crefeld, 1903-1904. Dalton Fellow, Instructor in Theoretical Chemistry, and Research Associate in Physical Chemistry, Massachusetts Institute of Technology, 1905-1910; Instructor in Physical Chemistry, University of Michigan, 1910-1911; Assistant Professor of Physical Chemistry, University of Cincinnati, 1911-1912; Assistant Professor of Chemistry, University of California, 1912-1916; Professor of Physical Chemistry, University of Illinois, 1916-1918; Chief, Dispersoid Section, Chemical Warfare Service, 1918; Associate Director and Director, Fixed Nitrogen Research Laboratory, Department of Agriculture, 1919-1921. Member of National Academy of Sciences, and of American Academy of Arts and Sciences.

Faculty Club.

HARRY CLARK VAN BUSKIRK, PH.B.

Professor of Mathematics

Registrar

Ph.B., Cornell University, 1897.

3400 East Colorado Street.

JAMES HAWES ELLIS, PH.D.

Associate Professor of Physical-Chemical Research

B.S., Massachusetts Institute of Technology, 1912; Ph.D., 1916. Assistant in Electrical Laboratory, Massachusetts Institute of Technology, 1913-1914; Research Associate in Physical Chemistry, Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology, 1914-1916.

Glendora.

WILLIAM NOBLE LACEY, PH.D.

Associate Professor of Chemical Engineering

A.B. in Chemical Engineering, 1911, and Chemical Engineer, 1912, Leland Stanford Junior University; M.S., 1913, and Ph.D., 1915, University of California; Assistant in Chemistry, Leland Stanford Junior University, 1911-1912; Assistant in Chemistry, University of California, 1912-1915; Research Chemist for Giant Powder Co., San Francisco, 1915; Research Associate, Massachusetts Institute of Technology, 1916.

1198 North Wilson Avenue.

HOWARD JOHNSON LUCAS, M.A.

Associate Professor of Organic Chemistry

B.A., Ohio State University, 1907; M.A., 1908; Assistant in Organic Chemistry, Ohio State University, 1907-1909; Fellow in Chemistry, University of Chicago, 1909-1910; Chemist, Bureau of Chemistry, United States Department of Agriculture, 1910-1912. Chemist, Government of Porto Rico, 1912-1913.

677 Oak Knoll Avenue.

GEORGE RUPERT MACMINN, A.B.

Associate Professor of English Language and Literature

A.B., Brown University, 1905. Instructor in English, Brown University, 1907-1909; Iowa State College, 1909-1910; University of California, 1910-1918. Manager of the University of California Press, 1912-1913. Editor, University of California Chronicle, 1915.

255 South Bonnie Avenue.

ROMEO RAOUL MARTEL, S.B.

Associate Professor of Civil Engineering

S.B., Brown University, 1912. Instructor in Civil Engineering, Rhode Island State College, 1913-1914; Instructor in Civil Engineering, Mechanics Institute, 1914-1915. With Sayles Finishing Plants, Saylesville, R. I., 1915-1918; with Atchison, Topeka and Santa Fe Railway, Amarillo, Texas, 1918. Resident Engineer, California Highway Commission, Willits, California, summer of 1921.

192 South Chester Avenue.

WILLIAM WHIPPLE MICHAEL, B.S.

Associate Professor of Civil Engineering

B.S. in Civil Engineering, Tufts College, 1909. With New York City on topographic surveys, 1909-1911; with The J. G. White Engineering Corporation, 1912-1913, and 1915; Instructor, Department of Drawing and Design, Michigan Agricultural College, 1914; with The Power Construction Company of Massachusetts, 1914-1915; in private practice, 1916-1918.

376 South Wilson Avenue.

WILLIAM L. STANTON, B.A.

Physical Director

B.A., Dickinson College, 1903. Assistant Director of Physical Education, Pratt Institute, 1903-1904; Actor, legitimate stage, 1904-1905; Director of Athletics and Physical Education, Morristown School, 1905-1906; Professor of English and Director of Athletics, Hamilton Institute, 1906-1908; Graduate student of English, Columbia University, 1907; Director of Athletics and Instructor in Dramatics, Pomona College, 1908-1916; Director of Athletics and Instructor in English and Dramatics, Occidental College, 1916-1917; Officer, U. S. Army, over-seas, 1917-1919; Director of Athletics and Dramatics, Occidental College, 1919-1921.

2460 Oswego Street.

EARNEST CHARLES WATSON, PH.B.

Associate Professor of Physics

Ph.B., Lafayette College, 1914; Scholar in Physics, University of Chicago, 1914-1915; Assistant in Physics, University of Chicago, 1915-1917.

1124 Stevenson Avenue.

LUTHER EWING WEAR, PH.D.

Associate Professor of Mathematics

A.B., Cumberland University, 1902; Ph.D., Johns Hopkins University, 1913. Graduate student and fellow, Johns Hopkins University, 1908-1909, 1910-1913. Instructor in Mathematics, University of Washington, 1913-1918.

68 South Grand Oaks Avenue.

GEORGE FORSTER, E.E.

Assistant Professor of Electrical Engineering

E.E., Lehigh University, 1914. With General Electric Company, Schenectady, N. Y., and Pittsfield, Mass., 1914-1915; Assistant Electrical Engineer, Delaware & Hudson Co., Coal Department, Scranton, Pennsylvania, 1915-1916; Engineering Assistant, Philadelphia Electric Company, Philadelphia, Pennsylvania, 1918-1919.

1114 Delmar Street.

DOSWELL GULLATT, FIRST LIEUTENANT

Corps of Engineers, U. S. Army

Assistant Professor of Military Science and Tactics

Graduate, U. S. Military Academy, West Point, with rank of Second Lieutenant, Corps of Engineers, 1918. Student, Engineer School, Camp A. A. Humphreys, Virginia, 1919-1921. With American Expeditionary Forces and American Forces in Germany, 1919; duty as Chief of Survey Detachment, Ninth Engineers, Fort Sam Houston, Texas, 1921.

63 North Allen Avenue.

WALTER TICKNOR WHITNEY, PH.D.

Assistant Professor of Physics

B.S., Pomona College, 1910; M.S., 1912; Ph.D., University of Chicago, 1916. Staff of Mount Wilson Observatory, 1913 and 1917. Fellow in Physics, University of Chicago, 1914-1916.

988 North Holliston Avenue.

CLYDE WOLFE, PH.D.

Assistant Professor of Mathematics

B.S., Occidental College, 1906; M.S., 1907; A.M., Harvard University, 1908; Ph.D., University of California, 1919. Harvard University, 1908-1910. Surveyor, Western States, 1910-1912. Acting Professor of Physics, Occidental College, 1912-1916; Associate Professor of Mathematics, 1916-1917. Teaching Fellow in Mathematics, University of California, 1917-1919. Dean, Santa Rosa Junior College, 1919-1920.

401 South Chester Avenue.

WALTER WILLIAM MARTIN[1]

Instructor in Wood Working (Part Time)

Graduate, Normal Arts Department, Throop Polytechnic Institute, 1900.

1782 Rose Villa Street.

FRANCIS WILLIAM MAXSTADT, M.E. (E.E.)

Instructor in Mechanical Engineering

M.E., Cornell University, 1916; Certificate of E.E., 1916. Draftsman and Designer, Otis Elevator Company, 1916-1917. Assistant in the Electrical Research Division, Interborough Rapid Transit Company, 1917-1919. Assistant in the Thomas A. Edison Laboratories, 1919.

267 Oak Knoll Avenue.

ALBERT ADAMS MERRILL

Instructor in Experimental Aeronautics and in Accounting

1172 North Michigan Avenue.

HAROLD Z. MUSSELMAN, A.B.

Instructor in Physical Education

A.B., Cornell College, 1920; Instructor in Science and Athletic Director, Sterling (Illinois) High School, 1920-1921.

929 East California Street.

WALTER WILLIAMS OGIER, JR., B.S.

Instructor in Mechanical Engineering

Assistant Director of Music

B.S., Throop College of Technology, 1919. With Signal Department, Pacific Electric Railway, 1919-1920.

64 North Hudson Avenue.

STANLEY MCCRORY PARGELLIS, B.A.

Instructor in English Language and Literature

B.A., University of Nevada, 1918; B.A., Oxford University, 1922.

974 Claremont Drive.

FRANCES HALSEY SPINING

Librarian

1067 North Catalina Avenue.

ERNEST HAYWOOD SWIFT, M.S.

Instructor in Analytical Chemistry

B.S. in Chemistry, University of Virginia, 1918; M.S., California Institute of Technology, 1920.

406 South Chester Avenue.

---

[1]Associated with the Pasadena High School.

LE ROY B. SHERRY, M.D.

Examining Physician

A.B., University of Illinois, 1910; M.D., Johns Hopkins Medical School, 1914.

221 Fremont Drive, South Pasadena.

FLOYD L. HANES, D.O.

Department of Physical Education

D.O., College of Osteopathic Physicians and Surgeons, Los Angeles, 1921.

909 Manzanita Avenue.

JOSEPH ADAM BECKER, PH.D.

National Research Fellow in Physics

B.A., Cornell University, 1918; Ph.D., 1922. Research Physicist, Bureau of Standards, Westinghouse Electric & Manufacturing Company, and Western Electric Company, 1918-1919. Instructor in Physics, Cornell University, 1919-1922.

481 Pepper Street.

ARTHUR FERGUSON BENTON, PH.D.

National Research Fellow in Chemistry

A.B., Princeton University, 1916; A.M., 1919; Ph.D., 1920.

225 South Holliston Avenue.

ALBERT BJORKESON, PH.D.

Research Associate in Physics on Liljewalch Foundation, Upsala, Sweden

Fil. Mag., University of Upsala, 1915; Fil. Lic., 1919; Ph.D., 1923. Assistant in Physics, University of Upsala, 1917-1922; Docent in Physics, 1922-.

207 South Catalina Avenue.

JOHN CARROLL, B.A.

Research Fellow of Sidney Sussex College, Cambridge

B.A., University of Cambridge, 1921.

28 Oak Knoll Gardens.

PHILIP S. DANNER, PH.D.

National Research Fellow in Chemistry

A.B., Pomona College, 1918; M.S., University of California, 1920; Ph.D., 1922.

2430 Ganesha Avenue, Altadena.

ARMOND G. DENIS, B.A.

Fellow of the Commission for the Relief of Belgium Educational Foundation

B.A., Oxford, 1920.

360 South Marengo Avenue.

GEORGE GLOCKLER, PH.D.

National Research Fellow in Chemistry

B.S., University of Washington, 1915; M.S., 1915; Ph.D., University of California, 1923.

Sierra Madre Villa.

MAURICE LOYAL HUGGINS, PH.D.

National Research Fellow in Chemistry

A.B. and B.S., University of California, 1919; M.S., 1920; Ph.D., 1922.

940 Delmar Street.

HERBERT KAHLER, PH.D.

National Research Fellow in Physics

B.S., University of Washington, 1918; Ph.D., Cornell, 1921.

187 Oak Knoll Avenue.

EDWARD H. KURTH, D.SC.

National Research Fellow in Physics

C.E., Princeton University, 1920; M.S., 1921; D.Sc., 1922.

29 North Meredith Avenue.

SAMUEL STUART MACKEOWN, PH.D.

National Research Fellow in Physics

A.B., Cornell University, 1917; Ph.D., 1923. Instructor in Physics, Cornell University, 1920-1923.

1240 New York Avenue.

MAURICE MUYLAERT, C.M.E.

Fellow of the Commission for the Relief of Belgium Educational Foundation

C.M.E., University of Louvain, 1922.

498 South Pasadena Avenue.

EDWIN LAWRENCE ROSE, S.M.

Charles A. Coffin Fellow in Physics (General Electric Company)

S.B., Massachusetts Institute of Technology, 1921; S.M., 1922.

233 Columbia Street.

WILLIAM RALPH SMYTHE, PH.D.

National Research Fellow in Physics

A.B., Colorado College, 1916; A.M., Dartmouth College, 1919; Ph.D., University of Chicago, 1921.

120 Woodbury Road.

WLADIMIR M. ZAIKOWSKY

Research Fellow in Physics (Standard Oil Company)

Graduate of Michel's Artillery Academy, 1911. Research Officer of Main Artillery Board (Russia), 1911-1914; Repetitor of Michel's Artillery Academy, 1914-1915. Captain of Russian Artillery, 1914-. Member of Russian Artillery Commissions in the United States, 1915-1921.

346 South Michigan Avenue.

GORDON ALBERT ALLES, B.S.

duPont Fellow in Chemistry

B.S., California Institute of Technology, 1922.

2100 Ynez Street, Alhambra.

DINSMORE ALTER, PH.D.

Teaching Fellow in Physics

B.S., Westminster College, 1909; M.S., University of Pittsburgh, 1911; Ph.D., University of California, 1916. Associate Professor of Astronomy, University of Kansas, on leave of absence.

385 North Euclid Avenue.

RICHARD BADGER, B.S.

Teaching Fellow in Chemistry

B.S., California Institute of Technology, 1921.

215 Highland Place, Monrovia.

ARNOLD ORVILLE BECKMAN, M.S.

Teaching Fellow in Chemistry

B.S., University of Illinois, 1922; M.S., 1923.

358 South Euclid Avenue

ROBERT BIGHAM BRODE, B.S.

Teaching Fellow in Physics

B.S., Whitman College, 1921.

1122 Division Street.

ROBERT CADY BURT, E.E.

Teaching Fellow in Physics

E.E., Cornell University, 1921.

327 South Michigan Avenue.

G. HARVEY CAMERON, B.Sc.

Assistant in Physics

B.Sc., University of Saskatchewan, 1922.

266 South Michigan Avenue

HUGH KENNETH DUNN, A.B.
Assistant in Physics
A.B., Miami University, 1918.
1122 Division Street.

PAUL HUGH EMMETT, B.S.
Teaching Fellow in Chemistry
B.S., Oregon Agricultural College, 1922.
1765 Oakdale Street.

ALEC LLOYD GREENLEES, M.A.
Teaching Fellow in Physics
M.A., Queen's University, 1920.
1122 Division Street.

L. MERLE KIRKPATRICK, B.S.
Teaching Fellow in Chemistry
B.S., California Institute of Technology, 1923.
596 North Chester Avenue.

ARTHUR LOUIS KLEIN, B.S.
Teaching Fellow in Physics
B.S., California Institute of Technology, 1921.
Faculty Club.

R. MEYER LANGER, M.A.
Research Assistant in Physics
B.S., College of the City of New York, 1920; M.A., Columbia University, 1921.
331 South Chester Avenue.

DONALD HOLT LOUGHRIDGE, B.S.
Assistant in Physics
B.S., California Institute of Technology, 1923.
1181 North Sierra Bonita Avenue.

GEORGE THOMAS MCKEE, B.S.
Teaching Fellow in Civil Engineering
B.S., California Institute of Technology, 1923.
119 North Serrano Avenue, Los Angeles.

HALLAM EVANS MENDENHALL, B.S.
Assistant in Physics
B.S., Whitman College, 1921.
1122 Division Street.

LEWIS MORTON MOTT-SMITH, B.S.
Assistant in Physics
B.S., California Institute of Technology, 1923.
2518 Grandview Drive, Los Angeles.

RUSSELL MORLEY OTIS, B.S.
Research Fellow in Physics
B.S., California Institute of Technology, 1920.
1286 Stevenson Avenue.

LINUS CARL PAULING, B.S.
Teaching Fellow in Chemistry
B.S., Oregon Agricultural College, 1922.
254 East Washington Street.

CHARLES HOLDEN PRESCOTT, A.B.
Teaching Fellow in Chemistry
A.B., Yale University, 1922.
Faculty Club.

ALBERT L. RAYMOND, M.S.
Research Fellow in Chemistry
B.S., California Institute of Technology, 1921; M.S., 1923.
382 East California Street.

HOWARD P. ROBERTSON, M.S.
Assistant in Physics
B.S., University of Washington, 1922; M.S., 1923.
107 South Wilson Avenue.

REINHARDT SCHUHMANN, M.A.
Teaching Fellow in Chemistry
B.A., University of Texas, 1910; M.A., 1921.
36 South Roosevelt Avenue.

SINCLAIR SMITH, B.S.
Teaching Fellow in Physics
B.S., California Institute of Technology, 1921.
102 North Michigan Avenue.

ARTHUR HOWARD WARNER, B.S.
Teaching Fellow in Physics
A.B., University of Colorado, 1917; B.S., 1920.
929 East California Street.

ERNEST C. WHITE, M.S.
Research Assistant in Chemistry
A.B., Randolph Macon College, 1910; M.S., George Washington University, 1922.
Faculty Club.

RALPH EDGAR WINGER, A.B.
Assistant in Physics
A.B., Baker University, 1914.
402 South Lake Avenue.

WILLIS HOWARD WISE, M.A.
Assistant in Physics
B.S., Montana State College, 1921; M.A., University of Oregon, 1923.
1122 Division Street.

OLIVER REYNOLDS WULF, M.S.
Teaching Fellow in Chemistry
B.S., Worcester Polytechnic Institute, 1920; M.S., The American University, 1922.
308½ East Bellevue Drive.

LOUIS H. BAILEY, STAFF SERGEANT, D. E. M. L., U. S. ARMY
Assistant, Department of Military Science and Tactics
692½ South Lake Avenue.

MARIEN H. DEGRAFF, MASTER SERGEANT, U. S. ARMY, RETIRED
Supply Sergeant, Department of Military Science and Tactics
397 East California Street.

JOSEPH LARACY, MASTER SERGEANT, ENGINEERS, U. S. ARMY, RETIRED.
Assistant, Department of Military Science and Tactics
1084 Stevenson Avenue.

# Technical Assistants

WILLIAM H. BRESLER.....Instrument Maker, Department of Physics
*1680 Locust Street.*

WILLIAM CLANCY.....Glass Blower, Department of Physics
*153 North Mentor Avenue.*

FRED C. HENSON.....Instrument Maker, Department of Chemistry
*966 North Stevenson Avenue.*

ROBERT LOOFBOURROW.....Store-Keeper, Department of Chemistry
*706 South Mentor Avenue.*

BRUNO E. MERKEL.....Instrument Maker, Department of Physics
*737 North Chester Avenue.*

ELSIE O'CONNELL, B.S.....Storekeeper, Department of Physics
*108 North Figueroa Street, Los Angeles.*

JULIUS PEARSON.....Head Instrument Maker, Department of Physics
*127 South Catalina Avenue.*

# Assistants in Administration

ROBERT E. CRANE.....Superintendent of Buildings and Grounds
*380 South Euclid Avenue.*

JANET CRISTY.....Secretary's Office
*549 La Loma Road.*

MARY A. HEWSON.....House Director
*Dormitory.*

INGA HOWARD.....Office of the Chairman of the
*1126 Division Street.* Executive Council

KATHERINE RIDDELL LATHROP.....Secretary's Office
*432 North Mentor Avenue.*

LILLIAN P. LEEFE.....Registrar's Office
*132 N. Sierra Bonita Avenue.*

NELLIE T. MURRAY.....Assistant in Biochemistry
*78 North Marengo Avenue.*

HERBERT H. G. NASH.....Bookkeeper
*406 South Chester Avenue.*

VERA PFANDER.....Secretary's Office
*140 West California Street.*

HELEN PFUSCH.....Secretary's Office
*1271 East Villa Street.*

GRACE E. SAGE.....Secretary's Office
*337 South Lake Avenue.*

BEATRICE J. WULF.....Department of Chemistry
*308½ East Bellevue Drive.*

# Historical Sketch

The school from which the California Institute of Technology has grown was established in 1891 as Throop Polytechnic Institute by Amos G. Throop of Chicago, who, during his lifetime, gave liberally for its support, and who left his estate for its endowment. The fund left by him is known as the Throop Estate Fund, and the Board of Trustees have in his honor given the name Throop Hall to the present central building, erected in 1910.

Throop Polytechnic Institute, though always offering collegiate instruction, was chiefly a secondary school, and in its capacity as a pioneer manual training school it met a real need of the time. In 1907, however, the Board of Trustees, after careful consideration, decided that the Institute could best serve the needs of the future by discontinuing its preparatory work, and becoming exclusively an institute of science and technology. The reasons on which this decision was based, and the ideals of the new Institute, were expressed, as follows, in a report by Dr. George E. Hale to the Board of Trustees:

"Here in California the conditions and the need for scientific education are unsurpassed. In no part of the world is electrical engineering so highly developed, especially in the transmission of power from great distances. In hydraulic engineering, we are facing today an undertaking of enormous magnitude. Under such conditions, and with the advantages afforded by climate, by the immediate neighborhood of mountains where water power can be developed, and experimental transmission

lines installed, who can deny that there is a place in Pasadena for a scientific school of the highest class?

"In developing such a school, we must provide the best of instruction, and the most perfect equipment that modern engineering offers. But in laying stress upon the practical aspects of the problem we must not forget that the greatest engineer is not the man who is trained merely to understand machines and to apply formulas, but is the man who, while knowing these things, has not failed to develop his breadth of view and the highest qualities of his imagination. No great creative work, whether in engineering or in art, in literature or in science, has ever been the work of a man devoid of the imaginative faculty."

The real work of the new Institute began in 1910 in Throop Hall on the new campus, which had been given to the Institute three years before.

In 1920, the name of the Institute was changed to California Institute of Technology, in recognition of the fact that, through the development of its work, especially of its graduate instruction and research, it was no longer an institution of merely local scope. Two years later it received a substantial endowment, which has made possible the fuller realization of its ideals.

The development of the Institute during the last few years has been rapid. In 1917, the chemistry building, named the Gates Chemical Laboratory from its donors, Messrs. C. W. Gates and P. G. Gates, was erected and equipped; and Dr. Arthur A. Noyes became its Director. In 1920, the east wing of the Norman Bridge Laboratory

of Physics, given by Dr. Norman Bridge of Chicago, was erected; in 1923, the central section, devoted to the physics library, was added; and the west wing is now nearly completed. Dr. Robert A. Millikan became Director of this Laboratory in 1921. In 1922, an auditorium, seating 500 persons, was erected. There has also now been completed the High-Voltage Research Laboratory, built and equipped in cooperation with the Southern California Edison Company.

All of this construction has been carried out in the style of Spanish architecture, under the direction of the well-known architect, Mr. Bertram G. Goodhue.

A Research Laboratory of Applied Chemistry has also been equipped, with the aid of funds furnished by Mr. C. W. Gates, in a building originally erected in war-time for research purposes. Fuller provision for student life on the campus has been made by the erection of a temporary building provided by Mr. and Mrs. Robert Roe Blacker.

During the past year eight acres have been added to the campus, giving it an area of thirty acres. On the new extension is an attractive residence which is used as a club-house for the faculty and graduate students.

Along with the material development of the Institute in the past few years has gone a striking development of its educational and research work. This has been made possible through the liberal support of various national foundations. The General Education Board has given an endowment of $300,000 to be used for salaries; the Carnegie Foundation for the Advancement of Teach-

ing, an endowment of $40,000 for teachers' insurance and annuities; the Carnegie Institution of Washington, $30,000 a year for five years for the support of researches on the structure of matter and radiation, under the direction of Drs. R. A. Millikan and A. A. Noyes; the Carnegie Corporation of New York, $10,000 for research upon insulin, under the supervision of Dr. A. A. Noyes. The National Research Council has provided payments totalling about $20,000 a year to National Research Fellows now working at the Institute. An endowment of $20,000 has also been given by Robert Roe Blacker and Nellie Canfield Blacker for scholarships for undergraduate and graduate students.

# Educational Policies

In pursuance of the plan of developing an institute of science and technology of the highest grade, the Trustees have recently adopted the following statement of policies:

(1) The four-year undergraduate engineering courses of the Institute shall include an unusually thorough training in the basic sciences of physics, chemistry, and mathematics, and a large proportion of cultural studies; the time for this being secured by eliminating some of the more specialized engineering subjects, which may be pursued in graduate courses by students desiring further professional training. It is hoped in this way to make the undergraduate courses of the Institute a combination of a fundamental scientific training with a broad cultural outlook, which will afford students with scientific interests a type of collegiate education which avoids the narrowness common with students in technical schools and the superficiality and the lack of purpose of many of those taking academic college courses. Their instruction in the basic engineering subjects will, however, be maintained at the highest efficiency so that the graduates of the engineering courses may be prepared for positions as constructing, designing, operating, and managing engineers. Provision will also continue to be made, especially in the Courses of Physics and Engineering, Chemistry, and Chemical Engineering, for the training of students for positions in the research and development departments of manufacturing industries.

(2) The departments of physics, chemistry, and mathematics shall be made as strong as possible, not only

because these subjects are essential to the plan of undergraduate instruction, but also because the best opportunities for advanced study and research in these fields must be provided in order to train the creative type of scientist and engineer urgently needed in our educational, governmental, and industrial development.

(3) Every effort shall be made to develop the ideals, breadth of view, general culture, and physical well-being of the students of the Institute. To this end the literary, historical, economic, and general scientific subjects shall continue to be taught by a permanent staff of men of mature judgment and broad experience; the regular work in these subjects shall be supplemented by courses of lectures given each year by men of distinction from other institutions; the weekly assemblies addressed by leading men in the fields of education, literature, art, science, and engineering, public service, commerce, and industry shall be maintained as effectively as possible; moderate participation of all students in student activities of a social, literary, or artistic character as in the student publications, debating and dramatic clubs, musical clubs, etc., shall be encouraged; and students shall be required or encouraged to take regular exercise, preferably in the form of games or contests affording recreation. It is the purpose of the Trustees to create as rapidly as possible additional facilities for these student activities by the erection of a student union, a gymnasium, and dormitories. Great importance is also attached to making the campus attractive in its architectural and landscape features, because of the influence of such surroundings on the students and on the public.

(4) In all the scientific and engineering departments

of the Institute research shall be made a large part of the work, not only because of the importance of contributing to the advancement of science and thus to the intellectual and material welfare of mankind, but also because without research the educational work of a higher institution of learning lacks vitality and fails to develop originality and creativeness in its students. To insure the development of research the Trustees will provide for it financially, not, as is so often the case, out of the residue that may be left after meeting the demands of the undergraduate work, but by duly limiting the extent of this work, and by setting apart in advance funds for research and graduate study. It is also the policy of the Trustees to make the advancement in grade and salary of members of the staff largely dependent on accomplishment in research or in other creative directions.

(5) In order that the policies already stated may be made fully effective as quickly as possible, and in order that the available funds may not be consumed merely by increase in the student body, it is the intention of the Trustees to limit the registration of students at any period to that number which can be satisfactorily provided for with the facilities and funds available. As students are admitted not on the basis of priority of application, but on that of a careful study of the merits of the individual applicants, the limitation has the highly important result of giving a select body of students of more than ordinary ability. A standard of scholarship is also maintained which rapidly eliminates from the Institute those who, from lack of ability or industry, are not fitted to pursue its work to the best advantage.

# Requirements for Admission

Each applicant must be thoroughly prepared in at least fifteen units of preparatory work, each unit representing one year's work in a given subject in an approved high school at the rate of five recitations weekly. Each applicant must offer all of the units in group A, three or more units selected from group B, and the remainder from group C.

| | | |
|---|---|---|
| Group A | English | 3 |
| | Algebra | 2 |
| | Plane and Solid Geometry | 1½ |
| | Trigonometry | ½ |
| | Physics | 1 |
| | Chemistry | 1 |
| | United States History and Government | 1 |

Group B: Foreign Languages; additional English, Mathematics, Laboratory Science, or History.

Group C: Drawing, Manual subjects, Commercial subjects, etc.

Applicants who offer for entrance a total of fifteen recommended units, but whose list of subjects is not in accord with this table, may be admitted at the discretion of the faculty, if they are successful in passing the general entrance examinations; but no applicant will be admitted whose preparation does not include English 2 units, Algebra 1½ units, Geometry 1 unit, Trigonometry ½ unit, Physics 1 unit. If United States History and Government is not offered for admission, American Government will be prescribed for one term during the sophomore year, unless the deficiency is removed before that time. All other entrance deficiencies must be made up before registration for the second year.

Each applicant is expected to show that he has satisfactorily completed the above-stated required preparation, by presenting a certificate of recommendation from an approved school showing his complete scholarship record.[1]

In addition to the above credentials, all applicants for admission to the freshman class are required to take entrance examinations. These examinations will not take the place of the high-school credentials, but will serve to supplement them. The subjects covered will be those listed in group A. The examinations will be general in character: they are intended to show the applicant's ability to think and express himself clearly, and his fitness for scientific and engineering training, rather than to test memorized information.

The examinations for the class entering September, 1924, will be given on Tuesday and Wednesday, July 1st and 2nd, or on Wednesday and Thursday, September 24th and 25th.

The number of students admitted to the freshman class is limited to 160 by action of the Trustees. For this reason, applicants should, so far as possible, conform to the following procedure:

[1]Incomplete certificates of recommendation may be supplemented by examinations in particular subjects taken at the Institute. The scope of subject matter for these examinations is the same as that covered by standard high schools. Applicants taking examinations in Physics, Chemistry, or United States History and Government must present their notebooks at the time of the examination. The schedule for 1924 is as follows: Monday, September 22, 9:00 A.M., Mathematics; 2:00 P.M., English. Tuesday, September 23, 9:00 A.M., Physics and Chemistry; 2:00 P.M., History and Foreign Languages.

These examinations may also be taken under the direction of the College Entrance Examination Board. The examinations are held at various points in the United States on June 16 to 21, 1924. Applications for these examinations must be addressed to the College Entrance Examination Board, 431 West One Hundred and Seventeenth Street, New York, N. Y., and must be received by the Board on or before May 19, 1924.

They should present themselves for examination upon the dates set, preferably upon those in July. At the same time they should make out, upon the form provided, their applications for admission. At that time, or as soon thereafter as practicable, but preferably not later than July 15th, they should submit certificates of recommendation from the principals of their high-schools, together with their complete scholastic record (for which forms will be provided upon request).

Applicants who comply with these conditions not later than July 15th, will be notified by the Registrar as to their acceptance on or about July 20th. The accepted applicants will, at that time, be sent registration cards; and these should, if possible, be returned to the Registrar not later than August 1st, together with the registration fee of $10.00 (which will be deducted from the first-term tuition). Applicants who fail to do this cannot be assured of admission in the Fall, since, as stated above, the number admitted to the Freshman class is limited to 160. However, until 160 have qualified, later applicants, including those that have postponed their entrance examinations till September, will be accepted, provided their examinations and credentials are satisfactory. On the other hand, applications completed before July 15th will not be given priority in the order of presentation; but on that date all applications then on file will be considered on their merits. Students of exceptional attainments will always be provided for.

For admission to the upper classes of the Institute applicants who have been students (but are not graduates) at other institutions of collegiate rank must present letters of honorable dismissal, together with

statements showing in detail the character of their previous training, and the grades which have been received. They will also be required to take general examinations in Mathematics, Physics and Chemistry. These examinations may be taken on Tuesday and Wednesday, July 1 and 2, 1924, or on Wednesday and Thursday, September 24 and 25, 1924.

Applicants who are graduates of colleges and scientific schools of recognized standing should also submit a detailed statement of the courses previously pursued, and of the grades received; but they will be admitted without examination, provided their previous scholastic record indicates attainment not inferior to the average of Institute students.

# Buildings and Educational Facilities

### THROOP HALL

Throop Hall, the central building on the new campus, contains the offices of administration; also the class-rooms and drawing-rooms of the engineering departments, and some of the engineering laboratories, described in connection with the Subjects of Instruction.

### NORMAN BRIDGE LABORATORY OF PHYSICS

The Norman Bridge Laboratory of Physics, the gift of Dr. Norman Bridge of Los Angeles, will consist of three units, each closing one of three sides of a hollow square. The first of these units, a building 128 by 58 feet, occupies five floors, and has a special photographic laboratory on the sixth floor, in addition to excellent facilities for outdoor experimentation on its large, flat roof.

It is provided with a lecture room seating 260 persons, two large undergraduate laboratories, with adjoining dark rooms and apparatus rooms, three class rooms, three laboratories for advanced instruction, nine offices, and fifteen research rooms capable of accommodating easily thirty research workers.

The general lecture hall receives its outside light through a skylight only, which makes it possible to darken it quickly, easily, and completely. An I-beam, mounted in the ceiling above the lecture table and extending the entire width of the room, carries a small crane, and renders possible the easy handling of heavy appa-

ratus for demonstration purposes. A special and unique feature is a lantern-screen carried on the same I-beam, and easily adjustable as to angle and height to facilitate projection vertically, or otherwise, from any part of the lecture hall.

The piping and wiring is all carried through large, easily accessible ducts, from which access to all rooms is had through covered trenches in the floors, the whole constituting an especially flexible system for the introduction of any sort of new electrical or pneumatic appliances which future developments may require.

A glass-blowing room and glass-blower, an especially large, well-equipped and well-manned instrument shop, and an adequate student shop and woodshop provide the best of facilities for both the research and the instructional work for which the laboratory is designed.

This unit is further equipped with a 250-volt, 220-ampere-hour storage battery, with a large capacity liquid air plant, with constant temperature rooms, and with special arrangements for obtaining direct and alternating currents of both high potential and high amperage in all rooms. The equipment is particularly adequate for work in the fields of high vacua, high potentials, X-rays, and spectroscopy.

A specially designed plane-grating spectrograph and a Rowland concave-grating spectrograph are mounted vertically in a constant temperature pit in the spectroscopy laboratory in the basement. Sunlight for this laboratory, for the lecture hall, and for various purposes upon other floors can be obtained at all times

throughout the day from a coelostat upon the roof by means of an open light-shaft extending from roof to sub-basement.

It is expected that before the Fall term of 1924 the west unit of the projected laboratory, a building of the same size and construction as the present east wing, will be completed. This will be primarily for research and will contain 80 rooms in all, of which 45 are research rooms, the rest being offices, classrooms, photographic darkrooms, and machinery and switchboard rooms.

The third unit, which forms the connection on the north between the other two wings, is now completed. It consists of two floors, 80 by 52 feet, one of which furnishes eight more research rooms, while the other will house the Norman Bridge Library of Physics, to provide for which Dr. Bridge has generously given a further $50,000.

### THE HIGH VOLTAGE RESEARCH LABORATORY

A high voltage laboratory, provided by the Southern California Edison Company, forms a companion building to the first unit of the Norman Bridge Laboratory, which it closely resembles in external design and dimensions. The equipment in this laboratory includes a million-volt transformer specially designed by Prof. R. W. Sorensen, which is capable of supplying 1,000 k.v.a. at the above potential with one end grounded. It will be available both for the pursuit of special scientific problems connected with the structure of matter and the nature of radiation, and for the conduct of the pressing engineering problems having to do with the improvement

in the art of high tension transmission. It also provides opportunities for instruction in this field, such as are not at present easily obtainable by students of science and engineering.

### GATES CHEMICAL LABORATORY

The Gates Chemical Laboratory includes laboratories used for the following branches of undergraduate instruction: Inorganic Chemistry, accommodating 160 freshman students; Analytical Chemistry, 40 students; Organic Chemistry, 23 students; Physical Chemistry, 20 students in two sections; Instrumental Analysis, 20 students in two sections. The undergraduate laboratories were intentionally limited in their accommodations, as it is the policy of the department to admit for the present to the upper years of the chemistry courses only a relatively small number of the more competent students, so as to secure the highest efficiency in the instruction, and so that graduate study and research may not be relegated to a secondary position, as happens in many institutions.

The remainder of the Gates Chemical Laboratory is devoted to facilities for research work. There are six unit laboratories for physico-chemical research accommodating two men each; organic and biochemical research laboratories, with space for six workers; and research laboratories of photochemistry and radiation chemistry providing for ten or more research men. In separate rooms special research facilities are also provided, including a well-equipped instrument shop, a students' carpenter shop, a glass-blowing room, a storage battery room, and large photographic dark rooms.

## RESEARCH LABORATORY OF APPLIED CHEMISTRY

An important addition has been made to the Gates Chemical Laboratory by the installation of a research laboratory of Applied Chemistry in a separate building especially adapted to the purpose. This research laboratory is equipped for carrying on chemical reactions on a fifty or a hundred pound scale. The machinery is as nearly like commercial plant equipment as is consistent with its size. It includes apparatus for grinding and pulverizing, roasting, melting, mixing, dissolving, extracting, pumping, decanting, centrifuging, filtering (by gravity, pressure, suction, plate and frame, and leaf filters), evaporating under pressure or vacuum, fractionating, condensing, crystallizing, drying under pressure or vacuum, and absorbing gases and vapors.

In this laboratory the student, after working out the process on a small laboratory scale, develops it further with larger scale apparatus. This "semi-works" phase of industrial research is very important, and its omission is the cause of great financial losses to the chemical industries. On the basis of his experience the student, towards the end of his laboratory course, formulates recommendations as to how the process should be tested in a trial plant unit.

The practice of the student in this laboratory, supplemented by the lecture and problem course in Chemical Engineering, serves not only to train the student in the methods and spirit of research, but also to acquaint him with the principles and the current practice involved in carrying on industrial chemical processes on a large scale.

### THE GENERAL LIBRARY

The general library is conveniently located on the main floor of Throop Hall, and contains a collection especially adapted to the needs of an institute of technology. While the main body of the books is scientific in character, there is a generous admixture of history, philosophy, and literature. The library is rapidly growing, and a persistent endeavor is made to keep abreast of the times, especially in securing complete files of technical and scientific periodicals.

The general reading-room is a part of the library, and contains current issues of the technical journals, including many foreign publications, with a number of the leading reviews.

There are two special libraries, one for Physics and Mathematics housed in the Bridge Laboratory, and one for Chemistry in the Gates Laboratory. These special libraries, with their reading-rooms, are arranged for the graduate departments and for men engaged in research.

### THE WEBB LIBRARY

The tower room of Throop Hall, designed especially to accommodate a library, is named in honor of the late Mr. William E. Webb of New York, whose private collection of some three thousand volumes, together with $30,000 for its maintenance and extension, was given to the Institute. The Webb Library includes a liberal representation of modern and classical French and German literature; many valuable books of history and travel, of ethnological science, and of the physical and

chemical sciences; a considerable number and variety of books in the fields of philosophy and religion; and an especially notable collection of volumes in astronomy.

### OTHER BUILDINGS

In addition to these permanent buildings, a temporary dormitory affords accommodations for about sixty students; and other temporary buildings house the power plant, hydraulic and steam laboratories, the research work in aerodynamics, and the departments of military engineering and physical education.

# Expenses

## TUITION

For the school year 1924-1925, the tuition for new students will be two hundred and fifty dollars ($250.00), payable $90.00 at the opening of the first term, and $80.00 at the opening of each of the other terms. Students in attendance at the Institute throughout the year 1923-1924, and students absent on leave, will have the benefit of the present rate of two hundred dollars ($200.00) per year for the school year of 1924-1925.

For the school year 1925-1926, and thereafter, the tuition will be two hundred and fifty dollars ($250.00) a year for all students.

The Associated Student Body fee, payable by all students, is $10.00 a year. This fee is used for the support of athletics and of other student activities. There is also a fee of 50c a term for locker rental. There are no other fees, but in the Department of Chemistry an annual deposit of $10 is required the first year, and $15 the last three years, to cover breakage and loss of laboratory materials. There are also small deposits for locker keys and for padlocks issued in the drawing rooms.

The cost of supplies and of books, most of which will be useful in later professional practice, ranges from $60 to $75 the first year, the larger part of which is required the first term, and from $20 to $30 a term thereafter.

### *THE CLEVELAND LOAN FUND*

This Fund was established by Miss Olive Cleveland, now deceased, for the purpose of aiding students to

obtain an education. The income is lent without interest to worthy students who may need such assistance. Applications for loans may be made to the Financial Secretary.

### THE PUBLIC WORKS FUND

Mr. William Thum, of Pasadena, has established a fund known as the Public Works Scholarship Fund, thereby making provision for the employment of a limited number of students in the various departments of municipal work. Under the provisions of this Fund, students approved by the faculty are employed in the Municipal Lighting Department, and other departments of the city of Pasadena, thereby gaining valuable practical experience.

### STUDENT EMPLOYMENT

The Institute endeavors to be of assistance in aiding students to find suitable employment when it is necessary for them thus to supplement their incomes in order to continue their education. The requirements of the courses at the Institute are so exacting, however, that under ordinary circumstances students who are entirely or largely self-supporting should not expect to complete a regular course satisfactorily in the usual time. Students wishing employment are advised to write to the Secretary of the Institute Y. M. C. A. in advance of their coming to the Institute.

### *DORMITORY*

The Institute has provided on the campus one dormitory, of frame construction, two stories in height, with large, airy, and well-lighted rooms for sixty students.

Several of the rooms have sleeping porches, and there are attractive living and recreation rooms. Table board is furnished to the students living in the dormitory, and to other students who desire it, on the cafeteria plan.

The minimum room rent is $75 a year, and the maximum $115. The rate for most of the rooms is $85. Each student in the dormitory is required to make a deposit of $10 at the opening of the college year to cover damage to dormitory property.

# Registration and General Regulations

Registration for the first term will take place Friday and Saturday, September 26 and 27, 1924 (9 A. M. to 3 P. M.); for the second term, January 5, 1925 (9 A. M. to 3 P. M.); for the third term, March 30, 1925 (9 A. M. to 3 P. M.). A special fee of two dollars is charged for registration after these dates.

All students, upon entering the Institute, must pass a physical examination satisfactory to the examining physician, and must show that they are physically qualified to carry the work for which they are registered.

The schedule of studies for each student is made out by the Registration Committee, and the student, after payment of his tuition and fees, is enrolled by the Registrar. No student is admitted to classes without an assignment card endorsed by the Registrar.

Any change of schedule is made by the Registrar, and after the first week of the term involves a fee of one dollar, unless made at the suggestion of officers of the Institute.

Every student is required to attend all class and assembly exercises for which he is registered, and to satisfy the requirements in each of the subjects in such ways as the instructors may determine.

Any student who is disorderly or persistently inattentive may be excluded from class by the Registration Committee upon recommendation of the instructor.

The following system of notation is used to indicate the student's standing.

4 denotes Marked Distinction,
3 denotes Above Average,
2 denotes Average,
1 denotes Below Average,
C denotes Conditioned,
F denotes Failed.

*Incomplete* means that the student has been prevented from completing the required work of the subject on account of sickness or other emergency. This mark may only be given in those cases where the student has carried with a grade of 2 or better at least three-fourths of the required work of the subject. Upon completion of the required work, the notation of incomplete shall not be considered a deficiency on the student's record.

*Conditioned* indicates deficiencies other than incomplete that may be made up without actually repeating the subject.

*Failed* means that credit may be secured only by repeating the subject.

Term examinations will be held in all subjects unless the instructor in charge of any subject shall arrange otherwise. No student will be exempt from these examinations. Leave of absence may be obtained only from the Deans, and can be allowed only for serious cause, such as physical inability to be present. Unexcused absence will count as a failure in the subject.

Special examinations may be arranged by the instructor for students having leave of absence, and must be

completed within four weeks from the beginning of the following term; or, if in work of the third term, during the week preceding registration.

A condition in any term's work must be removed during the next term in residence. Any condition not so removed shall automatically become a failure, unless otherwise recommended by the instructor at the time the condition is given.

A student who is recorded as having failed in a required subject must repeat that subject with the class next taking it, and such subjects will take precedence in the student's time over those that follow.

Reports of class work are prepared at the close of each term. These reports are sent to students, and to parents or guardians.

### SCHOLARSHIP REQUIREMENTS

The number of credits allowed for any subject is the number of units multiplied by the grade received.

1. A student will be *placed on probation,* if, at the end of any term, he does not receive at least 75 credits.*

2. A student will be *dismissed from the Institute* (a) if, at the end of any term, he does not receive at least 50 credits; or, (b) if he is already on probation and does not receive, at the end of the term, at least 75 credits.

3. A student will *not be admitted to the next year's work* of any specified four-year course, if, at the end of

* At the end of the first term of his first year at the Institute a student who has failed to secure 75 credits may be dismissed from the Institute (instead of being placed on probation), if it has become clear that he has not the qualifications required for the successful prosecution of an engineering or scientific course.

that year, he has not received at least 270 credits for the year (corresponding to an average of 90 credits per term); but the case of each student failing to meet this requirement will be considered by the Registration Committee in consultation with the department representing his course, and he may be allowed to continue in his course on probation or to transfer to another course when exceptional circumstances warrant such action.

4. A total of 1,080 credits is required for *graduation* (corresponding to an average of 90 credits per term), as well as the completing of the prescribed work of a course. A student who makes 1,620 credits for the four years (corresponding to an average of 135 credits per term), will be *graduated with honor.*

5. A student will be given *honor standing* in any term if he has received 135 credits during the preceding term; such honor standing to entitle him to special privileges and opportunities, such as relief from some of the more routine study and laboratory work, and admittance to more advanced courses and research work.

A student who is known to be exercising a harmful influence on the student life of the Institute may be summarily dismissed, whatever be his scholastic standing.

Petitions for immediate reinstatement from students who are dismissed for low scholarship will not be entertained by the faculty, except in cases of sickness or other unforeseen emergencies. The faculty will consider extension of the period of probation only in the case of students who are placed on probation for low scholarship at the close of the first term of their first year at the Institute, and then only till the end of that year.

A student who has met the minimum scholarship requirements, but has failed to fulfill the conditions for admission to the work of the following year, should communicate with the Registrar immediately after he receives his record at the end of the school year. The Registrar will then refer the matter to the Registration Committee; and this committee, after consultation with the professional department representing the course in which the student is registered, may, in case the general qualifications of the student warrant it, grant him the opportunity to qualify for admission to the work of the following year by additional study during the summer or by the fulfillment of other requirements.

A regular student who for satisfactory reasons desires to extend his course over a longer period than four years may, with the approval of the Registration Committee, be allowed to take less than the full prescribed work of about 48 units. Applications for registration in excess of 57 units (not including Physical Education) must be approved by the Registration Committee.

Prolonged leave of absence must be sought by written petition to the faculty, and the student must indicate the length of time, and the reasons, for which absence is requested. In case of brief absences from any given exercise, arrangements must be made with the instructor in charge.

Students are held responsible for any carelessness or wilful destruction or waste, and at the close of the year, or upon the severance of their connection with any part of the work of the Institute, they are required to return immediately all locker keys, and other property.

It is taken for granted that students enter the Institute with serious purpose, and that they will cheerfully conform to its requirements. The moral tone is exceptionally good; the honor system prevails at examinations, as well as in the general conduct of students, so that cases requiring severe discipline very rarely occur.

# General Information

## PHYSICAL EDUCATION

The Institute recognizes the importance of good health in relation to a student's career, and includes physical exercise and athletic activities in the required work of students of the two lower classes. The work in physical education is under the supervision of trained men who are members of the faculty, and who are also available for consultation with the students on matters pertaining to their physical development.

The plan of physical education is to bring all students into some form of exercise or participation in games, appropriate to their needs, while those with particular interest or ability for competitive games are given special coaching for the athletic teams representing the Institute.

Tournament Park, adjoining the campus, is available for the training of teams, and for intercollegiate sports.

The Institute is a member of the Southern California Intercollegiate Athletic Conference, and all competitive events are held under the rules of this body.

A physician is retained who examines each student upon his entrance to the Institute, and determines whether his work should be modified on account of his physical condition.

## MILITARY ENGINEERING

The Engineer Unit of the Reserve Officers' Training Corps was the first Engineer Unit to be established in the country, and is one of the largest. The training

given in the unit is required of all physically qualified men in the first two years. The advanced work of the two upper years is optional. Students enrolling for this advanced work receive commutation of subsistence from the Government. The instruction in the military courses, both theoretical and practical, aims to show the application to military requirements of the various elements of the technical training the student receives at the Institute, special effort being made to perfect this coordination. The War Department has furnished the unit with a large amount of the equipment appropriate for engineer troops. The field military engineering exercises constitute valuable supplementary training for the students of engineering which could otherwise be obtained only from experience upon construction projects.

### COLLATERAL CULTURAL OPPORTUNITIES

Under the auspices of the Pasadena Lecture Course Committee there are given each year at the Institute a number of public lectures on science, literature, and other subjects of general interest. Weekly public lectures in science, profusely illustrated by experiments, are also given by the staff of Norman Bridge Laboratory. Special opportunities are made available to students for attendance at concerts given by the Los Angeles Philharmonic Orchestra and noted artists under the auspices of the Pasadena Music and Art Association.

### STUDENT ORGANIZATIONS AND ACTIVITIES

The students are organized into an association known as the Associated Student Body, of which all are members, to deal with affairs of general concern to the students, and to deal with such matters as may be dele-

gated to them by the faculty. The Association elects its officers and a board of control, which investigates breaches of the honor system, or cases of misconduct, and suggests disciplinary penalties to the Associated Student Body for recommendation to the faculty.

Coordination in regard to campus affairs between faculty and students is obtained through periodic conferences of the Faculty Committee on Student Relations and the Executive Committee of the Student Body.

The Associated Students exercise general direction of matters of undergraduate concern in cooperation with the faculty. Athletic contests are managed by the Athletic Council, composed of faculty and student representatives. The student body, through its elected representatives, manages THE CALIFORNIA TECH, a weekly paper, and the BIG T, the annual. A glee club, an orchestra, and a band are maintained, with assistance from the Institute. There are at the Institute student branches of the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, and the American Society of Civil Engineers. A Chemists' Club includes men interested in this particular field.

The Astronomy and Physics Club, while composed of members of the faculty, graduate students of the Institute, and members of the staffs of neighboring scientific institutions, admits to its meetings undergraduate students who may be interested in its discussions.

A chapter of Tau Beta Pi, the national scholarship honor society of engineering colleges, is maintained at the Institute. Elections are made each year from the highest eighth of the junior class, and from the highest

quarter of the senior class. The additional qualifications of personal worth are also considered. Election to membership is regarded as a high honor.

A chapter of Pi Kappa Delta, national forensic honor society, elects to membership students who have represented the Institute in intercollegiate debates or oratorical contests. The society also aims to foster and promote interest on the part of the students in forensic activities.

# Scholarships and Prizes

## FRESHMAN PRIZE SCHOLARSHIPS

Three freshman scholarships will be awarded by the Institute, and a fourth scholarship by its Alumni, for the next school year, and in succeeding years, upon the basis of a competition open to properly qualified male students in the senior class of the high schools or college preparatory schools of southern California. The Institute Scholarships carry a payment of $250, equivalent to the year's tuition; and the Alumni Scholarship one of $300.

To enter the competition the student must meet the following conditions: He must complete by the end of the current school year at least fifteen units of studies of such a character as will fulfill the requirements for admission to the Institute, as set forth on pages 34-36; and he must, if awarded a scholarship, expect to enter the Institute at the beginning of the next college year. Moreover, he must be nominated as representative of his high school by his principal in consultation with the teachers of mathematics, physics, chemistry, and English. Each high school of southern California may nominate, not later than June 25, one representative and one additional representative for each fifty male students in regular standing in the senior class. The competitor for the Alumni Scholarship must be elected by vote of the senior class of his high school. Any student elected for the Alumni Scholarship, is also eligible for the Institute Scholarships (in case he should fail to receive the Alumni Scholarship).

Each student so nominated must mail to the Registrar of the Institute not later than June 25, on forms provided for the purpose, certain credentials giving the usual statistical information, and showing his high-school record, his participation in student activities, and his outside activities and personal interests.

All competitors for the scholarships must present themselves at the Institute for examination on Tuesday and Wednesday, July 1st and 2nd. The examinations will cover the branches of mathematics required for admission to the Institute, high-school physics and chemistry, English, American history, and general information. They will be of such a character as to determine the ability of the student to think and to express himself clearly, and to demonstrate his initiative and resourcefulness in planning experiments, and his power of applying his knowledge to concrete problems, rather than to test memorized information. The six or eight most successful applicants will be expected to present themselves later for personal interviews.

The scholarships will be awarded on the basis of all the information available in regard to the applicants—the results of their examinations, their high-school records and recommendations, the statements submitted as to their student activities and outside interests, and results of the personal interviews. The awards will be made without reference to financial need; but any successful student with adequate resources may relinquish the money payment in favor of the next most deserving competitor, while retaining the scholarship as an honorary recognition. The winners of these scholarships

will be designated Freshman Scholars, and will be so registered in the Institute Catalogue.

### SOPHOMORE PRIZE SCHOLARSHIPS

Three prize scholarships of $200 each (equivalent to the year's tuition) will be awarded by the Institute, at the end of this school year, and of succeeding years, on the basis of a competition, to students intending to pursue regular sophomore work at the Institute. The competition is open to Institute freshmen, under the conditions described below.

### BLACKER JUNIOR SCHOLARSHIPS

An endowment fund for undergraduate and graduate students, known as the Robert Roe Blacker and Nellie Canfield Blacker Scholarship Fund, has recently been given to the Institute. A part of the income of this fund will be used for maintaining three scholarships carrying free tuition during the junior year, to be known as the Blacker Junior Scholarships. These scholarships are awarded to members of the sophomore class on the basis of a competition of the character described below.

### SOPHOMORE AND JUNIOR TRAVEL PRIZES

Two Travel Prizes, one available for a sophomore and the other for a junior student, have been established through the liberality of an anonymous donor, in order to emphasize the educational value of travel as a means of broadening the student's cultural and professional viewpoints.

The Sophomore Travel Prize carries an award of $400, and is to be used for a tour through the eastern

states during the vacation between the sophomore and junior years, in which leading manufacturing works, government establishments, and universities will be visited. The Junior Prize carries an award of $900, and is to be used for a trip to Europe during the vacation between the junior and senior years. These tours are to be planned in consultation with the Travel Prize Committee of the Faculty, or with the Department in which the student takes his major work. The winners of the prizes will be expected to keep a diary of their experiences, and upon their return to file with the Institute a summarized report of their travels, and to present in as interesting a manner as possible an account of their experiences, at an Assembly of the student body.

### CONDITIONS OF THE COMPETITION FOR THE PRIZE SCHOLARSHIPS AND TRAVEL PRIZES

In regard to the competition for the Sophomore and Junior Scholarships, and for the Sophomore and Junior Travel Prizes, the Faculty has adopted the following regulations:

(a) Those students of the respective classes are eligible to compete for these scholarships and prizes who, during the three terms preceding the time when the award is made, have obtained 480 credits. (b) The selection from among the students so eligible of those to whom the awards are to be made shall be based not primarily on formal scholastic standing, but in larger measure on an estimate of the personal qualities essential to success in a scientific or professional career. (c) As a partial basis for this estimate individual opinions as to the personal qualities of the competitors will be obtained

from their instructors, and from other members of their own sections; and as a further basis for this estimate such competitive examinations (testing original thinking and scientific initiative), demonstration lectures, preparation of essays or monographs, or other means will be employed as may be determined by the Committee on Scholarships and Travel Prizes.

### THE CONGER PEACE PRIZE

Everett L. Conger, D.D., for the promotion of interest in the movement toward universal peace and for the furtherance of public speaking, established in 1912 the Conger Peace Prize. The income from one thousand dollars is given annually as a prize for the composition and delivery in public of the best essay on some subject related to the peace of the world. The general preparation for the contest is made under the direction of the Department of English.

# Graduate Study and Research

## REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE

Candidates for the Master's degree in either pure or applied science must complete, in residence at the Institute, one year's graduate work, consisting of not less than 150 units (1,500 hours). Of this, not less than one-fourth must consist of research; and not more than one-fourth may consist of subjects included in that undergraduate course of the Institute which pertains to that branch of science in which the graduate study is to be pursued. Although the credit for undergraduate work is thus limited, graduates of other colleges will be expected to become proficient in all of the more important subjects of the corresponding undergraduate course, of which they have not previously had substantial equivalents; and, in case such deficiencies amount to more than 40 units, candidates must expect to devote more than one college year to the work for the Master's degree. All candidates are required to pass, in addition to the examinations on the courses they are taking, general examinations in their main subject or in important branches of it.

The course of study of each candidate will be in charge of the department in which the student is registered. Candidates, at the beginning of the school year, should submit to the department for approval the detailed program of study and research which they desire to pursue.

The candidate is required to present, at least two weeks before the degree is to be conferred, two type-

written copies of a satisfactory thesis describing his research. He may also be required to prepare from the literature a monograph upon some topic of research interest, and submit it to the department concerned.

### REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

The degree of Doctor of Philosophy is conferred by the Institute in recognition of breadth of scientific attainment and of the power to investigate scientific problems independently and efficiently, as exhibited by the candidate during his period of graduate work. While the degree is not awarded for the completion of definite courses of study continued through a stated term of residence, the advanced study and research must in general be pursued for at least three full college years. Advanced work done at other institutions will be given due credit, but not less than one year must be spent in residence at the Institute.

Each student working for the Doctor's degree will be in charge of the department in which he is registered, which will exercise general oversight of his work; and at the beginning of each school year the candidate should submit to the department his program of study and research for that year.

The work for the degree must consist mainly of scientific research, and of the preparation of a thesis describing it, which must be presented at least two weeks before the degree is to be conferred. This must be supplemented, however, by systematic studies of an advanced character in some branch of science or engineering, which will be termed the *major subject* of the candidate. Thus, physics, chemistry, mathematics, or engineering may be chosen as the major subject. In addition, as *minor sub-*

*ject* (or subjects) studies such as will give a fundamental knowledge and research viewpoint must be pursued in at least one other branch of science or engineering. The choice and scope of the minor subject must be approved in each case by the department in charge of the course of study. The minor subject must involve not less than 45 units of advanced study. In addition, the candidate must have acquired the power of expressing himself clearly and forcefully, both orally and in written language, and he must have a good reading knowledge of French and German.

Proficiency in the major and minor subjects, which includes the power to use them effectively, will be tested by examinations, which may be written, or oral, or both, at the discretion of the department concerned.

### ASSISTANTSHIPS AND FELLOWSHIPS

The Institute offers a large number of Assistantships and Fellowships, carrying salaries ranging from $500 to $1,000 for ten months' service. The tuition for such Assistants and Fellows is $150.

The primary object of these appointments is to give to a group of well-qualified men a training in chemical and physical research which will prepare them for university teaching and research, and for the many important positions in scientific and industrial research laboratories and in development departments of American industries.

Teaching Assistants and Fellows will devote not more than fifteen hours a week to instruction of a character that will afford them useful experience. This time includes that required in preparation and in marking note books and papers, as well as that spent in class-

room and laboratory. Of the remaining time, at least one-half must be devoted to research; and the obligation to prosecute this earnestly is regarded as no less binding than that of showing proper interest in the teaching. Advanced courses of study may also be pursued, so far as time permits.

In general, only those men will be appointed Fellows who have had experience equivalent to that required for the Master's degree at a college or university of recognized standing, and who intend to carry on work for the Ph.D. degree. Students who have completed thorough undergraduate courses in chemistry and physics, and also courses in mathematics through calculus, and who have already demonstrated their interest and resourcefulness in scientific work may, however, be appointed Assistants with a salary which varies with the competence of the man, and the character of the work which he pursues. Assistants who show ability in research, and are satisfactory teachers, may be promoted to Fellowships the second year. In cases where the success of the research justifies it, Assistants and Fellows may be relieved from teaching in order to devote all their time to research.

In regard to the opportunities of working for advanced degrees afforded Fellows and Assistants, see pages 67-74.

### THE DUPONT FELLOWSHIP IN CHEMISTRY

This Fellowship, established by the DuPont Powder Company of Wilmington, Delaware, carrying a grant of $750, is awarded by the faculty to the graduate student in Chemistry or Chemical Engineering who gives the greatest promise of original productive work in these sciences in the future.

# Advanced and Graduate Courses

## STAFF

The following members of the Faculty will give graduate courses during the year 1924-1925:

Robert Andrews Millikan, Ph.D., Sc.D., Director of the Norman Bridge Laboratory of Physics.

Arthur Amos Noyes, Ph.D., LL.D., Sc.D., Director of the Gates Chemical Laboratory.

Harry Bateman, Ph.D., Professor of Mathematics, Theoretical Physics, and Aeronautics.

Stuart Jeffery Bates, Ph.D., Professor of Physical Chemistry.

Robert L. Daugherty, A.B., M.E., Professor of Mechanical and Hydraulic Engineering.

Paul Ehrenfest, Ph.D., Research Associate in Physics (1923-24).

Paul Sophus Epstein, Ph.D., Professor of Theoretical Physics.

Royal Wasson Sorensen, B.S. in E.E., Professor of Electrical Engineering.

Franklin Thomas, C.E., Professor of Civil Engineering.

Richard Chace Tolman, Ph.D., Professor of Physical Chemistry and Mathematical Physics.

James Hawes Ellis, Ph.D., Associate Professor of Physical-Chemical Research.

Earnest Charles Watson, Ph.B., Associate Professor of Physics.

Luther Ewing Wear, Ph.D., Associate Professor of Mathematics.

William Noel Birchby, M.A., Instructor in Mathematics.

Roscoe Gilkey Dickinson, Ph.D., Research Associate in Chemistry.

## COURSES

101. Vector Analysis.—In this course the fundamental operations of vector analysis are developed, using the notation of Gibbs, and the use of the analysis is illustrated by means of examples in mechanics and other branches of mathematical physics. Complex quantities are also represented by vectors and some geometrical applications are indicated. First term. (Bateman) **(15 units)**

102. Definite Integrals.—In this course the definite integral will be rigorously defined, and such fundamental topics as line integrals, surface integrals, Green's Formula, functions defined by integrals, will be considered. Prerequisites: Ma. 8 a, b, c, 10 a, b, c. First term. (Birchby) (9 units)

103 a, b. Functions of a Complex Variable.—This course treats of complex numbers, their algebraic combinations and geometric representations; rational functions of a complex variable and their conformal representations; continuities, derivatives, integrals, series developments, periodicity, and conformal representations of single valued and many valued analytic functions. Prerequisites: Ma. 8 a, b, c, 10 a, b, c; 102. First, second and third terms. (Bateman) (9 units each term)

104 a, b, c. Differential Geometry.—In this course geometrical ideas gained in previous courses will be extended, and the methods of the calculus applied to twisted curves and surfaces. Prerequisites: Ma. 8 a, b, c, 10 a, b, c. (Wear) (6 units each term)

110. Kinetic Theory.—Presents the modern aspects of the kinetic theory of gases, liquids, and solids largely from the experimental point of view, covering in gases the Clausius equations, Maxwell distribution law, viscosities, specific heats, mean free paths, molecular magnitudes, etc.; in liquids, critical states, Brownian movements, diffusion, osmotic pressure; in solids, the interpretation of the specific heat relations. Prerequisites: Ph. 1 a, b, c; Ma. 6 a, b, c. First term. (Millikan or Epstein) (15 units)

111. Thermodynamics.—Development of the Classical Theory, Entropy, etc. Application to gases, perfect and imperfect, and to vapors. Radiation theory (the general development of the classical theory up to Wien's Law). Elements of Phase Rule and Chemical Equilibrium. Prerequisites: Ph. 1 a, b, c; Ma. 6 a, b, c. Second term. (Millikan) (15 units)

114. ELECTRON THEORY.—A course of graduate lectures covering the subjects of ionic mobilities, electronic properties, thermionic and photoelectric phenomena, the electronic theory of thermoelectric currents, X-ray spectra, radioactivity, etc. Prerequisites: Ph. 1 a, b, c; Ma. 6 a, b, c. Third term. (Millikan or Epstein) (15 units)

115. STATISTICAL MECHANICS.—Discussion of the general principles underlying the statistical interpretation of entropy. Comparison of the points of view taken by Boltzmann and by Gibbs. Equipartition of energy.—Prerequisites: Ph. 1 a, b, c; 12 a, b; Ma. 8 a, b, c; 10 a, b, c. First term. (Epstein) (6 units)

(Not given in 1924-1925.)

116. ROENTGEN-RAYS AND CRYSTAL STRUCTURE. Discovery of X-rays and early investigations on them. Diffraction by gratings and space lattices. Intensity of reflected X-rays in its dependence on various factors. Various methods of X-ray analysis. Introduction to the theory of space groups. Prerequisites: Ph. 1 a, b, c; 20 a, b; Ma. 8 a, b, c; 10 a, b, c. First term. (Epstein) (6 units)

(Not given in 1924-1925.)

120. HYDRODYNAMICS.—Commences with a derivation of the equation of continuity and the equations of motion and includes studies of some simple cases of steady motion, vortex motion and of flow past an obstacle. Special attention is given to the theories of resistance based on the ideas of discontinuous flow and of the periodic formation of vortices. Prerequisites: Ma. 8 a, b, c. Third term. (Bateman) (15 units)

121. POTENTIAL THEORY.—An exposition of the properties of the potential functions occurring in the theories of gravitation, electricity and magnetism, hydrodynamics, conduction of

heat, and the theory of elasticity. Solution of special problems. Prerequisites: Ma. 8 a, b, c; 101. Second Term. (Bateman) (15 units)

122 a, b. THEORY OF ELECTRICITY AND MAGNETISM.—Electrostatics, electric currents, magnetostatics, ferromagnetism, electromagnetic field of stationary currents, electromagnetic induction, electromagnetic waves, phenomena in moving bodies, introduction to the theory of electrons, electromagnetic momentum, retarded potentials, stationary motion of electrons, radiation from electrons. Prerequisites: Ph. 1 a, b, c, 7 a, b, 8 a, b; Ma. 8 a, b, c. First term. (Epstein) (15 units)

125. HIGHER DYNAMICS.—Methods of solution of the Hamiltonian equations, conditionally periodic motions, contact transformations, introduction to the theory of perturbations, applications to special cases of interest in atomic theory and the theory of quanta. Prerequisites: Ph. 1 a, b, c, 12 a, b, 15 a, b; Ma. 8 a, b, c, 10 a, b, c. Third term. (Epstein) (15 units)

126. HEAT RADIATION AND QUANTUM THEORY. Historical treatment of the development of the mathematical theory of heat radiation and of the application of the theory of quanta to the phenomena of specific heats of solid and gaseous bodies, photoelectricity, photochemistry, chemical constants, etc.—Prerequisites: Ph. 1 a, b, c; 7 a, b, c; 12 a, b, c; Ma. 8 a, b, c; 10 a, b, c. Second term. (Epstein) (15 units)

127. PHYSICAL OPTICS AND QUANTUM THEORY OF SPECTRAL LINES. Treatment of dispersion and optical activity on the basis of the classical theory. Rutherford's atom model and the application of the quantum theory to it. Action of magnetic and electric fields on the emission of spectral lines.

X-ray spectra and the structure of atoms. Prerequisites: Ph. 1 a, b, c; 20 a, b; 12 a, b; Ma. 8 a, b, c; 10 a, b, c. Third term. (Epstein) (15 units)

(Not given in 1924-1925.)

128 a, b, c. PARTIAL DIFFERENTIAL EQUATIONS OF MATHEMATICAL PHYSICS.—Theory of the three fundamental equations of mathematical physics: the equation of potential, the equation of heat conduction and the wave-equation. Treatment of Fourier series, Fourier integrals, spherical and cylindrical harmonics. Applications to numerous physical problems. Prerequisites: Ph. 1 a, b, c, 12 a, b; Ma. 8 a, b, c, 10 a, b, c. Throughout the year. (Epstein) (9 units each term)

(Not given in 1924-1925.)

130. STRESS ANALYSIS FOR AIRPLANES AND DIRIGIBLES.—Determination of the stresses in spars, ribs, bracing wires and fuselage for an airplane in various types of flight. Discussion of the stresses in the framework of a dirigible balloon. Strength of materials used in aircraft construction. Prerequisites: Ph. 1 a, b, c; Ma. 6 a, b, c. Second term. (Bateman) (15 units)

131. AERODYNAMICS.—Stability of airplanes, dirigible balloons and parachutes. Free and forced oscillations, effects of a gust. Solution of the algebraic equations occurring in the theory of stability and determination of the nature of their roots. Use of graphical methods. Prerequisites: Ph. 12 a, b; Ma. 8 a, b, c, 10 a, b, c. Third term. (Bateman) (15 units)

132. AEROLOGY.—Variation with altitude of the pressure, wind velocity, temperature and humidity. General circulation of the atmosphere. Prevailing winds. World's air routes. Studies relating to clouds, fogs, thunderstorms and atmospheric eddies. Atmospheric electricity; airplane photography. Instruments for use on aircraft. Prerequisites: Ph. 1 a, b, c; Ma. 6 a, b, c. Third term. (Bateman) (15 units)

135. Introduction to Mathematical Physics.—Deductive methods in physical science. The nature of the measurable quantities of physics. The nature of the equations of mathematical physics. The principle of dimensional homogeneity. The principle of similitude or relativity of size. The relativity of motion. Hamilton's principle. The principles of mechanics, electromagnetics, and thermodynamics. First term. (Tolman) (6 units)

136. Introduction to the Theory of Relativity.—Elementary development of the relativity of motion in free space. Simple applications to mechanical and electromagnetic problems. Use of four dimensional language for expressing the results of relativity. Extension to space in the neighborhood of matter. The theory of gravitation. Third term. (Tolman) (6 units)

150. Statistical Mechanics Applied to Physical Chemical Problems.—The equations of motion in the Hamiltonian form. Liouville's theorem. The Maxwell-Boltzmann distribution law. Application of statistical mechanics to the theory of matter, and of the hohlraum. Application to the theory of rate of chemical reaction. Relation between statistical mechanics and thermodynamics. Second term. (Tolman) (6 units)

151. Advanced Thermodynamics Applied to Physical Chemical Problems.—The first, second and third laws of thermodynamics. The concepts of energy, entropy, free energy, thermodynamic potential and fugacity. Practice in the calculation of chemical equilibria from thermal and thermodynamic data. Second term. (Tolman) (6 units)
(Not given in 1924-1925.)

152. Surface and Colloid Chemistry.—Lectures and classroom discussions with outside reading and problems, devoted

to the general principles relating to surface-tension, absorption, contact catalysis, and to disperse systems and the colloidal state. Third term. (8 units)

153. THERMODYNAMIC CHEMISTRY.—Lectures and class-room exercises on the applications of the laws of thermodynamics to the equilibrium of chemical reactions and to the electromotive force of voltaic cells. The subject is considered from the free-energy standpoint, and at the close of the course practice is given in the computation of the free-energies of typical substances upon the basis of experimental data to be gathered from the literature. Text-book, Noyes and Sherrill's "Chemical Principles." Second term. (Bates) (9 units)

160. ADVANCED WORK IN ENGINEERING.—Special problems in the various engineering courses will be arranged to meet the needs of students wishing to do advanced work in these departments. (Daugherty, Sorensen, Thomas)

170-174.—CHEMICAL RESEARCH.—Opportunities for research are offered to graduate students in all the main branches of chemistry, namely, in analytical or inorganic chemistry (170), physical chemistry (171) organic chemistry (172), applied chemistry (173), and biochemistry (174). The main lines of research now in progress in these fields are as follows:

Systematic qualitative analysis of the rare elements.

Properties of ionized substances in relation to the interionic attraction theory.

Free energies and electrode-potentials of chemical substances.

Rates of chemical reactions in relation to the quantum theory.

Crystal structure determined by X-ray methods.

Catalytic mechanism of heterogeneous reactions.

Organic reactions in relation to the electron theory.

Properties and chemical nature of insulin.

175. Research Conferences in Physics.—Meets twice a week for report and discussion of the work appearing in the literature and that in progress in the laboratory. All advanced students in physics and members of the physics staff are expected to take part. (Millikan, Bateman, Epstein, Tolman, Watson) (4 units each term)

177. Seminar in Physical Chemistry.—This course consists in the discussion, under guidance of different members of the Chemistry staff, of various topics concerned with recent advances in physical chemistry. During the year 1923-1924 the relations of atomic structure to chemical phenomena are being discussed. The subject for 1924-1925 will be announced later. Throughout the year. (Noyes, Tolman, Bates, Ellis, Dickinson) (6 units each term)

178. Research Conferences in Chemistry.—This subject consists of reports on the researches in progress in the laboratory and on related ones which have appeared in the literature. These conferences are participated in by all men engaged in research in the laboratory. Throughout the year. (Noyes) (2 units each term)

Astronomy and Physics Club.—This club is a cooperative enterprise carried on by the physicists of the Institute and those of the Mount Wilson Observatory. This group of from thirty to forty physicists meets every week at either the Institute or the Mount Wilson laboratory for the discussion of the researches carried on by its members, as well as of those appearing in the physical journals.

# Undergraduate Courses

GENERAL PLAN OF INSTRUCTION*

The curriculum of the Institute is designed to graduate at the end of four years men who can enter with credit the profession of engineering or the field of pure science. In furtherance of this purpose it lays particular emphasis on two principles that have been found to be of primary importance: first that discipline in certain liberal studies is not only ideally desirable but practically necessary; and second that a thorough training in mathematics, physics, and chemistry must precede the application of those sciences. The severance of scientific from liberal education is considered mistaken, and the Institute aims to integrate the two phases into a whole that more nearly approaches the ideal education.

The knowledge of English usage in oral and written expression; some perception of the finer imaginative quality of the human mind displayed in literature; an appreciation of historical development, political, social, and economic; and an insight into current events the world over: these are necessary to every man who is to take an important place in the world of work. Added to these marks of the educated man are the information gained from scientific text-books and lectures; the technique of expression and design learned in the drafting-room; precision acquired in using instruments in the laboratory and in the field; the knowledge of physical properties and limitations discovered in the experimental laboratories; the impetus toward research fos-

*See announcement of new undergraduate and fifth-year courses, page 101.

tered by enthusiastic directors; in short a realization of the possibilities of science in an age of scientific progress.

The first two years are given over to a common training; thereafter the more diversified specialization is provided. A student is thereby given a chance to determine more intelligently than he could at entrance just what work he can best undertake, but, what is more important, he is brought to see the essential unity of the applied sciences. Class work is conducted in small sections, ordinarily of not more than twenty men, an arrangement which allows each student an unusual amount of individual attention.

Besides the curriculum there are provided educational advantages no less desirable. The library contains all the notable scientific periodicals, the most valuable books on science, and carefully selected books and magazines in other fields. Weekly assemblies are held which are addressed by men whose theories or experiences enable them to contribute something of value. Inspection trips are organized for visits to the most modern factories, to oil-fields and refineries, to hydro-electric plants, and to other engineering projects; the accessibility of these examples of scientific development, and the generous assistance of their managers and superintendents make possible to the student a valuable object lesson in the application of theory.

The engineering profession includes three types of functions, the general character of which is roughly indicated by the terms: (1) Construction and operating engineering; (2) administrative engineering; and (3)

engineering development and research. The Institute originally provided for the first of these types, which meets the needs of the largest number of engineering students, by its courses in Mechanical, Electrical, Civil, and Chemical Engineering. Somewhat later it provided for the second type by establishing a course in Engineering and Economics, which aims to prepare students to take business and administrative positions in manufacturing and transportation enterprises based largely on engineering. Later, as a result of the fuller development of its instruction in physics, chemistry, and mathematics, it announced three other courses, corresponding to the third type of engineering function, which is so vital to the development of our industries and commerce.

The Institute offers advanced courses leading to the degrees of Master of Science and Doctor of Philosophy. See page 63. Definite provision has been made for such advanced work, especially in the sciences of physics, chemistry, mathematics, and aeronautics.

The Institute also makes provision for students who desire to prepare themselves for teaching in higher institutions and for scientific research in universities or in governmental or industrial laboratories. The courses in Physics and Engineering and in Physics provide satisfactory training for those who specialize in physics. A separate course in Chemistry is offered to meet the needs of those who desire to pursue this subject on the scientific side and wish to replace the engineering subjects of the course in Chemical Engineering by additional physics, mathematics, and research.

ELECTRICAL, MECHANICAL, AND CIVIL ENGINEERING

The fundamental scientific principles are the same for Electrical, Mechanical, and Civil Engineering. Narrow specialization on the part of undergraduates is not encouraged for the reason that necessary fundamental subjects would be omitted thereby and such specialization often might be misplaced. The desire is rather to lay first a broad and deep foundation in the subjects forming the basis of engineering. After two years devoted to thorough preparation in Mathematics, Physics, Chemistry, Drawing, English and History, the student may choose his course according to his aptitude and ambition. Electrical Engineering deals with the generation, transmission, and utilization in many ways of electrical energy. Mechanical Engineering relates to problems of heat, power, design of machinery, and to problems of manufacture. Civil Engineering comprises the design and construction of stationary structures involved in engineering projects. The professional courses in these three branches necessarily diverge more or less in the later years, each laying particular emphasis on subjects peculiar to itself. On the other hand, there are many subjects in the advanced years common to all three branches, for the Electrical, Mechanical, and Civil Engineering students all take courses in Surveying, Mechanism, Applied Mechanics, Strength of Materials, Hydraulics, Geology, Accounting, Electrical Engineering, Heat Engines, and Testing Materials Laboratory. It is the aim of the curriculum during the last two years to link up and definitely correlate the different fundamental studies

with their varied applications to engineering science. Schedules of these courses are printed on pages 86-90.

### ENGINEERING AND ECONOMICS

This course should not be confused with the courses in commerce offered by various universities and colleges. Engineering is its basis, students taking four-fifths of the subjects offered in the engineering courses described on pages 86-90, the remainder of their time being devoted to a scientific study of the principles of commerce and industry. It is designed to provide adequate education for students who, while desiring a systematic training in the applied sciences, have interests and aptitudes which fit them for positions on the business side of manufacturing and transportation enterprises, rather than for specialized engineering.

The course includes (1) the instruction common to all courses, in literature, science, and mathematics; (2) an assignment of engineering studies in one of the three groups: Electrical, Mechanical, or Civil Engineering; and (3) a selected group of subjects in economics and business. The subjects in group (3) may be briefly described as follows:

Economics, being fundamental to all that follows, provides a general survey of the principles governing the production, distribution, and consumption of wealth; while the study of Economic History acquaints the student with economic problems and forces as affecting the development of the United States of America. Business Law is designed to provide such knowledge of the law as will give a general understanding of legal rights and duties in ordinary circumstances. Instruction in Financial Organization, Accounting and Statistics, Taxa-

tion and Corporate Finance deals thoroughly with the broad outlines and fundamental principles of these several subjects. The work in Business Administration is designed to give students a general training in the fundamentals of scientifically managed and organized business. It deals with business both from the productive and the distributive sides, and includes a discussion of the application of scientific ideas to such subjects as corporation management, office management, purchasing and sales organization, as well as location of plants and industries, routing of materials, wages systems, and welfare organization. Students will be required to inspect factories or businesses in operation, in order to describe and criticise the methods they observe. An historical and critical study of the evolution of our social and economic organization is required, the class being conducted in the form of a seminar, with each student taking part in the discussions.

The schedule of this course is given on pages 86, 87, 91, and 92.

### PHYSICS AND ENGINEERING

The course in Physics and Engineering aims to prepare men for research positions in the laboratories and development departments of large manufacturing companies, and in educational and governmental institutions. Such positions are being created in constantly increasing numbers, owing to the rapidly growing recognition of the importance of research.

For the creative work which such positions require there is demanded a considerably more thorough grounding in mathematics, physics, and chemistry than it has been customary to give in the usual course in engineering.

The course in Physics and Engineering aims to give this fundamental training, in addition to furnishing the requisite amount of engineering work.

Two principal options are possible which allow a greater or less amount of practical engineering work to be elected by the student as he finds his bent to be more towards industrial research or pure science. For further information see the course schedules on pages 86, 93, 94, and 95.

### PHYSICS

The course in Physics carries still further the replacement of the more technical engineering work by additional mathematics, physics, chemistry, and research. It aims to afford the able student a training in the more refined mathematical and physical aspects of engineering, and to prepare him to enter upon more purely scientific research in either our universities and colleges, or other research institutions. It aims, in addition, to give the student a thorough grounding in the fundamentals of mathematics, physics, and chemistry, and to surround him with the atmosphere of research from his junior year on.

The course affords excellent preparation for graduate work. Such advanced work is highly advisable; for to give the broad cultural training, the intensive grasp of fundamentals, and the practical engineering knowledge which is demanded by the man whose life is to be devoted to creative work in Physics and Engineering clearly requires more time than is available in the undergraduate engineering course.

A considerable portion of the last two years' work is left elective, and several options are possible, so that the

student may be free to follow his own bent. The schedules will be found on pages 86, 93, 96, and 97.

### CHEMICAL ENGINEERING

The course in Chemical Engineering is of a type somewhat distinct from the other engineering courses. Chemical industry differs from the industries based on Mechanical, Electrical, and Civil Engineering, in that its operations and processes have not become standardized to nearly the same extent. The chemical engineer cannot, therefore, be merely an engineer of the operating type, with a combined knowledge of chemical processes and engineering operations. He constantly has to deal with development and research problems; and to that end he must have a thorough working knowledge of the principles of chemistry, physics, mathematics, and some training in research. Even though this may make it necessary to limit his study of engineering to its general methods and principles, his fundamental training in the underlying sciences will enable him to acquire rapidly in the works the additional technical knowledge he needs, while enabling him to attack new problems and meet difficulties far more effectively. The course in Chemical Engineering, therefore, fits men both for the operating side and for the development or research side of chemical industries.

### CHEMISTRY

The course in Chemistry includes all the chemical subjects in the course in Chemical Engineering, but omits the engineering subjects. In place of these are introduced advanced mathematical and physical subjects and additional time for research. It is intended to pre-

pare able students for university teaching, scientific research, and expert work in chemistry; and also to fit them for industrial research positions in which a thorough knowledge of both chemistry and physics is of more importance than a knowledge of chemistry combined with that of engineering. Men with such a training are especially needed in the research laboratories of many large chemical, metallurgical, and electrical companies.

### GENERAL COURSES

General Courses are provided primarily for those who may desire a thorough collegiate education in which science predominates, but with a generous admixture of other cultural studies, all of which are pursued according to the standards and with the thoroughness of a professional school. They also afford an opportunity for students who plan to become teachers of science, or who may desire scientific preparation for a business career.

Students in General Courses must take all the required work common to all courses. The remainder of their work is elective, varying in accordance with their respective plans and requirements. This work must be arranged subject to the approval of the faculty so as to form a consistent whole.

### REQUIREMENTS FOR GRADUATION

For graduation students must complete such work as is prescribed by the faculty for their several courses, amounting to approximately 600 units; and must maintain such standing as will give them 1080 credits (see page 51). Students who make 1620 credits will be graduated with honor.

A student must file with the Registrar a declaration of his candidacy for the degree of Bachelor of Science on or before the second Monday of January preceding the date at which he expects to receive the degree. His record at that time must show that he is not more than 30 units behind the requirement in the regular work of his course. All subjects required for graduation, with the exception of those for which the candidate is registered during the last term of his study, must be completed by the second Monday of May preceding commencement.

# Schedules of Undergraduate Courses

The schedules presented in the following pages are those offered to classes that entered the Institute in 1920 to 1923. For classes entering in 1924 and thereafter the newly adopted plan of instruction described on pages 101-103 will be in effect.

### EXPLANATION OF TERMS

Subjects are designated by numbers attached to the departmental abbreviations, which are as follows:

| | |
|---|---|
| Aeronautics | A. |
| Applied Mechanics | Me. |
| Chemistry | Ch. |
| Civil Engineering | C. |
| Drawing | D. |
| Economics and History | Ec. |
| Electrical Engineering | E. |
| English | En. |
| Geology | Ge. |
| Hydraulics | H. |
| Mathematics | Ma. |
| Mechanical Engineering | M. |
| Military | Mi. |
| Modern Languages | L. |
| Physical Education | PE. |
| Physics | Ph. |
| Shop | Sh. |
| Supplementary Subjects (Orientation and Journals) | SS. |
| Thesis | Th. |

Subjects to which an asterisk is prefixed are open only to students in honor standing. They may be substituted for required subjects, as shown in the schedules, or for other required subjects with the approval of the department concerned. Only a few such special courses are

provided in the first and second years, since freshman and sophomore students in honor standing are grouped in sections by themselves, and these sections are given more advanced work adapted to their abilities.

The number of units given in each term for any course is the total number of hours per week required in that course, including class and laboratory work and the estimated time for preparation.

The year is divided into three terms. The normal work of a term amounts to forty-eight units, exclusive of physical education and of the field work of Military Science and Tactics.

## ALL COURSES

### FIRST YEAR

| SUBJECTS | Subject Number | Hours per Week | | | Units |
|---|---|---|---|---|---|
| | | Class | Lab. | Prep. | |
| REQUIRED (Throughout the Year) | | | | | |
| English and History | En. 1 a, b, c. | 3 | 0 | 6 | 9 |
| Physics | Ph. 2 a, b, c. | 3 | 2 | 4 | 9 |
| Chemistry | Ch. 1 a, b, c. | 3 | 6 | 3 | 12 |
| Mathematics | Ma 1 a, b, c. | 3 | 0 | 6 | 9 |
| Orientation | SS. 1 a, b, c. | 1 | 0 | 0 | 1 |
| Drawing | D. 1 a, b, c. | 0 | 3 | 0 | 3 |
| Drawing | D. 1d, 2 a, b. | 0 | 3 | 0 | 3 |
| or Shop | Sh. 1-4 | 0 | 4 | 0 | 4 |
| Physical Education | PE. | 0 | 3 | 0 | 3 |
| Military Science | Mi. 1 a, b, c. | 1 | 2 | 1 | 4 |
| *Elementary Analysis (3rd Term) | Ma. 5 | 2 | 0 | 2 | 4 |
| SUMMER (FIRST THREE WEEKS)[1] | | | | | |
| Shop | Sh. 1-4 | 0 | 4 | 0 | 4 |
| or Drawing | D.1d, 2 a,b. | 0 | 3 | 0 | 3 |

[1]Students who present satisfactory evidences of proficiency in either of these subjects or who are excused from an equivalent number of units of other subjects may complete both drawing and shop during the school year.

## SECOND YEAR

### ELECTRICAL, MECHANICAL, AND CIVIL ENGINEERING, AND ENGINEERING AND ECONOMICS

| SUBJECTS | Subject Number | Hours per Week | | | Units | |
|---|---|---|---|---|---|---|
| | | Class | Lab. | Prep. | E M | C |
| **1ST TERM** | | | | | | |
| English and History | En. 4 a | 2 | 0 | 4 | 6 | 6 |
| Calculus | Ma. 6 a | 4 | 0 | 8 | 12 | 12 |
| Physics | Ph. 2 d | 3 | 2 | 4 | 9 | 9 |
| Mechanism | M. 1 | 3 | 3 | 3 | 9 | 9 |
| Surveying | C. 1 a | 2 | 3 | 2 | 7 | 7 |
| Machine Drawing | D. 5 | 0 | 3 | 0 | 3 | 3 |
| Military Science and Tactics | Mi. 4 a | 1 | 2 | 1 | 4 | 4 |
| Physical Education | PE. | 0 | 2 | 0 | 2 | 2 |
| **2ND TERM** | | | | | | |
| English and History | En. 4 b | 2 | 0 | 4 | 6 | 6 |
| Calculus | Ma. 6 b | 4 | 0 | 8 | 12 | 12 |
| Physics | Ph. 2 e | 3 | 2 | 4 | 9 | 9 |
| Applied Mechanics | Me. 1 a | 4 | 0 | 8 | 12 | 12 |
| Mechanism | M. 2 | 2 | 3 | 2 | 7 | .. |
| Surveying | C. 1 b | 2 | 3 | 2 | .. | 7 |
| Military Science and Tactics | Mi. 4 b | 1 | 2 | 1 | 4 | 4 |
| Physical Education | PE. | 0 | 2 | 0 | 2 | 2 |
| **3RD TERM** | | | | | | |
| English and History | En. 4 c | 2 | 0 | 4 | 6 | 6 |
| Calculus | Ma. 6 c | 4 | 0 | 8 | 12 | 12 |
| Physics | Ph. 2 f | 3 | 2 | 4 | 9 | 9 |
| Applied Mechanics | Me. 1 b | 4 | 0 | 8 | 12 | 12 |
| Machine Drawing | D. 6 | 0 | 6 | 1 | 7 | .. |
| Surveying | C. 1 c | 2 | 3 | 2 | .. | 7 |
| Military Science and Tactics | Mi. 4 c | 1 | 2 | 1 | 4 | 4 |
| Physical Education | PE. | 0 | 2 | 0 | 2 | 2 |
| *Atomic Structure | Ch. 20 | 3 | 0 | 3 | 6 | .. |

## THIRD YEAR

## ELECTRICAL, MECHANICAL, AND CIVIL ENGINEERING

| SUBJECTS | Subject Number | Hours per Week | | | Units | |
|---|---|---|---|---|---|---|
| | | Class | Lab. | Prep. | E M | C |
| 1ST TERM | | | | | | |
| English and Current Topics | En. 7 a | 3 | 0 | 3 | 6 | 6 |
| Geology | Ge. 1 a | 3 | 0 | 3 | 6 | 6 |
| Strength of Materials | Me. 5 | 4 | 0 | 8 | 12 | 12 |
| Testing Materials Laboratory | Me. 6 a | 0 | 3 | 0 | 3 | 3 |
| Engineering Journals | SS. 10 a | 1 | 0 | 1 | 2 | 2 |
| Direct Currents | E. 2 | 3 | 0 | 5 | 8 | .. |
| Direct Current Laboratory | E. 3 | 0 | 3 | 2 | 5 | .. |
| Graphic Statics | Me. 4 | 1 | 3 | 2 | 6 | .. |
| Railway Engineering | C. 8 a | 3 | 0 | 5 | .. | 8 |
| Theory of Structures | C. 20 a | 3 | 3 | 5 | .. | 11 |
| *Differential Equations (replacing Me. 4 or part of C. 20 a) | Ma. 10 a | 2 | 0 | 4 | 6 | 6 |
| 2ND TERM | | | | | | |
| English and Current Topics | En. 7 b | 3 | 0 | 3 | 6 | 6 |
| Geology | Ge. 1 b | 3 | 0 | 3 | 6 | 6 |
| Testing Materials Laboratory | Me. 6 b | 0 | 3 | 0 | 3 | 3 |
| Hydraulics | H. 1 | 3 | 0 | 5 | 8 | 8 |
| Hydraulic Laboratory | H. 2 | 0 | 3 | 0 | 3 | 3 |
| Machine Design | M. 5 | 2 | 3 | 2 | 7 | 7 |
| Engineering Journals | SS. 10 b | 1 | 0 | 1 | 2 | 2 |
| Alternating Currents | E. 4 | 3 | 0 | 5 | 8 | .. |
| Alternating Current Laboratory | E. 5 | 0 | 3 | 2 | 5 | .. |
| Theory of Structures | C. 20 b | 3 | 0 | 5 | .. | 8 |
| Railway Surveying | C. 8 b | 2 | 0 | 3 | .. | 5 |
| *Differential Equations | Ma. 10 b | 2 | 0 | 4 | 6 | 6 |
| 3RD TERM | | | | | | |
| English and Current Topics | En. 7 c | 3 | 0 | 3 | 6 | 6 |
| Economics | Ec. 2 | 3 | 0 | 3 | 6 | 6 |
| Hydraulic Turbines | H. 5 | 2 | 0 | 3 | 5 | 5 |
| Hydraulic Laboratory | H. 6 | 0 | 3 | 0 | 3 | 3 |
| Engineering Journals | SS. 10 c | 1 | 0 | 1 | 2 | 2 |
| Electrical Machinery | E. 6 | 3 | 0 | 4 | 7 | .. |
| Electrical Laboratory | E. 7 | 0 | 3 | 2 | 5 | .. |
| Thermodynamics | M. 15 | 3 | 0 | 4 | 7 | .. |
| Machine Design | M. 6 | 2 | 3 | 2 | 7 | .. |
| Theory of Structures | C. 20 c | 3 | 0 | 5 | .. | |
| Railway Surveying | C. 8 c | 0 | 6 | 0 | .. | 6 |
| Highway Engineering | C. 4 | 2 | 0 | 3 | .. | 5 |
| Sewerage | C. 10 | 3 | 0 | 4 | .. | 7 |
| *Differential Equations (replacing M. 6) | Ma. 10 c | 2 | 0 | 4 | 6 | 6 |

## FOURTH YEAR

### ELECTRICAL AND MECHANICAL ENGINEERING

| SUBJECTS | Subject Number | Hours per Week | | | Units | |
|---|---|---|---|---|---|---|
| | | Class | Lab. | Prep. | E | M |
| **1ST TERM** | | | | | | |
| English and Current Topics | En. 10 a | 2 | 0 | 4 | 6 | 6 |
| Economic History | Ec. 3 | 1 | 0 | 1 | 2 | 2 |
| Selected Economic Problems | Ec. 4 | 2 | 0 | 2 | 4 | 4 |
| Heat Engines | M. 16 | 3 | 0 | 5 | 8 | 8 |
| Steam Laboratory | M. 25 | 0 | 3 | 2 | 5 | 5 |
| Induction Machinery | E. 22 | 3 | 0 | 6 | 9 | .. |
| Alternating Current Laboratory | E. 21 | 0 | 6 | 0 | 6 | .. |
| Electrical Measurements | Ph. 5 | 1 | 6 | 1 | 8 | .. |
| Heat Engineering | M. 20 | 3 | 0 | 5 | .. | 8 |
| Machine Design | M. 7 | 1 | 6 | 0 | .. | 7 |
| Metallurgy and Heat Treatment | M. 12 | 3 | 0 | 5 | .. | 8 |
| *Analytical Mechanics (replacing M. 20 or M. 12) | Ph. 12 a | 4 | 0 | 8 | .. | 12 |
| **2ND TERM** | | | | | | |
| English and Current Topics | En. 10 b | 2 | 0 | 4 | 6 | 6 |
| Accounting | Ec. 17 | 3 | 0 | 5 | 8 | 8 |
| Power Plant Engineering | M. 17 | 3 | 0 | 5 | 8 | 8 |
| Power Plant Laboratory | M. 26 | 0 | 3 | 4 | 7 | 7 |
| Electric Traction | E. 28 | 4 | 0 | 6 | 10 | .. |
| Alternating Current Analysis | E. 20 | 3 | 0 | 6 | 9 | .. |
| Elements of Civil Engineering | C. 25 | 2 | 3 | 2 | .. | 7 |
| Machine Design | M. 8 | 1 | 6 | 0 | .. | 7 |
| Problems or Elective | Th. 100 | ..... | ..... | ..... | .. | 4 |
| *Analytical Mechanics (replacing Ec. 17 and Th. 100) | Ph. 12 b | 4 | 0 | 8 | .. | 12 |
| *Engineering Research (replacing Ec. 17) | | 0 | 12 | 0 | 12 | .. |
| **3RD TERM** | | | | | | |
| English and Current Topics | En. 10c | 2 | 0 | 4 | 6 | 6 |
| Business Law | Ec. 25 | 3 | 0 | 3 | 6 | 6 |
| Electric Power Transmission | E. 44 | 5 | 0 | 5 | 10 | .. |
| Dielectrics | E. 52 | 2 | 0 | 3 | 5 | .. |
| Specifications and Design of Electric Machines | E. 48 | 0 | 3 | 1 | 4 | .. |
| Electrical Engineering Laboratory | E. 33 | 0 | 3 | 1 | 4 | .. |
| Advanced Alternating Current Machinery | E. 40 | 2 | 0 | 4 | 6 | .. |
| Elements of Civil Engineering | C. 25 | 2 | 3 | 2 | 7 | .. |
| Electric Light and Power Distribution | E. 30 | 2 | 0 | 2 | .. | 4 |
| Mechanical Engineering Laboratory | M. 27 | 0 | 3 | 5 | .. | 8 |
| Machine Design | M. 9 | 1 | 6 | 0 | .. | 7 |
| Power Plant Design | M. 18 | 2 | 6 | 4 | .. | 12 |
| Industrial Plants | Ec. 40 | 2 | 0 | 4 | .. | 6 |
| *Engineering Research (replacing M. 27 M. 9 or M. 18) | | 0 | 12 | 0 | 12 | 12 |

## FOURTH YEAR

## CIVIL ENGINEERING

| SUBJECTS | Subject Number | Hours per Week | | | Units |
|---|---|---|---|---|---|
| | | Class | Lab. | Prep. | |
| 1ST TERM | | | | | |
| English and Current Topics | En. 10 a | 2 | 0 | 4 | 6 |
| Economic History | Ec. 3 | 1 | 0 | 1 | 2 |
| Selected Economic Problems | Ec. 4 | 2 | 0 | 2 | 4 |
| Metallurgy and Heat Treatment | M. 12 | 3 | 0 | 5 | 8 |
| Reinforced Concrete | C. 12 a | 3 | 0 | 5 | 8 |
| Structural Design | C 21 a | 0 | 9 | 0 | 9 |
| Direct Currents | E. 16 | 3 | 0 | 4 | 7 |
| Direct Current Laboratory | E. 3 | 0 | 3 | 2 | 5 |
| *Analytical Mechanics (replacing part of M. 12) | Ph. 12 a | 4 | 0 | 8 | 12 |
| 2ND TERM | | | | | |
| English and Current Topics | En. 10 b | 2 | 0 | 4 | 6 |
| Accounting | Ec. 17 | 3 | 0 | 5 | 8 |
| Alternating Currents | E. 18 | 3 | 0 | 4 | 7 |
| Alternating Current Laboratory | E. 5 | 0 | 3 | 2 | 5 |
| Structural Design | C. 21 b | 0 | 9 | 0 | 9 |
| Masonry Structures | C. 12 b | 2 | 3 | 3 | 8 |
| Problems or Elective | Th. 100 | ..... | ..... | ..... | 5 |
| *Analytical Mechanics (replacing Th. 100) | Ph. 12 b | 4 | 0 | 8 | 12 |
| 3RD TERM | | | | | |
| English and Current Topics | En. 10 c | 2 | 0 | 4 | 6 |
| Business Law | Ec. 25 | 3 | 0 | 3 | 6 |
| Water Supply and Irrigation | C. 15 | 4 | 0 | 6 | 10 |
| Elements of Heat Engineering | M. 21 | 3 | 0 | 3 | 6 |
| Civil Engineering Design | C. 21 c | 0 | 12 | 0 | 12 |
| Problems or Elective | Th. 100 | ..... | ..... | ..... | 7 |
| *Engineering Research (replacing Th. 100) | ..... | 0 | 12 | 0 | 12 |

## THIRD YEAR[1]

## ENGINEERING AND ECONOMICS

| SUBJECTS | Subject Number | Hours per Week | | | Units |
|---|---|---|---|---|---|
| | | Class | Lab. | Prep. | |
| **1ST TERM** | | | | | |
| English and Current Topics | En. 7 a | 3 | 0 | 3 | 6 |
| Geology | Ge. 1 a | 3 | 0 | 3 | 6 |
| Strength of Materials | Me. 5 | 4 | 0 | 8 | 12 |
| Testing Materials Laboratory | Me. 6 a | 0 | 3 | 0 | 3 |
| Direct Currents | E. 16 | 3 | 0 | 4 | 7 |
| Direct Current Laboratory | E. 3 | 0 | 3 | 2 | 5 |
| Engineering Journals | SS. 10 a | 1 | 0 | 1 | 2 |
| Elective | | | | | 7 |
| **2ND TERM** | | | | | |
| English and Current Topics | En. 7 b | 3 | 0 | 3 | 6 |
| Geology | Ge. 1 b | 3 | 0 | 3 | 6 |
| Hydraulics | H. 1 | 3 | 0 | 5 | 8 |
| Hydraulic Laboratory | H. 2 | 0 | 3 | 0 | 3 |
| Engineering Journals | SS. 10 b | 1 | 0 | 1 | 2 |
| Alternating Currents | E. 18 | 3 | 0 | 4 | 7 |
| Alternating Current Laboratory | E. 5 | 0 | 3 | 2 | 5 |
| Accounting | Ec. 16 a | 3 | 0 | 6 | 9 |
| Testing Materials Laboratory | Me. 6 b | 0 | 3 | 0 | 3 |
| **3RD TERM** | | | | | |
| English and Current Topics | En. 7 c | 3 | 0 | 3 | 6 |
| Economics | Ec. 2 | 3 | 0 | 3 | 6 |
| Statistics | Ec. 11 | 1 | 0 | 2 | 3 |
| Engineering Journals | SS. 10 c | 1 | 0 | 1 | 2 |
| Business Law | Ec. 26 a | 3 | 0 | 5 | 8 |
| Financial Organization | Ec. 20 | 3 | 0 | 5 | 8 |
| Accounting | Ec. 16 b | 3 | 0 | 6 | 9 |
| Elective | | | | | 6 |

[1]—For first and second year schedules of this course, see pages 86 and 87.

FOURTH YEAR

ENGINEERING AND ECONOMICS

| SUBJECTS | Subject Number | Hours per Week | | | Units |
|---|---|---|---|---|---|
| | | Class | Lab. | Prep. | |
| 1ST TERM | | | | | |
| English and Current Topics | En. 10 a | 2 | 0 | 4 | 6 |
| Economic History | Ec. 3 | 1 | 0 | 1 | 2 |
| Selected Economic Problems | Ec. 4 | 2 | 0 | 2 | 4 |
| Business Law | Ec. 26 b | 3 | 0 | 5 | 8 |
| Accounting | Ec. 16 c | 3 | 0 | 6 | 9 |
| Business Administration | Ec. 30 a | 3 | 0 | 5 | 8 |
| Corporation Finance | Ec. 34 | 2 | 0 | 4 | 6 |
| Thesis | Th. 100 | ..... | ..... | ..... | 5 |
| 2ND TERM | | | | | |
| English and Current Topics | En. 10 b | 2 | 0 | 4 | 6 |
| Taxation | Ec. 14 | 2 | 0 | 2 | 4 |
| Business Administration | Ec. 30 b | 2 | 3 | 3 | 8 |
| Municipalities | Ec. 37 | 1 | 0 | 2 | 3 |
| Thesis | Th. 100 | ..... | ..... | ..... | 6 |
| Elective | ..... | ..... | ..... | ..... | 21 |
| 3RD TERM | | | | | |
| English and Current Topics | En. 10 c | 2 | 0 | 4 | 6 |
| [1]Business Administration | Ec. 30 c | 3 | 0 | 5 | 8 |
| Thesis | Th. 100 | ..... | ..... | ..... | 10 |
| Elective | ..... | ..... | ..... | ..... | 24 |

1—Beginning with 1924-1925 Industrial Plants Ec. 40 will take the place of Business Administration Ec. 30 c.

## SECOND YEAR

### PHYSICS, PHYSICS AND ENGINEERING *(Physics Option)*, CHEMISTRY, CHEMICAL ENGINEERING

| SUBJECTS | Subject Number | Hours per Week | | | Units |
|---|---|---|---|---|---|
| | | Class | Lab. | Prep. | |
| ALL THREE TERMS | | | | | |
| English and History | En. 4 a, b, c | 2 | 0 | 4 | 6 |
| German | L. 31 a, b, c | 4 | 0 | 6 | 10 |
| Calculus | Ma. 6a, b, c | 4 | 0 | 8 | 12 |
| Physics | Ph. 2 d, e, f | 3 | 2 | 4 | 9 |
| Physical Education | PE | 0 | 2 | 0 | 2 |
| Military Science and Tactics | Mi. 4 a, b, c | 1 | 2 | 1 | 4 |
| Analytical Chemistry[1] | Ch. 11, 12 a, b | 2 | 7 | 2 | 11 |
| 2ND & 3RD TERMS | | | | | |
| *Analytical Chem. Research (replacing part of Ch. 12) | Ch. 70 | 0 | 6-9 | 0 | 6-9 |
| 3RD TERM | | | | | |
| *Atomic Structure | Ch. 20 | 3 | 0 | 3 | 6 |

In the third term Organic Chemistry Ch. 43 is taken in place of Analytical Chemistry Ch. 12 b by students in the Courses in Physics and in Physics and Engineering.

### PHYSICS AND ENGINEERING *(Engineering Option)*

| | | | | | |
|---|---|---|---|---|---|
| ALL THREE TERMS | | | | | |
| English and History | En. 4 a, b, c | 2 | 0 | 4 | 6 |
| German | L. 31 a, b, c | 4 | 0 | 6 | 10 |
| Calculus | Ma. 6 a, b, c | 4 | 0 | 8 | 12 |
| Physics | Ph. 2 d, e, f | 3 | 2 | 4 | 9 |
| Physical Education | PE | 0 | 2 | 0 | 2 |
| Military Science and Tactics | Mi. 4 a, b, c | 1 | 2 | 1 | 4 |
| 1ST TERM | | | | | |
| Mechanism | M. 1 | 3 | 3 | 3 | 9 |
| Machine Drawing | D. 5 | 0 | 3 | 0 | 3 |
| 2ND TERM | | | | | |
| Applied Mechanics | Me. 1 a | 4 | 0 | 8 | 12 |
| 3RD TERM | | | | | |
| Applied Mechanics | Me. 1 b | 4 | 0 | 8 | 12 |
| *Atomic Structure | Ch. 20 | 3 | 0 | 3 | 6 |

## THIRD YEAR

### PHYSICS AND ENGINEERING

| SUBJECTS | Subject Number | Hours per Week | | | Units |
|---|---|---|---|---|---|
| | | Class | Lab. | Prep. | |
| 1ST TERM | | | | | |
| English and Current Topics | En. 7 a | 3 | 0 | 3 | 6 |
| Geology | Ge. 1 a | 3 | 0 | 3 | 6 |
| Scientific German | L. 34 a | 3 | 0 | 3 | 6 |
| Advanced Calculus | Ma. 8 a | 3 | 0 | 6 | 9 |
| Direct Current Machinery | E. 10 | 2 | 0 | 3 | 5 |
| Direct Current Laboratory | E. 3 | 0 | 3 | 2 | 5 |
| *A. Physics Option:* | | | | | |
| Analytical Mechanics | Ph. 12 a | 4 | 0 | 8 | 12 |
| *B. Engineering Option:* | | | | | |
| Strength of Materials | Me. 5 | 4 | 0 | 8 | 12 |
| 2ND TERM | | | | | |
| English and Current Topics | En. 7 b | 3 | 0 | 3 | 6 |
| Geology | Ge. 1 b | 3 | 0 | 3 | 6 |
| Scientific German | L. 34 b | 3 | 0 | 3 | 6 |
| Advanced Calculus | Ma. 8 b | 3 | 0 | 6 | 9 |
| Alternating Current Machinery | E. 12 | 2 | 0 | 3 | 5 |
| Alternating Current Laboratory | E. 5 | 0 | 3 | 2 | 5 |
| *A. Physics Option:* | | | | | |
| Analytical Mechanics | Ph. 12 b | 4 | 0 | 8 | 12 |
| *B. Engineering Option:* | | | | | |
| Hydraulics and | H. 1 | 3 | 0 | 5 | 8 |
| Hydraulic Laboratory | H. 2 | 0 | 3 | 0 | 3 |
| 3RD TERM | | | | | |
| English and Current Topics | En. 7 c | 3 | 0 | 3 | 6 |
| Economics | Ec. 2 | 3 | 0 | 3 | 6 |
| Scientific German | L. 34 c | 3 | 0 | 3 | 6 |
| Advanced Calculus | Ma. 8 c | 3 | 0 | 6 | 9 |
| *A. Physics Option:* | | | | | |
| Physical Optics | Ph. 20 a | 3 | 0 | 6 | 9 |
| Optics Laboratory | Ph. 21 a | 0 | 6 | 0 | 6 |
| Heat Engineering | M. 21 | 3 | 0 | 3 | 6 |
| *B. Engineering Option:* | | | | | |
| Electrical Machinery | E. 6 | 3 | 0 | 4 | 7 |
| Electrical Laboratory | E. 7 | 0 | 3 | 2 | 5 |
| Thermodynamics | M. 15 | 3 | 0 | 5 | 8 |

## FOURTH YEAR

### PHYSICS AND ENGINEERING

| SUBJECTS | Subject Number | Hours per Week | | | Units |
|---|---|---|---|---|---|
| | | Class | Lab. | Prep. | |
| **1ST TERM** | | | | | |
| English and Current Topics | En. 10 a | 2 | 0 | 4 | 6 |
| Economic History | Ec. 3 | 1 | 0 | 1 | 2 |
| Selected Economic Problems | Ec. 4 | 2 | 0 | 2 | 4 |
| French | L. 1 a | 3 | 0 | 3 | 6 |
| Differential Equations | Ma. 10 a | 2 | 0 | 4 | 6 |
| *A. Physics Option:* | | | | | |
| Physical Optics | Ph. 20 b | 3 | 0 | 6 | 9 |
| Optics Laboratory | Ph. 21 b | 0 | 6 | 0 | 6 |
| Electives | | | | | |
| Introduction to Math. Physics *or* | Ph. 15 a | 3 | 0 | 6 | 9 |
| Chemical Principles | Ch. 21 a | 4 | 0 | 6 | 10 |
| *Kinetic Theory | 110 | 5 | 0 | 10 | 15 |
| *Research | ..... | 0 | 15 | 0 | 15 |
| *B. Engineering Option:* | | | | | |
| Heat Engines | M. 16 | 3 | 0 | 5 | 8 |
| Steam Laboratory | M. 25 | 0 | 3 | 2 | 5 |
| Induction Machinery | E. 22 | 3 | 0 | 6 | 9 |
| Alternating Current Laboratory | E. 21 | 0 | 6 | 0 | 6 |
| **2ND TERM** | | | | | |
| English and Current Topics | En. 10 b | 2 | 0 | 4 | 6 |
| French | L. 1 b | 3 | 0 | 3 | 6 |
| Differential Equations | Ma. 10 b | 2 | 0 | 4 | 6 |
| Electricity and Magnetism | Ph. 7 a | 3 | 0 | 6 | 9 |
| Electrical Measurements | Ph. 8 a | 0 | 4 | 2 | 6 |
| *A. Physics Option:* | | | | | |
| Introduction to Mathematical Physics *or* | Ph. 15 b | 3 | 0 | 6 | 9 |
| Chemical Principles | Ch. 21 b | 4 | 0 | 6 | 10 |
| *Thermodynamics | 111 | 5 | 0 | 10 | 15 |
| *Research | ..... | 0 | 15 | 0 | 15 |
| *B. Engineering Option:* | | | | | |
| Alternating Current Analysis | E. 20 | 3 | 0 | 6 | 9 |
| Advanced Electrical Engineering | E. 60 | 2 | 0 | 3 | 5 |
| **3RD TERM** | | | | | |
| English and Current Topics | En. 10 c | 2 | 0 | 4 | 6 |
| French | L. 1 c | 3 | 0 | 3 | 6 |
| Differential Equations | Ma. 10 c | 2 | 0 | 4 | 6 |
| Electricity and Magnetism | Ph. 7 b | 3 | 0 | 6 | 9 |
| Electrical Measurements | Ph. 8 b | 0 | 4 | 2 | 6 |
| Electives | ..... | ..... | ..... | ..... | 15 |
| Chemical Principles | Ch. 21 c | 3 | 0 | 6 | 9 |
| Steam Laboratory | M. 28 | 0 | 3 | 2 | 5 |
| Element of Civil Engineering | C. 25 | 2 | 3 | 2 | 7 |
| Dielectrics | E. 52 | 2 | 0 | 3 | 5 |
| Electrical Engineering Laboratory | E. 33 | 0 | 3 | 1 | 4 |
| Business Law | Ec. 25 | 3 | 0 | 3 | 6 |
| *Electron Theory | 114 | 5 | 0 | 10 | 15 |
| *Research | ..... | 0 | 15 | 0 | 15 |

## THIRD YEAR

### PHYSICS

| SUBJECTS | Subject Number | Hours per Week | | | Units |
|---|---|---|---|---|---|
| | | Class | Lab. | Prep. | |
| 1ST TERM | | | | | |
| English and Current Topics | En. 7 a | 3 | 0 | 3 | 6 |
| Geology | Ge. 1 a | 3 | 0 | 3 | 6 |
| Scientific German | L. 34 a | 3 | 0 | 3 | 6 |
| Advanced Calculus | Ma. 8 a | 3 | 0 | 6 | 9 |
| Analytical Mechanics | Ph. 12 a | 4 | 0 | 8 | 12 |
| Electives | | | | | 9-10 |
| Direct Current Machinery and | E. 10 | 2 | 0 | 3 | 5 |
| Direct Current Laboratory | E. 3 | 0 | 3 | 2 | 5 |
| Chemical Principles | Ch. 21 a | 4 | 0 | 6 | 10 |
| Introduction to Mathematical Physics | Ph. 15 a | 3 | 0 | 6 | 9 |
| 2ND TERM | | | | | |
| English and Current Topics | En. 7 b | 3 | 0 | 3 | 6 |
| Geology | Ge. 1 b | 3 | 0 | 3 | 6 |
| Scientific German | L. 34 b | 3 | 0 | 3 | 6 |
| Advanced Calculus | Ma. 8 b | 3 | 0 | 6 | 9 |
| Analytical Mechanics | Ph. 12 b | 4 | 0 | 8 | 12 |
| Electives | | | | | 9-10 |
| Alternating Current Machinery | E. 12 | 2 | 0 | 3 | 5 |
| Alternating Current Laboratory | E. 5 | 0 | 3 | 2 | 5 |
| Chemical Principles | Ch. 21 b | 4 | 0 | 6 | 10 |
| Introduction to Mathematical Physics | Ph. 15 b | 3 | 0 | 6 | 9 |
| 3RD TERM | | | | | |
| English and Current Topics | En. 7 c | 3 | 0 | 3 | 6 |
| Economics | Ec. 2 | 3 | 0 | 3 | 6 |
| Scientific German | L. 34 c | 3 | 0 | 3 | 6 |
| Advanced Calculus | Ma. 8 c | 3 | 0 | 6 | 9 |
| Physical Optics | Ph. 20 a | 3 | 0 | 6 | 9 |
| Optics Laboratory | Ph. 21 a | 0 | 6 | 0 | 6 |
| Heat Engineering *or* | M. 21 | 3 | 0 | 3 | 6 |
| Chemical Principles *or* | Ch. 21 c | 3 | 0 | 6 | 9 |
| Probability and Least Squares | Ma. 12 | 2 | 0 | 3 | 5 |

## FOURTH YEAR

### PHYSICS

| SUBJECTS | Subject Number | Hours per Week | | | Units |
|---|---|---|---|---|---|
| | | Class | Lab. | Prep. | |
| **1ST TERM** | | | | | |
| English and Current Topics | En. 10 a | 2 | 0 | 4 | 6 |
| Economic History | Ec. 3 | 1 | 0 | 1 | 2 |
| Selected Economic Problems | Ec. 4 | 2 | 0 | 2 | 4 |
| French | L. 1 a | 3 | 0 | 3 | 6 |
| Differential Equations | Ma. 10 a | 2 | 0 | 4 | 6 |
| Physical Optics | Ph. 20 b | 3 | 0 | 6 | 9 |
| Optics Laboratory | Ph. 21 b | 0 | 6 | 0 | 6 |
| Elective | | | | | 9 |
| ELECTIVES: | | | | | |
| Introduction to Mathematical Physics | Ph. 15 a | 3 | 0 | 6 | 9 |
| Definite Integrals | 102 | 3 | 0 | 6 | 9 |
| Organic Chemistry | Ch. 41 a | 3 | 0 | 5 | 8 |
| Organic Chemistry Laboratory | Ch. 46 a | 0 | 6 | 0 | 6 |
| Chemical Principles | Ch. 21 a | 3 | 0 | 6 | 9 |
| Direct Current Machinery | E. 10 | 2 | 0 | 3 | 5 |
| Direct Current Laboratory | E. 3 | 0 | 3 | 2 | 5 |
| *Research | | | | | 9 |
| *Kinetic Theory | 110 | 5 | 0 | 10 | 15 |
| **2ND TERM** | | | | | |
| English and Current Topics | En. 10 b | 2 | 0 | 4 | 6 |
| French | L. 1 b | 3 | 0 | 3 | 6 |
| Differential Equations | Ma. 10 b | 2 | 0 | 4 | 6 |
| Electricity and Magnetism | Ph. 7 a | 3 | 0 | 6 | 9 |
| Electrical Measurements | Ph. 8 a | 0 | 4 | 2 | 6 |
| Elective | | | | | 15 |
| ELECTIVES: | | | | | |
| Introduction to Mathematical Physics | Ph. 15 b | 3 | 0 | 6 | 9 |
| *Thermodynamics | 111 | 5 | 0 | 10 | 15 |
| Organic Chemistry | Ch. 41 b | 3 | 0 | 5 | 8 |
| Organic Chemistry Laboratory | Ch. 46 b | 0 | 6 | 0 | 6 |
| Chemical Principles | Ch. 21 b | 3 | 0 | 6 | 9 |
| Thermodynamic Chemistry | Ch. 22 | 3 | 0 | 6 | 9 |
| Alternating Current Machinery | E. 12 | 2 | 0 | 3 | 5 |
| Alternating Current Laboratory | E. 5 | 0 | 3 | 2 | 5 |
| *Research | | | | | 6-15 |
| **3RD TERM** | | | | | |
| English and Current Topics | En. 10 c | 2 | 0 | 4 | 6 |
| French | L. 1 c | 3 | 0 | 3 | 6 |
| Differential Equations | Ma. 10c | 2 | 0 | 4 | 6 |
| Electricity and Magnetism | Ph. 7 b | 3 | 0 | 6 | 9 |
| Electrical Measurements | Ph. 8 b | 0 | 4 | 2 | 6 |
| Elective | | | | | 15 |
| ELECTIVES: | | | | | |
| *Electron Theory | 114 | 5 | 0 | 10 | 15 |
| Chemical Principles | Ch. 21 c | 3 | 0 | 6 | 9 |
| Organic Chemistry | Ch. 43 | 3 | 6 | 6 | 15 |
| Surface and Colloid Chemistry | Ch. 29 | 3 | 0 | 5 | 8 |
| Steam Laboratory | M. 28 | 0 | 3 | 2 | 5 |
| Organic Chemistry | Ch. 41 c | 3 | 0 | 5 | 8 |
| Organic Chemistry Laboratory | Ch. 46 c | 0 | 6 | 0 | 6 |
| *Research | | | | | 6-15 |

## THIRD YEAR

### CHEMICAL ENGINEERING AND CHEMISTRY

| SUBJECTS | Subject Number | Hours per Week | | | Units | |
|---|---|---|---|---|---|---|
| | | Class | Lab. | Prep. | ChE | Ch |
| 1ST TERM | | | | | | |
| English and Current Topics | En. 7 a | 3 | 0 | 3 | 6 | 6 |
| Chemical Principles | Ch. 21 a | 4 | 0 | 6 | 10 | 10 |
| Organic Chemistry | Ch. 41 a | 3 | 0 | 5 | 8 | 8 |
| Organic Chemistry Laboratory | Ch. 46 a | 0 | 9 | 0 | 9 | 9 |
| Scientific German | L. 34 a | 3 | 0 | 3 | 6 | 6 |
| Applied Mechanics | Me. 7 a | 3 | 0 | 6 | 9 | .. |
| Advanced Calculus | Ma. 8 a | 3 | 0 | 6 | .. | 9 |
| 2ND TERM | | | | | | |
| English and Current Topics | En. 7 b | 3 | 0 | 3 | 6 | 6 |
| Chemical Principles | Ch. 21 b | 4 | 0 | 6 | 10 | 10 |
| Organic Chemistry | Ch. 41 b | 3 | 0 | 5 | 8 | 8 |
| Organic Chemistry Laboratory | Ch. 46 b | 0 | 9 | 0 | 9 | 9 |
| Scientific German | L. 34 b | 3 | 0 | 3 | 6 | 6 |
| Applied Mechanics | Me. 7 b | 3 | 0 | 6 | 9 | .. |
| Advanced Calculus | Ma. 8 b | 3 | 0 | 6 | .. | 9 |
| 3RD TERM | | | | | | |
| English and Current Topics | En. 7 c | 3 | 0 | 3 | 6 | 6 |
| Economics | Ec. 2 | 3 | 0 | 3 | 6 | 6 |
| Chemical Principles | Ch. 21 c | 4 | 0 | 6 | 10 | 10 |
| Organic Chemistry | Ch. 41 c | 3 | 0 | 5 | 8 | 8 |
| Elements of Heat Engineering | M. 21 | 3 | 0 | 3 | 6 | .. |
| Machine Drawing | D. 8 | 0 | 3 | 0 | 3 | .. |
| Advanced Calculus | Ma. 8 c | 3 | 0 | 6 | .. | 9 |
| Physico-Chemical Laboratory | Ch. 23 | 0 | 9 | 0 | 9 | 9 |
| *Physico-Chemical Research (replacing Ch. 23) | | 0 | 10 | 0 | 10 | 10 |

## FOURTH YEAR

### CHEMICAL ENGINEERING

| SUBJECTS | Subject Number | Hours per Week | | | Units |
|---|---|---|---|---|---|
| | | Class | Lab. | Prep. | |
| **1ST TERM** | | | | | |
| English and Current Topics | En. 10 a | 2 | 0 | 4 | 6 |
| Economic History | Ec. 3 | 1 | 0 | 1 | 2 |
| Selected Economic Problems | Ec. 4 | 2 | 0 | 2 | 4 |
| Geology | Ge. 1 a | 3 | 0 | 3 | 6 |
| Instrumental Analysis | Ch. 16 | 0 | 6 | 4 | 10 |
| Direct Current Machinery | E. 10 | 2 | 0 | 3 | 5 |
| Direct Current Laboratory | E. 3 | 0 | 3 | 2 | 5 |
| Industrial Chemistry | Ch. 61 a | 4 | 0 | 6 | 10 |
| **2ND TERM** | | | | | |
| English and Current Topics | En. 10 b | 2 | 0 | 4 | 6 |
| Geology | Ge. 1 b | 3 | 0 | 3 | 6 |
| Industrial Chemistry | Ch. 61 b | 2 | 0 | 3 | 5 |
| Chemical Engineering | Ch. 66 a | 3 | 0 | 6 | 9 |
| Alternating Current Machinery | E. 12 | 2 | 0 | 3 | 5 |
| Alternating Current Laboratory | E. 5 | 0 | 3 | 2 | 5 |
| Research | Ch. 70 | 1 | 11 | 0 | 12 |
| *Thermodynamic Chemistry (substituted for Ch. 61 B) | Ch. 22 | 3 | 0 | 6 | 9 |
| **3RD TERM** | | | | | |
| English and Current Topics | En. 10 c | 2 | 0 | 4 | 6 |
| Chemical Engineering | Ch. 66 b | 5 | 0 | 10 | 15 |
| Electro-Chemistry | Ch. - - | 3 | 0 | 5 | 8 |
| Steam Laboratory | M. 28 | 0 | 3 | 2 | 5 |
| Research | Ch. 70 | 1 | 13 | 0 | 14 |

## FOURTH YEAR

### CHEMISTRY

| SUBJECTS | Subject Number | Hours per Week | | | Units |
|---|---|---|---|---|---|
| | | Class | Lab. | Prep. | |
| 1ST TERM | | | | | |
| English and Current Topics | En. 10 a | 2 | 0 | 4 | 6 |
| Economic History | Ec. 3 | 1 | 0 | 1 | 2 |
| Selected Economic Problems | Ec. 4 | 2 | 0 | 2 | 4 |
| Geology | Ge. 1 a | 3 | 0 | 3 | 6 |
| Industrial Chemistry | Ch. 61 a | 4 | 0 | 6 | 10 |
| Instrumental Analysis | Ch. 16 | 0 | 6 | 4 | 10 |
| Research | ..... | 1 | 8 | 1 | 10 |
| 2ND TERM | | | | | |
| English and Current Topics | En. 10 b | 2 | 0 | 4 | 6 |
| Thermodynamic Chemistry | Ch. 22 | 3 | 0 | 6 | 9 |
| Geology | Ge. 1 b | 3 | 0 | 3 | 6 |
| Elective in Physics, Mathematics or Chemistry | ..... | 5 | 0 | 10 | 15 |
| Research | Ch. 70 | 1 | 10 | 1 | 12 |
| 3RD TERM | | | | | |
| English and Current Topics | En. 10 c | 2 | 0 | 4 | 6 |
| Electro-Chemistry | Ch. - - | 3 | 0 | 5 | 8 |
| Elective in Physics, Mathematics or Chemistry | ..... | 5 | 0 | 10 | 15 |
| Research | Ch. 70 | 1 | 16 | 2 | 19 |

# Announcement of New Undergraduate and Fifth Year Courses

For classes entering the Institute in 1924 and thereafter, the various Courses of Undergraduate Study outlined on the preceding pages will be replaced by two four-year courses, known as the Course in Engineering and the Course in Chemistry and Physics. For the satisfactory completion of these Courses the degree of Bachelor of Science will be awarded. These will be supplemented by definitely laid out fifth-year Courses in Civil Engineering, Electrical Engineering, Mechanical Engineering, Chemical Engineering, Chemistry, Physics, Geology, and Mathematics, for the completion of which the degree of Master of Science will be awarded.

This development is based on recognition of the fact that a four-year period of study is inadequate to give satisfactorily the combination of cultural, basic scientific, and engineering studies essential to the highest type of engineer, and to afford at the same time leisure for the development of the physical well-being and human interests of the students. The four-year Courses will train, more broadly and fundamentally than the Engineering Courses now given at most institutions, the large proportion of students who study engineering, not to make themselves engineering experts in a specialized sense, but to fit themselves to fill satisfactorily administrative positions in the manufacturing and transportation industries, and to serve as operating and constructing engineers in such industries. The fifth-year Courses, based on this broad fundamental preparation, and coordinated with it so as to constitute a harmonious, unified

five-year period of study, with no sharp break between the undergraduate and graduate periods, will afford the more intensive training required by the engineer, physicist, or chemist who is to do creative work in his field, for example, by designing new structures or machines, improving and developing processes, or making discoveries or inventions.

The four-year Course in Engineering will include an exceptionally thorough training in physics and mathematics, and instruction in chemistry and geology; also extensive courses, continuing throughout the four years, in humanistic studies, including English writing and speaking, literature, evolutionary science, history of civilization, current social and political problems, economics, and business principles; and, finally, those engineering subjects common to all branches of engineering, and now included in the second and third years of the present engineering Courses, such as surveying, mechanism, drawing, applied mechanics, engineering materials, hydraulics, and preliminary courses in civil, mechanical, and electrical engineering. The fifth-year Courses in the separate branches of engineering will consist mainly of the engineering subjects now included in the fourth year of the corresponding present four-year Course; but the additional time available will make possible more advanced work in the design of machines or structures, and the pursuit of engineering research.

The new four-year Course in Chemistry and Physics will include the same basic work in chemistry, physics, and mathematics, and the same humanistic subjects as the four-year Course in Engineering, as well as some of the more fundamental engineering studies as electives,

but most of the latter will be replaced by advanced work in mathematics, physics, chemistry, or geology (options being given among these subjects) and by research. The fifth-year Courses in Chemistry, Chemical Engineering, Physics, Mathematics, and Geology will be based on this four-year Course in Chemistry and Physics. This Course will also afford excellent preparation for students pursuing the fifth-year Course in Electrical Engineering, with the object of preparing themselves for scientific or industrial research in that field.

# Description of Subjects

## AERONAUTICS

PROFESSOR: HARRY BATEMAN
INSTRUCTOR: ALBERT A. MERRILL

1 a, b, c. ELEMENTARY AERONAUTICS.—Deals with the mechanics of the aeroplane and the balloon, with special reference to the properties of aerofoils, propellers, and spindle shaped bodies. Prescriptive for students who have taken or are taking, Ph. 2. (Bateman) (3 units each term)

4 a, b, c. AERODYNAMICAL LABORATORY.—Determination of the resistance coefficients for a square plate, circular disc, cylindrical rod and spindle shaped body. Exploration of the cross section of the wind channel by means of the Pitot tube. Experimental determination of the air forces on model wings, propeller sections and model airplanes for different arrangements of the model. Full scale tests. Prerequisites: Ph. 2. Throughout the year. (Merrill) (6 units each term)

7. AIRPLANE DESIGN.—Design and construction of the wings, fuselage and control surfaces of an airplane. Location of the center of gravity and determination of the moments of inertia of an airplane. General considerations regarding the choice and arrangement of the power plant, gasoline tank, chassis and skid. Prerequisites: Ph. 2. Second term. (Merrill) (15 units)

For advanced courses in aeronautics, see page 71.

## APPLIED MECHANICS

PROFESSOR: FREDERIC W. HINRICHS, JR.
ASSOCIATE PROFESSOR: ROMEO R. MARTEL.
INSTRUCTORS: FRED J. CONVERSE, JAMES B. FRIAUF, ROBERT T. KNAPP, WALTER W. OGIER, JR.
TEACHING FELLOWS: GEORGE T. MCKEE, ARTHUR H. WARNER.

1 a, b. APPLIED MECHANICS.—Analytical treatment of problems involving the action of external forces upon rigid bodies; composition and resolution of forces; equilibrium; couples; framed structures; cords and chains; centroids; rectilinear and curvilinear motion; velocity and acceleration; harmonic motion; translation and rotation; the pendulum; centrifugal action; moments of inertia; inertia forces; kinetic and potential energy; impact; resistance and work; stored energy; fly-wheels; power; machines; friction; mechanical efficiency. Prerequisites: Ma. 1 a, b, c. If evidence of the satisfactory completion of a course in Calculus cannot be presented, registration in Ma. 6 a, b, c is an additional prerequisite. Required in Civil, Electrical, and Mechanical Engineering, and in Engineering and Economics courses, second and third terms, sophomore year. (Hinrichs, Ogier, Friauf, Warner)
(12 units each term)

4. GRAPHIC STATICS.—Graphical solution of problems in mechanics and strength of materials; vector quantities and vectors; force and space diagrams; funicular polygons; shear and moment diagrams; beams; trusses; problems in simple machines; efficiency; friction. Prerequisites: 1 a, b. Required in Electrical and Mechanical Engineering courses, first term, junior year. (Ogier, McKee) (6 units)

5. STRENGTH OF MATERIALS.—Elasticity and strength of materials of construction; theory of stresses and strains; elastic limit; ultimate strength; safe loads; repeated stresses; beams; flat plates; cylinders; shafts; columns; riveted joints; structural shapes. Prerequisites: 1 a, b, Ph. 2. Required in Civil, Electrical, and Mechanical Engineering, and in Engineering and Economics courses, first term, junior year. (Hinrichs, Friauf, Knapp) (12 units)

6 a, b. Testing Materials Laboratory.—Tests of the ordinary materials of construction in tension, compression, torsion and flexure, with determination of elastic limit, yield point, ultimate strength, and modulus of elasticity; cement tests; tests of hardness, fragility, and endurance; experimental verification of formulas derived in the theory of strength of materials. To be taken in connection with 5. Required in Civil, Electrical, and Mechanical Engineering, and in Engineering and Economics courses, first and second terms, junior year. (Martel, Converse, McKee) (3 units each term)

7 a, b. Applied Mechanics and Strength of Materials. An abridged course for students in Chemical Engineering, condensing in the work of two terms as much as possible of the general field outlined above in 1 a, b, 5, 6 a, b. Prerequisites: Ma. 1 a, b, c, 6 a, b, c. Required in the Chemical Engineering course, first and second terms, junior year. (Hinrichs) (9 units each term)

## EQUIPMENT FOR APPLIED MECHANICS

The equipment in the various laboratories was selected with great care and with a view to performing such tests and experiments as are valuable in assisting the student to gain a thorough understanding of the theory of design, as well as a practical knowledge of the laws of operation of the machines and apparatus with which he will come in contact in his engineering career.

Testing Materials Laboratory.—The testing materials laboratory has two divisions, the first a cement and concrete laboratory, and the second a laboratory for the general testing of the materials of construction. The equipment includes all necessary apparatus for standard tests in tension, compression, bending, torsion, fatigue, friction, and hardness. The cement and concrete laboratory is provided with the usual tables for weighing and mixing, and with a complete equipment of sieves, needles, molds, etc., for the determination of the various properties of cement and concrete, as recommended by the Joint Committee of the American Society of Civil Engineers and the American Society for Testing Materials.

## CHEMISTRY

PROFESSORS: ARTHUR A. NOYES, STUART J. BATES, JAMES E. BELL, RICHARD C. TOLMAN

ASSOCIATE PROFESSORS: JAMES H. ELLIS, WILLIAM N. LACEY, HOWARD J. LUCAS

RESEARCH ASSOCIATE: ROSCOE G. DICKINSON

INSTRUCTOR: ERNEST H. SWIFT

NATIONAL RESEARCH FELLOWS: ARTHUR F. BENTON, PHILIP S. DANNER, GEORGE GLOCKLER, MAURICE L. HUGGINS

RESEARCH FELLOW: ALBERT L. RAYMOND

DUPONT FELLOW: GORDON A. ALLES

TEACHING FELLOWS AND GRADUATE ASSISTANTS: RICHARD M. BADGER, ARNOLD O. BECKMAN, PAUL H. EMMETT, L. MERLE KIRKPATRICK, LINUS C. PAULING, CHARLES H. PRESCOTT, REINHARDT SCHUHMANN, ERNEST C. WHITE, OLIVER B. WULF

Thorough training is provided in the five main divisions of the science: inorganic, analytical, organic, physical, and industrial chemistry. Systematic instruction in these subjects is given throughout the chemical courses, and chemical research is carried on during the entire senior year.

It is believed that the education of the chemist will be most effective if he is given a thorough and accurate training in the elements of the science, and in research methods; for this reason the effort of the student is directed largely to the acquirement of this fundamental scientific training instead of being diffused over the purely technical sides of the subject. The graduate should thus be able to apply his scientific knowledge to original investigation, or to the study of chemical problems of a technical nature.

Facilities for research are offered in the various branches of chemistry (see especially pages 41, 72-74).

The experience and training obtained through research are the most important results of the student's course in chemistry. The searching and accurate methods used and the quality of self-reliance acquired are invaluable in giving the ability to solve independently the intricate problems sure to be encountered.

1 a. INORGANIC CHEMISTRY.—Lectures, recitations, and laboratory exercises in the general principles of chemistry. Attention is given to the cultivation in the student of clearness in thinking, resourcefulness in laboratory work, accuracy in observation and inference, care in manipulation, and neatness and clearness in the recording of his work. Required in all courses, first term, freshman year. (Bell and Assistants) (12 units)

1 b. INORGANIC CHEMISTRY.—A continuation of 1 a. Prerequisite: 1 a. Required in all courses, second term, freshman year. (Bell and Assistants) (12 units)

1 c. QUALITATIVE ANALYSIS.—This is a study in the qualitative analysis of solutions of inorganic substances. Six hours a week are devoted to laboratory practice, and three hours a week to a class-room discussion of the work that is being pursued in the laboratory. Prerequisite: 1 b. Required in all courses, third term, freshman year. (Bell and Assistants) (12 units)

11. ANALYTICAL CHEMISTRY.—A laboratory study, accompanied by informal conferences, which supplements the freshman course in the same subject by affording instruction in methods for the separation and detection of certain important elements not considered in that course. It includes also extensive laboratory practice in the complete analysis of solid substances, such as alloys, minerals, and industrial products. Text-book: A. A. Noyes, Qualitative Analysis. Prerequisite: 1 c. Required in Chemistry and Chemical Engineering courses, third term, sophomore year. (Swift) (11 units)

12 a, b. QUANTITATIVE ANALYSIS.—Laboratory practice, supplemented by occasional lectures and by personal confer-

ences. The course furnishes an introduction to the subjects of gravimetric and volumetric analysis. Text-book: Blasdale, Quantitative Analysis. Prerequisite: 11. Required in Chemistry and Chemical Engineering courses, first and second terms. sophomore year. (Swift) (11 units each term)

13 a, b. QUANTITATIVE ANALYSIS.—A continuation of 12 b. Prerequisite: 12 b. Prescriptive in the junior year. (Swift) (8 units each term)

16. INSTRUMENTAL ANALYSIS.—A laboratory course designed to familiarize the student with special analytical apparatus and methods, used both for process control and for research. Prerequisite: 12 b. Required in Chemistry and Chemical Engineering courses, first term, senior year. (Lacey) (10 units)

20. ATOMIC STRUCTURE.—This subject will consist of a series of conferences on the recent developments of the theories of electrons and ions, and of the structure of atoms. It is elective for sophomore students in honor standing in the Courses in Physics, Physics and Engineering, Chemistry, Chemical Engineering, and Electrical Engineering. Prerequisites: Ph. 1 a-e; Ma. 6 a, b. Third term. (Millikan, Watson, Noyes, Dickinson) (6 units)

21 a, b, c. CHEMICAL PRINCIPLES.—Conferences and recitations in which the general principles of chemistry are considered from an exact, quantitative standpoint. Includes a study of the pressure-volume relations of gases; of vapor-pressure, boiling point, freezing point, and osmotic pressure of solutions; of the molecular and ionic theories; of electrical transference and conduction; of reaction rate and chemical equilibrium; of phase equilibria and of thermochemistry. A large number of problems are assigned to be solved by the student. Prerequisites: Ch. 12 b, Ph. 1 a, b, c, Ma. 6 a, b, c. Required in Chemistry and Chemical Engineering courses, junior year. (Bates) (9 units each term)

22. THERMODYNAMIC CHEMISTRY.—A continuation of 21 c. Required in Chemistry course, second term, senior year. (Bates) (9 units)

29. Surface and Colloid Chemistry.—Class-room exercises with outside reading and problems, devoted to surface tension, adsorption, contact catalysis, and the general principles relating to disperse systems with particular reference to the colloidal state. Supplementary laboratory work can be provided if desired. Prerequisite: 22. Required in Chemistry and Chemical Engineering courses, third term, senior year. (8 units)

41 a, b, c. Organic Chemistry.—Lectures and recitations in which the properties, characteristic reactions and classification of the compounds of carbon are studied. Must accompany 46 a, b, c. Prerequisite: 12 b. Required in Chemistry and Chemical Engineering courses, throughout the junior year. (Lucas) (8 units each term)

43. Organic Chemistry.—Lectures and recitations accompanied by laboratory exercises, dealing with the more important compounds of carbon. Prerequisite: 1 c. Required in Physics and Engineering, third term, sophomore year. (Lucas) (11 units)

46 a, b. Organic Chemistry Laboratory.—Laboratory exercises to accompany 41 a, b, c. Preparation and purification of carbon compounds, and study of their characteristic properties. Required in Chemistry and Chemical Engineering courses, first and second terms, junior year. (Lucas) (9 units each term)

49. Organic Analysis.—The first half of the term is devoted to a study of the class reactions of carbon compounds, and to the identification of substances by means of these reactions. During the last half of the term a study is made of the methods used quantitatively to determine the elements by combustion. Prerequisites: 41 c and 46 c. Prescriptive for qualified students, third term, junior year. (Lucas) (9 units)

61 a, b. Industrial Chemistry.—A study of the more important industrial chemical processes, from the point of view not only of the chemical reactions, but of the conditions and equipment necessary to carry on these reactions. Required in

Chemistry course, first term, senior year, and in Chemical Engineering course, first and second terms, senior year. (Lacey)
(10 units first term, 5 units second term)

66 a, b. CHEMICAL ENGINEERING.—A lecture, problem, and discussion course to bring the student in touch with modern practice and the problems involved in efficiently carrying out chemical reactions on a commercial scale. The basic operations of chemical industry (such as transportation of materials, mixing, separation, combustion, etc.) are studied both as to principle and practice. Required in Chemical Engineering course, second and third terms, senior year. (Lacey)
(9 units second term, 15 units third term)

70-74. CHEMICAL RESEARCH.—Opportunities for research are afforded to undergraduate students in all the main branches in chemistry; thus, in analytical or inorganic chemistry (Ch. 70), in physical chemistry (Ch. 71), in organic chemistry (Ch. 72), in applied chemistry (73), and in biochemistry (Ch. 74). Such research may be taken as electives by students in honor standing in the sophomore and junior years; and every candidate for a degree in the Chemistry or Chemical Engineering course is required to undertake in his senior year an experimental investigation of a problem in chemistry. A thesis embodying the results and conclusions of this investigation must be submitted to the faculty not later than one week before the degree is to be conferred. (9 to 20 units)

ADVANCED SUBJECTS IN CHEMISTRY.—See pages 72-74.

## CIVIL ENGINEERING

PROFESSOR: FRANKLIN THOMAS.

ASSOCIATE PROFESSORS: ROMEO R. MARTEL, WILLIAM W. MICHAEL.

INSTRUCTOR: FRED J. CONVERSE.

1 a. SURVEYING.—A study of the elementary operations employed in making surveys for engineering work, including the use, care and adjustment of instruments, linear measurements, angle measurements, note keeping stadia surveys, calculation and balancing of traverses, topographic mapping and field methods. Required in Electrical, Mechanical and Civil Engineering courses, first term, sophomore year. (Michael, Martel, Converse) (7 units)

1 b, c. ADVANCED SURVEYING.—A continuation of 1 a, covering topographic surveys, plane table surveys, base line measurements, triangulation, determination of latitude and a true meridian by sun and circumpolar star observations, curves, cross-section surveys and earthwork estimates, stream gauging, draughting room methods and mapping and the solution of problems. Required in Civil Engineering courses, second and third terms, sophomore year. (Michael) (7 units each term)

4. HIGHWAY ENGINEERING.—A comparison of various types of highway construction; the design, construction and maintenance of roads and pavements; methods of road improvement; financing, contracts and specifications. Required in Civil Engineering courses, third term, junior year. (Michael) (5 units)

8 a. RAILWAY ENGINEERING.—A study of economic railway location and operation; railway plant and equipment; the solution of grade problems; signaling. Required in Civil Engineering courses, first term, junior year. (Thomas) (8 units)

8 b. RAILWAY SURVEYING.—The theory of railway location and surveys; problems relating to curves, track layout, grades and earthwork, including a study of the mass diagram as applied to railway earthwork. Required in Civil Engineering courses, second term, junior. (Michael) (5 units)

8 c. Railway Surveying.—The class devotes one entire day a week to field surveys of a railroad location, applying the principles as outlined under course 8 b. Required in Civil Engineering courses, third term, junior year. (Michael) (6 units)

10. Sewerage.—Systems for the collection and disposal of sewage; the design of sanitary and storm sewers; inspection of local sewage disposal plants; the drainage of land; cost assessments. Required in Civil Engineering courses, third term, junior year. (Martel) (7 units)

12 a. Reinforced Concrete.—The theory of reinforced concrete design, with a study of the applications of this type of construction to various engineering structures. Required in Civil Engineering courses, first term, senior year. (Martel) (8 units)

12 b. Masonry Structures.—Theory of design and methods of construction of masonry structures; foundations, dams, retaining walls, and arches. Required in Civil Engineering courses, second term, senior year. (Martel) (8 units)

15. Water Supply and Irrigation.—A study of modern practice of the collection, storage and distribution of water for municipal, domestic and irrigation uses; design, construction and operation of systems; consideration of the conditions adapted to irrigation developments, dams, reservoirs, canals; laws pertaining to irrigation; the economic aspects of projects. Required in Civil Engineering courses, third term, senior year. (Thomas) (10 units)

20 a. Theory of Structures.—Methods used in the analysis of framed structures for the analytical and graphical determination of stresses; the use of influence lines; graphic statics applied to roofs and bridges. Required in Civil Engineering courses, first term, junior year. (Thomas) (11 units)

20 b, c.—Theory of Structures.—A continuation of 20 a, covering the design of structural parts, connections, portals,

and bracing; a study of arches, cantilever and continuous bridges, and deflections of trusses. Required in Civil Engineering courses, second and third terms, junior year. (Thomas) (8 units each term)

21 a. Structural Design.—The design of a plate girder bridge and a truss bridge or a steel frame building; stress sheets and general drawings are made. Designing office practice is followed as affecting both computations and drawings. Required in Civil Engineering courses, first term, senior year. (Thomas, Converse) (9 units)

21 b. Structural Design.—The design of a reinforced concrete building in accordance with a selected building ordinance, with computations and drawings. Required in Civil Engineering courses, second term, senior year. (Thomas, Martel) (9 units)

21 c. Civil Engineering Design.—Special problems including preliminary investigations of irrigation or water power projects; study of stream flow data, the effect of reservoir storage upon distributed flow, determination of size and type of economic development. Required in Civil Engineering courses, third term, senior year. (Thomas, Martel) (12 units)

25. Elements of Civil Engineering.—An abridged course of design and construction methods for structures of wood, steel, masonry and reinforced concrete. Required in Mechanical Engineering courses, second term, and Electrical Engineering courses, third term, senior year. (Thomas, Michael, Martel, Converse) (7 units)

[See also Subjects E. 3, 5, 16, 64; Ec. 17, 25; H. 1, 2, 5, 6; M. 1, 5, 21; Me. 1 a, b, 5, 6 a, b.]

### CIVIL ENGINEERING EQUIPMENT

The equipment used for instruction in Civil Engineering may be grouped under the following heads: instruments for field and office work; models; and reference

material. The selection of the equipment, to which additions are continually being made, is designed to be representative of such instruments and materials, characteristic of good practice, as the student later may be called upon to use.

FIELD AND OFFICE INSTRUMENTS.—Transits, levels, rods, rangepoles, tapes, etc., in such numbers as fully to equip the students for field exercises. The equipment also includes the instruments necessary for work requiring the use of solar attachments, sextant, plane-tables, prismatic compass, aneroid barometer, and a current meter for stream gauging. Planimeters, pantographs, protractors, special calculating instruments, and beam compasses are used by the students in office work.

MODELS.—The department has model bridge trusses of wood, so constructed as to illustrate the behavior of the truss members under strain; model bridge joints; a locomotive slide rule, and a collection of structural shapes and construction materials.

REFERENCE MATERIAL.—In the designing room of the department there are a large number of sets of drawings and plans for bridges, dams, buildings, sewage purification works, irrigation and power plants, railroad maps and profiles illustrating good practice. There are also photographs of typical and notable structures, and a complete set of topographical maps of Southern California.

TESTING MATERIAL LABORATORY.—(Described on page 101.) This laboratory is used in Civil Engineering courses in the investigation of stresses and causes of failure in full sized reinforced concrete beams, and in the general testing of the materials of construction.

HYDRAULICS LABORATORY.—For equipment and description see page 132.

## ECONOMICS AND GOVERNMENT

PROFESSORS: PAUL PERIGORD, GRAHAM A. LAING
INSTRUCTOR: ALBERT A. MERRILL

The subjects in this group have the two-fold purpose of giving the student an insight into fundamental economic principles, and of acquainting him with some of the aspects of the practical operation of business enterprises. They furnish the important connecting link between the technical engineer and the man of affairs.

2. GENERAL ECONOMICS.—The principles of economics governing the production, distribution, and consumption of wealth, with particular reference to some of the important business and social problems of the day. Required in all courses, third term, junior year. (Perigord, Laing) (6 units)

3. ECONOMIC HISTORY.—The general purpose of the course is to show the dynamic nature of economic society. The various stages in the development of economic life from primitive beginnings to the industrial revolution are dealt with. The problems of economic organization that have arisen under a competitive and a quasi-competitive system are considered from the point of view of the causative and developmental influences which have produced them. Required in all courses, first term, senior year. (Laing) (2 units)

4. SELECTED ECONOMIC PROBLEMS.—A development of the course in General Economics, presenting a fuller treatment of specific problems such as: transportation, agriculture, labor legislation, socialism, present labor policies. Required in all courses, first term, senior year. (Laing) (4 units)

11. STATISTICS.—Statistical methods and the graphic portrayal of results, with their application to concrete business problems. Required in the course in Engineering and Economics, third term, junior year. (Wolfe) (3 units)

14. TAXATION.—A study of the general principles of public expenditure and public revenues with special reference to

American taxation methods. Required in the course in Engineering and Economics, second term, senior year. (Laing) (4 units)

16 a, b, c. ACCOUNTING.—A study of the principles of accounting, starting with simple double entry bookkeeping and carrying the student through a complete system of accounts for a modern concern. The use of percentages and statistics in accounting will be treated, and the interpretation of financial reports and the graphical method of presenting accounting facts will be studied. Required in Engineering and Economics course, second and third terms, junior year and first term, senior year. (Merrill) (9 units each term)

17. ACCOUNTING.—An abridged course in accounting required in Electrical, Mechanical, and Civil Engineering courses, second term, senior year. (Merrill) (8 units)

20. FINANCIAL ORGANIZATION.—A general study of the financial organization of society. The course includes a study of the following topics: Principles of money; nature and functions of credit; the varieties of credit and instruments; the marketing of low and high grade securities; the functions of the corporation and the stock exchange as capital-raising devices; the development of the banking system and the general principles of banking, including studies of commercial banking, the national banking system, and the Federal Reserve system. Required in Engineering and Economics, third term, junior year. (Laing) (8 units)

25. BUSINESS LAW.—The principles of law as applied to business affairs, including discussion of such fundamental topics as the definition of law, its sources, and a brief study of the law governing contracts, negotiable instruments, agency, partnership, corporations, and employer's liability. Required in Electrical, Mechanical, and Civil Engineering courses, third term, senior year. (Laing) (6 units)

26 a, b. BUSINESS LAW.—Similar in scope to Ec. 25, but giving a more extensive treatment of the different subjects considered. Required in the course in Engineering and Economics, third term, junior year, and first term, senior year. (Laing) (8 units each term)

30 a, b, c. BUSINESS ADMINISTRATION.—General consideration of the problems of business and more detailed study of the main problems, including location of industry and plant, scientific management, wage systems, labor relations, marketing and sales problems, financial organization and business risks, outlining principal forms of risk and methods of dealing with them. Discussion of the forms and varieties of business unit: individual producer, partnership, joint-stock company, and corporation. Required in Engineering and Economics course, throughout the senior year. (Laing) (8 units each term)

34. CORPORATION FINANCE.—Corporation promotion; the issue and payment of securities; underwriting; the sale of speculative securities. Discussion of the principles of capitalization, the management of corporate income, and the relation of dividend to income. Financial problems of expansion, combination, and reconstruction of corporations. Required in the course in Engineering and Economics, first term, senior year. (Laing) (6 units)

40. INDUSTRIAL PLANTS.—A study of the methods that are employed in machine shops and manufacturing plants. The course is similar in scope to 34, but briefer, and especially adapted to the needs of the practicing engineer. Required in Mechanical Engineering course, third term, senior year. (Clapp) (6 units)

45. SEMINAR IN SOCIAL AND ECONOMIC ORGANIZATION.—This course consists in weekly lectures and discussions of the development of economic and social organization from a broad standpoint, and includes consideration of such subjects as primitive economic and political groupings and methods, development of gild and feudal systems, evolution of the competitive and quasi-competitive systems in economic life and of democratic organization in political life. A considerable amount of outside reading is required from each student. The class meets once a week for two hours, the first being devoted to lecture and the second to discussion of the problems treated in the lecture. Elective, senior year, second term. (Laing) (4 units)

50. UNITED STATES GOVERNMENT AND POLITICS.—This course is intended to give the students a fuller understanding and appreciation of the Constitution of the United States, and draw their attention to American political ideals. It deals also with the administrative organization and activities of our national government, and with the structure and functions of the state government in the United States. There will be three lectures a week. Reports on selected topics will be required from each student. Required in all courses. (Perigord) (6 units)

55. MUNICIPALITIES.—An examination of the origin, development, and organization of the modern city, and a comparative study of municipal government in Europe and America. Special attention is given to a comparison of the operation of the three characteristic forms of city government in the United States: Federal, Commission, and City Manager. Required in the course in Engineering and Economics, second term, senior year. (Perigord) (3 units)

## ELECTRICAL ENGINEERING

PROFESSOR: ROYAL W. SORENSEN
ASSISTANT PROFESSOR: GEORGE FORSTER
INSTRUCTOR: FRANCIS W. MAXSTADT
RESEARCH FELLOW IN PHYSICS: RUSSELL M. OTIS
ASSISTANTS: ROBERT C. BURT, DONALD H. LOUGHRIDGE, HALLAM N. MENDENHALL, ARTHUR H. WARNER.

2. DIRECT CURRENTS.—Theory and practice of direct current machinery, and measuring instruments. Numerous problems are solved. Text: Principles of Direct Current Machines, Langsdorf. Prerequisites: Ph. 2; Ma. 6 a, b, c. Required in Electrical and Mechanical Engineering courses, first term, junior year. (Sorensen, Forster, Maxstadt) (8 units)

3. DIRECT CURRENT LABORATORY.—Supplementary to 2, 10, and 16. Uses of measuring instruments, determination of direct current machinery characteristics, and the operation of direct current motors and generators. Required in Electrical and Mechanical Engineering, Engineering and Economics, and Physics and Engineering courses, first term, junior year, and in Civil and Chemical Engineering courses, first term, senior year. (Forster, Maxstadt, Otis, Warner, Burt, Mendenhall, Loughridge) (5 units)

4. PRINCIPLES OF ALTERNATING CURRENT ENGINEERING.—Elementary study of alternating currents by analytical and graphical methods. Theory of alternating current measuring instruments; inductance, capacitance, harmonic electromotive force and harmonic current; problems of reactive circuits; resonance; problems of coils in series and multiple; single and polyphase alternators; single and polyphase systems; synchronous motors; rotary converters; transformers; induction, and single phase motors. Numerous problems are worked. Required in Electrical and Mechanical Engineering courses, second term, junior year. (Sorensen, Forster, Maxstadt) (8 units)

5. ALTERNATING CURRENT LABORATORY.—Supplementary to 4, 12 and 18. Uses of alternating current indicating and recording instruments; determination of characteristics of al-

ternating current machinery, operation of alternators, induction and synchronous motors, and transformers. Required in Electrical and Mechanical Engineering, Engineering and Economics, and Physics and Engineering courses, second term, junior year, and in Civil and Chemical Engineering courses, second term, senior year. (Forster, Maxstadt, Otis, Warner, Burt, Mendenhall, Loughridge) (5 units)

6. ELECTRICAL MACHINERY.—A continuation of courses 2 and 4. The application of the principles taught in these courses to the study and operation of direct and alternating current machinery. Required in Electrical and Mechanical Engineering courses, third term, junior year. (Sorensen, Forster, Maxstadt) (7 units)

7. ELECTRICAL LABORATORY.—A continuation of 3 and 5. Efficiency tests of direct and alternating current machinery, operation of motors and generators in parallel, calibration of indicating and recording meters. Required in Electrical and Mechanical Engineering courses, third term, junior year. (Forster, Maxstadt, Otis, Warner, Burt, Mendenhall, Loughridge) (5 units)

10. DIRECT CURRENT MACHINERY.—Abridged course in direct currents similar to 2. Prerequisite: Ph. 2. Required in Physics and Engineering courses, first term, junior year, and in Chemical Engineering courses, first term, senior year. (Forster) (5 units)

12. ALTERNATING CURRENT MACHINERY.—A study of the fundamental principles of alternating current machinery. Required in Physics and Engineering courses, second term, junior year, and in Chemical Engineering courses, second term, senior year. (Sorensen) (5 units)

16. DIRECT CURRENT MACHINERY.—Similar to 10. Required in Civil Engineering courses, first term, senior year, and in Engineering and Economics courses, first term, junior year. (Sorensen) (7 units)

18. Alternating Current Machinery.—Similar to 12. Required in Civil Engineering courses, second term, senior year, and in Engineering and Economics courses, second term, junior year. (Forster) (7 units)

20. Alternating Current Analysis.—Advanced study of the magnetic and electric circuits; problems of the electrostatic and electromagnetic fields; study of magnetic materials, solution of problems involving the symbolic method and complex notation; analysis of electromotive force, and current, nonsinusoidal wave forms; use of the oscillograph. Required in Electrical Engineering courses, second term, senior year. (Sorensen, Forster) (9 units)

21. Alternating Current Laboratory.—Complete tests of the synchronous motor; the operation of synchronous machines in parallel; complete tests of transformers; study of polyphase connections; rotary converter tests; photometric measurements; use of the oscillograph; testing of magnetic materials. Required in Electrical Engineering courses, first term, senior year. (Forster, Maxstadt) (6 units)

22. Induction Machinery.—An advanced study of the stationary transformer, with special emphasis upon problems of multiple operation which involve problems of polyphase polarity, together with single and polyphase multiple circuits. Required in Electrical Engineering courses, first term, senior year. (Sorensen, Forster) (9 units)

28. Electric Traction.—The electric railway, selection of equipment in rolling stock, location and equipment of substations, comparison of systems and power requirements for operation of electric cars and trams. Required in Electrical Engineering courses, second term, senior year. (Sorensen, Forster, Maxstadt) (10 units)

30. Electric Lighting and Power Distribution.—Electric distribution and wiring; calculation of simple alternating current circuits; installation and operation costs and selling price of electric power. Required in Mechanical Engineering courses, third term, senior year. (Forster) (4 units)

33. Electrical Engineering Laboratory.—Supplementary to courses 6, 20, 52. Testing insulating materials, and comparing dimensions and design of electrical machines found in the laboratories of the Institute. Required in Electrical Engineering courses, third term, senior year. (Forster) (4 units)

40. Advanced Alternating Current Machinery.—An advanced study of the principles involved in alternating current machinery, other than the transformer, with particular emphasis upon the induction and synchronous motors. Required in Electrical Engineering courses, third term, senior year. (Forster) (6 units)

44. Electric Power Transmission.—Determination of economic voltage for transmission lines; line protection; elementary transient phenomena; corona; use of hyperbolic functions in line calculations. Required in Electrical Engineering courses, third term, senior year. (Sorensen) (10 units)

48. Specifications and Design of Electric Machines.—Preparation of specifications and design calculations for alternating and direct current machinery. Required in Electrical Engineering courses, third term, senior year. (Sorensen) (4 units)

52. Dielectrics.—The relations of phenomena of dielectrics in high voltage engineering. Required in Electrical Engineering courses, third term, senior year. (Sorensen) (5 units)

56. Electrical Communication.—A study of the elements of telephone, telegraph and call systems. Prescriptive, first term, senior year. (5 units)

60. Advanced Electrical Engineering.—A detailed study of circuits, including advanced work in wave propagation and transient phenomena in electric conductors. Prescriptive, second term, senior year. (Sorensen) (5 units)

62 a, b. Vacuum Tubes.—Theory, construction, characteristics, application and operation of Vacuum Tubes, as used for

electrical purposes. Prescriptive first and second terms, senior year. (Forster) (5 units each term)

[See also Subjects C. 1 a, 25; Ec. 17, 25; H. 1, 2, 5, 6; M. 1, 2, 5, 6, 15, 16, 17, 25, 26, 27; Me. 1 a, b, 4, 5 6 a, b.]

### ELECTRICAL ENGINEERING EQUIPMENT

The laboratories of the department of Electrical Engineering are exceptionally well equipped with a large assortment of carefully selected apparatus and instruments for making fundamental experiments and conducting research with both direct and alternating currents. Many of the motors and generators are 10 horse power and 7½ kilowatts capacity, respectively, sizes large enough to give standard characteristics and teach respect for power currents, but at the same time small enough to avoid heavy current manipulations and consequent distraction of the student's attention from the true objective of the work. These standard units are grouped in pairs as motor-generator sets which may be interconnected to simulate a power or distributing system.

This apparatus may be classified under the following headings: Power apparatus—alternators, switchboards, dynamos, transformer regulators, etc.; photometer apparatus; calibrating instruments; measuring instruments, and high voltage apparatus.

The high voltage apparatus is grouped in two laboratories, one entirely for undergraduate work in the department of Electrical Engineering, where voltages up to 250,000 may be obtained, and the High Voltage Laboratory described on page 40 for the more advanced work.

## ENGINEERING DRAWING

INSTRUCTORS: GEORGE B. BRIGHAM, JR., HENRY G. CORDES, CLARENCE V. ELLIOTT.
TEACHING FELLOW: ARTHUR H. WARNER.

The courses in Engineering Drawing are arranged to equip the student with the technique of graphic expression necessary for the development of his future professional work. The instruction comprises practice to develop manual facility in the use of instruments, exercises to develop speed and accuracy in the application of the methods of projection, dimensioning, and lettering. The essentials of descriptive geometry are used in the solution of numerous practical examples which are designed to develop in the student the ability to visualize the object and to describe it in the language of projection. The freehand sketching of machine parts is followed by accurate pencil drawings of details and assemblies, which are then traced in ink and blueprinted ready for use in the shop.

1 a, b, c, d. DRAWING AND LETTERING.—Involves the use of instruments, geometric construction, orthographic projection, and principles of dimensioning. Practice in the construction of freehand letters adapted to use on working drawings, and the layout of titles.

2 a, b. DESCRIPTIVE GEOMETRY AND PERSPECTIVE.—A study of simple problems in lines, planes, and solids, illustrated by the solution of practical problems; studies in intersections and developments, isometric and perspective drawing. Particular emphasis is laid on neatness and conformity with the specifications. Isometric and perspective sketching of machine parts. Design sketching without the use of models.

1 a, b, c, d, 2 a, b. (Above courses.) Required in all courses, freshman year. 1 a, b, c is taken during the college year. 1 d and 2 a, b are taken during the college year or first three weeks of summer. (18 units for the year)

5. MACHINE DRAWING.—Detail sketches of machines in the shop and laboratory, followed by detailed drawing suitable for shop use. Emphasis is placed on general principles and the best accepted methods of representation. Prerequisite, D 1 a, b, c, d. Required in Electrical, Mechanical and Civil Engineering courses, first term, sophomore year. (3 units)

6. MACHINE DRAWING.—A continuation of work in course 5 with practice in sketching, detailing, tracing, and making assembled views. A study of blueprints and an acquaintance with the details of good commercial practice. Required in Electrical and Mechanical Engineering courses, third term, sophomore year. (7 units)

8. MACHINE DRAWING.—Similar to course 5. Required in Chemical Engineering courses, third term, junior year. (3 units)

## ENGLISH AND HISTORY

PROFESSORS: CLINTON K. JUDY, PAUL PERIGORD
ASSOCIATE PROFESSOR: GEORGE R. MACMINN
INSTRUCTORS: WILLIAM D. CRANE, STANLEY M. PARGELLIS

The Institute requires for graduation a four-years' course in English, with a complementary study of history and current topics. The work in English comprises both composition and literature. A thorough grounding is given in the principles and practice of both written and spoken English, with special attention, in the later years, to the particular requirements of the technical professions. The instruction in literature is intended to familiarize the student with masterpieces and to give him an appreciative acquaintance with the best literary products of the present time. It is believed, however, that the cultural value of this study would be incomplete without collateral instruction in history and critical discussion of current topics. A fusion of English and history is therefore effected, with the general aim of broadening and deepening the student's sense of values in the world of cultivated society, of strengthening his capacity for good citizenship, and at the same time of heightening his ability to use the English language to the best advantage in both professional and social life. It is to be noted also that the formal courses in these subjects do not exhaust the attention given to the student's English; all written work, in whatever department of study, is subject to correction with regard to English composition.

1 a, b, c. ENGLISH AND HISTORY.—This course is designed to give the student a thorough review of the principles of

composition; a familiarity with some of the great names and works of English literature; and an introductory reading in modern history. Special emphasis is placed on theme-writing. The weekly exercises in composition are corrected, not only for the mechanics of spelling, punctuation, and grammar, but also for the qualities of clearness, exactness, and force in the expression of thought. The student is offered every encouragement to self-cultivation, and is expected to show signs of his intellectual growth in the increasingly effective form and matter of his written and oral work. The work of the honors section is such as especially to foster the spirit of intellectual initiative. Each student pursues at some length a carefully chosen subject in accordance with elementary principles of research. The members of this section are held to particularly high standards of excellence in writing and speaking, and are expected to undertake a considerable amount of cultural, as well as technical, reading. Required in all courses, throughout the freshman year. (9 units each term)

4 a, b, c. English and History.—Lectures on the history of Europe and America since 1770 will be supplemented by class discussions and exercises to ensure a grasp of the fundamental ideas, the events and movements underlying present social and political conditions. Required in all courses, throughout the sophomore year. (6 units each term)

7 a, b, c. English and Current Topics.—The literary interest of this course is centered in some of the chief writers belonging to one or more of the main periods in English and American literature. Special attention is also given to the historical background of the works assigned for reading. The study of current topics is articulated with a selected weekly journal of general information and opinion. Approximately one-third of the time allowed for the course is given to class discussion of political, social, and scientific subjects. Required in all courses, throughout the junior year. (6 units each term)

10 a, b, c. English and Current Topics.—This course is a continuation of the work done in the junior year. Special

instruction is also given in the kinds of technical writing that the student nearing graduation should be qualified to undertake. Required in all courses, throughout the senior year.
(6 units each term)

14. SPECIAL COMPOSITION.—This course may be prescribed for any student whose work in composition, general or technical, is unsatisfactory. Prescriptive. (2 units, any term)

15. SPELLING.—This course may be prescribed for any student whose spelling, general or technical, is unsatisfactory. Prescriptive. (No credit)

## GEOLOGY

Courses 1 a, b are required of all students during the junior year. The assumption is that the intellectual equipment of any educated man, whether he be a scientist or not, is incomplete without some acquaintance with the fundamental principles of geology. The object is cultural rather than technical; the student is led to appreciate the immensity of geologic time, the nature and work of the forces of inorganic evolution, and the broad panorama of life of all times. The treatment of the physical side of the subject emphasizes structural relationships with the object of training the student to reason, so that this introductory course may serve as a foundation for more advanced work. The historical presentation aims to treat in careful detail a few well selected examples illustrating the evolution of types and to avoid the confusion incident to too much detail.

Provision is made for frequent inspection trips to neighboring regions; few places afford facilities of greater interest to the geologist than Los Angeles County.

Courses 5 and 8 are elective courses for those who desire further work of a more technical character.

1 a, b. GEOLOGY.—A presentation of the broader facts of the subject from the latest viewpoint and with due regard to the cultural value of the science; the history of the earth, the work of inorganic evolution, stellar as well as terrestrial. Required in Chemical Engineering and Chemistry courses, first and second terms, senior year, and in all other courses, first and second terms, junior year. (6 units each term)

5. MINERALOGY.—A study of the elements of crystallography, and of the physical and chemical properties, uses, and determination of the more common minerals. Prescriptive, third term, junior year. (6 units)

8. GEOLOGY.—The nature and distribution of geologic resources of industrial importance. Prescriptive, third term, senior year. (6 units)

## HYDRAULICS

PROFESSOR: ROBERT L. DAUGHERTY.
ASSOCIATE PROFESSOR: WILLIAM W. MICHAEL.
INSTRUCTOR: FRED J. CONVERSE.

1. HYDRAULICS.—Physical properties of water; hydrostatics; flow of water in pipes, nozzles, and channels; hydrodynamics. Prerequisites: Me. 1 a, b. Required in Electrical, Mechanical, and Civil Engineering, and Engineering and Economics courses, second term, junior year. (8 units)

2. HYDRAULIC LABORATORY.—Experiments on the flow of water through orifices and nozzles, through pipes and Venturi meters, over weirs, use of Pitot tube, and tests illustrating fundamental hydraulic laws. Required in Electrical, Mechanical, and Civil Engineering, and Engineering and Economics courses, second term, junior year. (3 units)

5. HYDRAULIC TURBINES.—Theory, construction, operation, and installation of modern hydraulic turbines, and a study of their characteristics with a view to intelligent selection of the proper type for any given conditions. Required in Electrical, Mechanical, and Civil Engineering courses, third term, junior year. (5 units)

6. HYDRAULIC LABORATORY.—Tests of impulse and reaction turbines, of centrifugal and other pumps, and of other hydraulic apparatus. Required in Electrical, Mechanical, and Civil Engineering courses, third term, junior year. (3 units)

### EQUIPMENT FOR HYDRAULICS

The hydraulics laboratory is equipped with various types of pumps, turbines, and other apparatus so that the standard hydraulic experiments may be performed. The facilities are such that certain research problems may also be attacked.

# MATHEMATICS

PROFESSORS: HARRY C. VAN BUSKIRK, HARRY BATEMAN
ASSOCIATE PROFESSOR: LUTHER E. WEAR
ASSISTANT PROFESSOR: CLYDE WOLFE
INSTRUCTOR: WILLIAM N. BIRCHBY
TEACHING FELLOWS AND ASSISTANTS: DINSMORE ALTER, A. LLOYD GREENLEES, HOWARD P. ROBERTSON, WILLIS H. WISE.

The work in engineering and science is so largely mathematical in character that too much emphasis can hardly be placed upon the necessity of a good foundation in mathematics. Care is taken to present both underlying principles and a great variety of applications, thus connecting the mathematical work closely with the professional studies.

1 a, b, c. FRESHMAN MATHEMATICS.—Including the fundamentals of Analytical Geometry, certain topics in College Algebra, and some of the principles of the Differential and Integral Calculus. Required in all courses, throughout the freshman year. (9 units each term)

2 a, b, c. SOPHOMORE MATHEMATICS.—Includes additional topics in Analytical Geometry, and completes the usual subjects of the Calculus, begun in the freshman year. Required in all courses, throughout the sophomore year.

(Not offered in 1923-1924) (12 units each term)

Courses 1 a, b, c, and 2 a, b, c, form a continuous two-year course in Analytical Geometry, College Algebra, and the Differential and Integral Calculus.

5. ELEMENTARY ANALYSIS.—A continuation of 1, designed to present portions of advanced algebra of especial interest in engineering, including work in permutations, combinations, probability, continued fractions, solution of equations, empirical equations, and an introduction to Vector Analysis. Elective, third term, freshman year. (4 units)

6 a, b, c. CALCULUS.—The aim of this study in Differential and Integral Calculus is to familiarize the student with the processes and methods that are continually applied in the various branches of science and engineering. Required in all courses, throughout the sophomore year. (12 units each term) (Replaced by 2 a, b, c after 1923-1924.)

8 a, b, c. ADVANCED CALCULUS.—Planned to extend the knowledge gained from the previous studies in Calculus and Analytic Geometry and to lay a better foundation for advanced work in mathematics and science. Required in Physics and Engineering and Chemistry courses, throughout the junior year. (Van Buskirk) (9 units each term)

10 a, b, c. DIFFERENTIAL EQUATIONS.—A study of differential equations of the first order, linear differential equations with constant coefficients, systems of such equations, total differential equations, linear equations with variable coefficients, integrating factors, method of infinite series, partial differential equations. This course is designed to be helpful in the study of physics, mechanics, and electrical engineering. Prerequisites: 8 a, b, c. Required in Physics and Engineering and Physics courses throughout the senior year. (Bateman, Wear) (6 units each term)

12. PROBABILITY AND LEAST SQUARES.—This subject aims to enable the scientific worker properly to judge and improve the accuracy of his work. Numerous problems are given to illustrate the methods of adjusting observations and determining the precision measures of the results. Criteria for the rejection of doubtful observations are considered and methods of representing the results of approved observations by curves or equations are given. Elective. Second term. (Wolfe) (5 units)

For advanced courses in mathematics, see pages 67 and 68.

## MECHANICAL ENGINEERING

PROFESSORS: ROBERT L. DAUGHERTY, W. HOWARD CLAPP.
ASSOCIATE PROFESSOR: ROMEO R. MARTEL.
INSTRUCTORS: CLARENCE V. ELLIOTT, ROBERT T. KNAPP, WALTER W. OGIER, JR.

1. MECHANISM.—Kinematics of machinery. A study of machine elements, cams, linkages, belt and gear drives; velocity relations of parts. Class discussion, problems, and drawing board studies. Prerequisite: D. 1 a, b, c. Required in Electrical, Mechanical, and Civil Engineering courses, first term, sophomore year. (Clapp, Ogier and Assistants) (9 units)

2. MECHANISM.—A continuation of Course 1, with special reference to valve gears, governing devices, and other power-plant machinery mechanisms. Required in Mechanical and Electrical Engineering courses, second term, sophomore year. (Ogier, Elliott) (7 units)

5. MACHINE DESIGN.—A study of the fundamental principles of machine design; energy and force problems; straining actions in machines; axles, shafting, and couplings; springs, tubes and flat plates; screws and screw fastenings; keys and cotters; force and shrink fits; flywheels, pulleys, and rotating disks; machine frames and attachments. Class work and drawing board studies. Prerequisites: Me. 5, 6 a, b. Required in Mechanical, Electrical, and Civil Engineering courses, second term, junior year. (Clapp, Ogier, and Assistants) (7 units)

6. MACHINE DESIGN.—A continuation of Course 5. Riveted fastenings; belt and rope transmission; chains; friction wheels, brakes, and clutches; toothed gearing; spur, bevel, and screw gears; journals, bearings, and lubrication; balancing of machine parts. Required in Mechanical and Electrical Engineering courses, third term, junior year. (Clapp, Ogier) (7 units)

7 a, b, c. ADVANCED MACHINE DESIGN.—Each student will make a detailed study, under the guidance of the instructor, of some particular problem in design involving a thorough acquaintance with what has been accomplished in that field,

and an appreciation of the various factors that influence the design. The work includes research reading, computations, and drawing board studies, and seminar for joint discussion of the several problems. Required in Mechanical Engineering courses, senior year. (Clapp) (7 units each term)

8. MACHINE DESIGN.[1]—The complete design of some machine with the necessary shop drawings. Required in Mechanical Engineering courses, second term, senior year. (Clapp) (6 units)

9. OIL AND GAS ENGINE DESIGN.—A study of the principles and a comparison of different types of two and four cycle, horizontal and vertical, oil and gas engines. A critical study of the problems involved in proportioning valve openings, cylinder castings to minimize temperature strains, fuel injection, timing, balancing, etc. Required in Mechanical Engineering courses, third term, senior year. (Clapp) (8 units)

12. METALLURGY AND HEAT TREATMENT.—A study of the methods used in manufacturing iron, normal carbon steels, the special alloy steels and other engineering alloys. A study of the relation of the chemical composition and crystal structure of the metal to its physical behavior. The principles governing modern heat treatment methods are studied. The various uses of heat treated parts and of special alloy steels for peculiar purposes are investigated. A continuation of the work in machine design. Required in Mechanical and Civil Engineering courses, first term, senior year. (Martel) (8 units)

15. THERMODYNAMICS.—Principles of thermodynamics, discussion of properties of gases, saturated and superheated vapors, various cycles of vapor engines and internal combustion engines. Prerequisites: Me. 1 a, b. Required in Electrical and Mechanical Engineering courses, third term, junior year. (Daugherty, Knapp) (8 units)

16. HEAT ENGINES.—Continuation of 15. Comparison is made of ideal and actual cycles of vapor, hot air and internal combustion engines. Relative economics of steam engines, tur-

[1]A portion of the time may be given to Special Problems at the option of the instructor.

bines and internal combustion engines are discussed. Study is made of flow of vapors and gases through orifices and pipes. Required in Electrical and Mechanical Engineering courses, first term, senior year. (Daugherty) (8 units)

17. Power Plant Engineering.—A study of the apparatus used in power plants of all types with comparisons of cost of installation and operation. The course includes a study of the principles of combustion, and of the various apparatus of the power plant, including boilers, heaters, economizers, engines, turbines, condensers, gas producers, piping, pumps, forced draft apparatus, chimneys, etc. California offers many examples of power plants of large and small installations, including some of the best and most modern equipment. Frequent inspection trips are made to these plants. Prerequisites: 15, 16. Required in Electrical and Mechanical Engineering courses, second term, senior year. (Daugherty) (8 units)

18. Power Plant Design.—A continuation of the work in Power Plant Engineering with a detailed study of modern practice. Typical power plant problems are worked out in considerable detail in the drawing room. Application is made to the design of a plant to meet certain conditions. Required in Mechanical Engineering courses, third term, senior year. (Daugherty) (12 units)

20. Heat Engineering.—Additional work in thermodynamics with special reference to heating and ventilating, refrigeration, and compressors. Prerequisites: 15, 16. Required in Mechanical Engineering courses, first term, senior year. (Daugherty) (8 units)

21. Elements of Heat Engineering.—Principles of thermodynamics and their applications to steam engines, turbines, and internal combustion engines. Study of power plant apparatus. Required in Civil Engineering courses, third term, senior year, and in Physics and Engineering, and Chemical Engineering courses, third term, junior year. (Ogier) (6 units)

25. Steam Laboratory.—Calibration of instruments; tests of steam calorimeters; valve setting; tests on the steam engine, steam turbine, gas engine, and steam pump for efficiency and economy; test of boiler for economy. Prerequisites: 15,

16. Required in Electrical and Mechanical Engineering courses, first term, senior year. (Daugherty, Knapp) (5 units)

26. POWER PLANT LABORATORY.—Tests of lubricants; investigation of friction in bearings; fuel and gas analysis and calorimetry; further tests of steam engines, gas engines and steam turbines; and tests of heating systems and complete power plants. Required in Electrical and Mechanical Engineering courses, second term, senior year. (Daugherty, Knapp) (7 units)

27. MECHANICAL ENGINEERING LABORATORY.—Tests of power plant equipment and other apparatus; special tests and investigations suggested by previous work and by a study of engineering journals. This may take the form of an original investigation of some special problem. Required in Mechanical Engineering courses, third term, senior year. (Daugherty, Knapp) (8 units)

28. STEAM LABORATORY.—Similar to 25 but adapted to the needs of students in Physics and Engineering and Chemical Engineering. Required in Physics and Engineering and Chemical Engineering courses, third term, senior year. (Daugherty, Knapp) (5 units)

[SEE ALSO SUBJECTS C. 1 a, 25; E. 2, 3, 4, 5, 6, 7, 30; Ec. 17, 25, 40; H. 1, 2, 5, 6; Me. 1 a, b, 4, 5, 6 a, b.]

### MECHANICAL ENGINEERING EQUIPMENT

The mechanical engineering laboratory provides facilities for making the customary tests in steam and gas engineering, together with related fields. It includes a steam laboratory, a gas engine laboratory, a fuel and oil testing laboratory, and a small shop. Each of these laboratories has the necessary equipment and instruments for its work. In addition to the standard tests, it is possible to arrange the apparatus so that certain research problems may be attacked. The instruments may also be used in conjunction with equipment in outside industrial plants for the solution of special problems.

## MILITARY TRAINING

PROFESSOR : LIEUTENANT HANS KRAMER
ASSISTANT PROFESSOR: LIEUTENANT DOSWELL GULLATT
MASTER SERGEANT MARIEN H. DEGRAFF
STAFF SERGEANT LOUIS H. BAILEY
REGIMENTAL COMMISSARY SERGEANT WILLIAM C. COOK

By direction of the Secretary of War, an Engineer Unit of the Senior Division, Reserve Officers' Training Corps, is maintained at the Institute, under supervision of an officer of the Corps of Engineers, Regular Army, detailed by the War Department, who is designated as Professor of Military Science and Tactics.

The primary object of the Reserve Officers' Training Corps is to provide systematic military training for the purpose of qualifying selected students as Reserve Officers in the military forces of the United States. This object is attained by employing methods designed to fit men physically, mentally, and morally for pursuits of peace as well as pursuits of war.

The policy of the War Department is to inculcate in the students a respect for lawful authority, to teach the fundamentals of the military profession, to develop leadership, and to give the special knowledge required to enable them to act efficiently in the engineering branch of the military service. The equipment furnished by the government for the instruction of this unit affords to all classes practical training in engineering fundamentals which greatly enhances the student's preparation for his civil career.

All freshmen and sophomores are required to take Military Training. Satisfactory completion of the two

years of the basic course is a prerequisite for graduation. Uniforms, text-books, and other equipment are provided by the Government, and are loaned to the students while pursuing the basic course.

A basic summer camp is held each year at a U. S. Army cantonment. Attendance at this camp is optional. The Government furnishes clothing, food, and quarters, and pays travel expenses to and from the camp.

1 a, b, c. MILITARY SCIENCE AND TACTICS (Basic Course).—Freshmen work consists of drills, lectures, and recitations covering the following subjects: Infantry drill and leadership, rifle marksmanship, interior guard duty, hygiene, military courtesy and discipline. Practical instruction is given in knots and lashings, field fortifications, map reading, map making, and pontoon bridge construction. All freshmen are assigned as privates in the R. O. T. C. battalion. Required in all courses, freshman year. (4 units each term)

4 a, b, c. MILITARY SCIENCE AND TACTICS (Basic Course).—Sophomore work consists of drills, lectures, recitations, and conferences covering the following subjects: Infantry drill, leadership, musketry, and minor tactics. Practical instruction is given in knots and lashings, splicing, blocks and tackles, gins, shears and tripods, topographic sketching, and bridge construction. Selected sophomores are assigned as corporals in the R. O. T. C. battalion. Required in all courses, sophomore year. (4 units each term)

Members of the Reserve Officers' Training Corps who have completed two academic years of service in the basic course (or the authorized equivalent of such service) and have been selected by the head of the Institute and the Professor of Military Science and Tactics as qualified for further training, are eligible for admission to the advanced course. Such selected students

receive a money allowance from the United States Government for commutation of rations of approximately forty dollars ($40) per term. They are required to attend one advanced summer training camp of six weeks' duration prior to their graduation before becoming eligible for appointment as reserve officers. The Government furnishes clothing, food, and quarters, pays travel expenses, and pays each advanced student one dollar ($1.00) per day for attendance at this summer camp. The advanced course covers the instruction necessary for the training of the students in the duties of a commissioned officer, who must be not only schooled in the theory of war, but skilled also in practical leadership, with trained judgment, resourcefulness, and initiative.

7 a, b, c. MILITARY SCIENCE AND TACTICS (Advanced Course).—Junior work consists of recitations and conferences on the following subjects: Minor tactics, field fortifications, demolitions, roads, and railroads. The junior class furnishes the cadet sergeants and first sergeants for the R. O. T. C. battalion. Elective in all courses, junior year.

(5 units each term)

10 a, b, c. MILITARY SCIENCE AND TACTICS (Advanced Course).—Senior work consists of recitations and conferences in the following subjects: Military bridges, military law, Engineer organization and operations. Practical instruction is given in civil-military construction, mapping, and map reproduction. The cadet officers in the R. O. T. C. battalion are selected from the senior class. Elective in all courses, senior year. (7 units each term)

## MODERN LANGUAGES

PROFESSOR: JOHN R. MACARTHUR.

The courses in this department are primarily arranged to meet the needs of men who find it necessary to read scientific treatises in French and German. Correct pronunciation and the elements of grammar will be taught, but the emphasis will be laid on the ability to read with accurate comprehension. Owing to the general plan of the curriculum it is the technical value rather than a literary appreciation that must be considered.

1 a, b, c. ELEMENTARY FRENCH.—A course in grammar, pronunciation and reading that will provide the student with a vocabulary of extent and accuracy sufficient to enable him to read at sight simple scientific prose. Accuracy and facility will be insisted upon in the final tests of proficiency in this course. Required in the Physics and Engineering and Physics courses throughout the senior year. (6 units each term)

31 a, b, c. ELEMENTARY GERMAN.—A course in plan similar to Elementary French. Required in Physics and Engineering, Physics, Chemical Engineering, and Chemistry courses throughout the sophomore year. (10 units each term)

34 a, b. SCIENTIFIC GERMAN.—A continuation of German 31 a, b, c, with special emphasis on the reading of scientific literature. Required in the Physics and Engineering and Physics courses throughout the junior year, and in the Chemical Engineering and Chemistry courses, first and second terms, junior year. (6 units each term)

## PHYSICAL EDUCATION

PHYSICAL DIRECTOR: WILLIAM L. STANTON
INSTRUCTOR: HAROLD Z. MUSSELMAN
EXAMINING PHYSICIAN: LEROY B. SHERRY, M.D.
PHYSICIAN TO FOOTBALL TEAM: FLOYD L. HANES, D.O.

All freshmen and other new students must pass a medical examination given by the Department of Physical Education before his registration is complete; all other students must satisfy the department that they are physically qualified to continue the work for which they are registered. A student ambitious to become an engineer must first be a man with a sound body and stored-up nervous energy, fundamental to a sound mind and subsequent success.

Industrial efficiency and good citizenship can be obtained only on an adequate physical basis. Consequently, the program of physical education is designed to give general physical development to all. The aim is to insure health with perfect functioning of all organs of the human body, in order that the individual may meet his physiological obligations to himself, to his family, and to his country. When a student has completed the year's work he should exhibit some progress in attaining the following results: (1) strength and endurance, self-respecting and erect carriage of the body, and neuro-muscular control; (2) aggressiveness, self-confidence, courage, decision, perseverance, and initiative; (3) self-control, self-sacrifice, loyalty, cooperation, mental and moral poise, a spirit of fair play, and sportsmanship.

The required work is divided into three parts:

1. PHYSICAL EXAMINATIONS AND STRENGTH TESTS FOR FRESHMEN (First and Third Terms).—Used as a basis of comparison

with other men of same weight and height; corrective exercises prescribed for underdevelopment and deformities. Optional with sophomores.

2. Intramural Sports (Under the Supervision of Instructors).—Competition between classes, clubs, fraternities, in all sports, including football, cross-country running, track and field events, baseball, basketball, swimming, boxing, wrestling, tennis, handball, etc. Required of freshmen and sophomores not taking part in intercollegiate sports.

(Freshmen—3 units each term)
(Sophomores—2 units each term)

3. Intercollegiate Sports.—The Institute is a member of the Southern California Intercollegiate Conference. Representative freshmen and varsity teams in the major sports are developed and trained by experienced coaches. Fair-spirited and clean-cut athletic competition is encouraged as a part of the physical program for its social and physical values, and as a foundation for genuine college spirit.

(Freshmen—3 units each term)
(Sophomores—2 units each term)

The required work is divided into three parts: (1) setting-up drill, consisting of progressive calisthenic movements; (2) group games; (3) fundamentals of highly organized athletics. The formal work for sophomores is of course more difficult in its execution than that for freshmen. This work is modified by various activities designed to encourage voluntary recreational exercises, including football, basketball, baseball, track and field athletics, boxing, swimming, wrestling, and other sports. Required in all courses throughout the freshman and sophomore years.

(Freshmen—3 units each term)
(Sophomores—2 units each term)

## PHYSICS

PROFESSORS: ROBERT A. MILLIKAN, HARRY BATEMAN, PAUL EHRENFEST (1923-24), PAUL S. EPSTEIN, LUCIEN H. GILMORE, RICHARD C. TOLMAN

ASSOCIATE PROFESSOR: EARNEST C. WATSON

ASSISTANT PROFESSOR: WALTER T. WHITNEY

INSTRUCTORS: IRA S. BOWEN, JAMES B. FRIAUF

RESEARCH ASSOCIATES: SAMUEL J. BARNETT, ROSWELL C. GIBBS, STANISLAW LORIA

NATIONAL RESEARCH FELLOWS: JOSEPH A. BECKER, HERBERT KAHLER, EDWARD H. KURTH, SAMUEL S. MACKEOWN, WILLIAM R. SMYTHE

RESEARCH FELLOWS: ALBERT BJORKESON, JOHN CARROLL, EDWIN L. ROSE, WALDIMIR M. ZAIKOWSKY

TEACHING FELLOWS AND GRADUATE ASSISTANTS: DINSMORE ALTER, ROBERT B. BRODE, ROBERT C. BURT, G. HARVEY CAMERON, HUGH K. DUNN, A. LLOYD GREENLEES, ARTHUR L. KLEIN, RUSSELL M. OTIS, R. MEYER LANGER, DONALD H. LOUGHRIDGE, HALLAM E. MENDENHALL, LEWIS M. MOTT-SMITH, HOWARD P. ROBERTSON, SINCLAIR SMITH, ARTHUR H. WARNER, RALPH E. WINGER, WILLIS H. WISE

The courses in Physics have been developed with reference to the needs and interests of (1) students preparing for general engineering work, and (2) students who plan to specialize in Physics, Chemistry, Mathematics, or Aeronautics.

Both groups take the same general course, which has high school Physics and Trigonometry as prerequisites. It is a thorough analytical course, in which the laboratory carries the thread of the work, and the problem method is largely used. A single weekly demonstration lecture on alternate weeks, participated in by all members of the department, adds the inspirational and informational element, and serves for the development of breadth of view.

The advanced and graduate courses are designed thoroughly to equip research physicists, chemists, and engineers. Candidates for the degree of Bachelor of Science in Physics select from these courses those which best fit their objectives, viz., research work in Physics, Chemistry, or Engineering.

*2* a, b, c, d, e, f. GENERAL PHYSICS.—A general college course in Physics extending through two years. Mechanics, Molecular Physics, and Heat are taken up during the freshman year, and Electricity, Sound, and Light during the sophomore year. The subject is presented mainly from the experimental point of view, but the course includes a demonstration lecture every other week. A high school course or its equivalent, and Trigonometry are required as prerequisites. Required in all courses throughout the freshman and sophomore years.
(9 units each term)

5. ELECTRICAL MEASUREMENTS.—Deals with the theory and use of electrical and magnetic measurements and methods, with special reference to convenience of use, precision, and possible sources of error. Prerequisites: *2* a-f; Ma. 6 a, b, c. Required in Electrical Engineering courses, first term, senior year. (Gilmore) (8 units)

*7* a, b. ELECTRICITY AND MAGNETISM.—A course of advanced work in Theoretical Electricity and Magnetism with many applications to electrical and magnetic apparatus and measurements. Prerequisites: *2* a-f; Ma. 6 a, b, c. Required in Physics and Engineering and Physics courses, second and third terms, senior year. (Gilmore) (9 units each term)

8 a, b. ELECTRICAL MEASUREMENTS.—A course in electrical and magnetic measurements designed to accompany *7* a, b. Prerequisites: *2* a-f; Ma. 6 a, b, c. Required in Physics and Engineering and Physics courses, second and third terms, senior year. (Gilmore) (6 units each term)

*12* a, b. ANALYTICAL MECHANICS.—A study of the fundamental principles of theoretical mechanics; force and the laws

of motion; statics of systems of particles; the principle of virtual work, potential energy, stable and unstable equilibrium; motion of particles, systems of particles and rigid bodies; generalized co-ordinates, Hamilton's principle and the principle of least action. Prerequisites: 2 a-f; Ma. 6 a, b, c. Required in Physics and Engineering and Physics courses, first and second terms, junior year. (Friauf) (12 units each term)

15 a, b. Introduction to Mathematical Physics.—An Introduction to the application of mathematics to physics and chemistry, and practice in the solution of problems. Prerequisites: 2 a-f; Ma. 6 a, b, c. First and second terms. (Friauf) (9 units each term)

20 a, b. Physical Optics.—Lectures and class work dealing with the fundamental theoretical equations of diffraction, interference, etc., and their experimental verification. Prerequisites: 2 a-f; Ma. 6 a, b, c. Required in the Physics course, third term junior year and first term senior year. (Whitney) (9 units each term)

21 a, b. Laboratory Optics.—A course in advanced laboratory work in light, consisting of accurate measurements in diffraction, dispersion, interference, polarization, and spectrophotometry. Prerequisites: 2 a-f; Ma. 6 a, b, c. Required in the Physics course, third term junior year and first term senior year. (Whitney) (6 units each term)

For advanced courses in physics, see pages 68-74.

## SHOP INSTRUCTION

INSTRUCTORS: ARTHUR F. HALL, OSCAR L. HEALD, GEORGE D. HENCK, WALTER W. MARTIN

The aim of the subjects listed under this heading is the experimental determination of the more easily observed properties of the materials used in engineering construction, and the effects on such materials of the various manipulations and treatments common in the mechanic arts. These subjects are given in shop laboratories suitably equipped for wood and metal working, and it is assumed that during the preparation of specimens and the experiments the student will acquire some skill in the handling of tools and machines and an understanding of the practical application of the processes studied.

1. WOOD WORKING. PROPERTIES OF WOOD AND OTHER MATERIALS USED IN TIMBER CONSTRUCTION.—Study of wood growth and structure from illustrative timber sections; discussion of the relation of wood-cell structure to strength, hardness, etc., of timber; experimental comparison of wood and metals as to their strength and other properties; strength of joining devices, as glue, nails, joints; study of the general design and operation of wood working tools and machines.

2. FORGING. HOT WORKING OF METALS.—Experimental study of the strength, hardness, ductility, etc., of steel, wrought iron, cast iron and other metals; their behavior when worked at high temperatures; ability to unite by welding in forge or oxy-acetylene flame; effects of case hardening, sudden cooling, annealing on various metals; essential requirements in the design and operation of forges, heating-furnaces and metal working tools or machines.

3. PATTERN MAKING. METAL CASTINGS AND THE PATTERNS THEREFOR.—Lectures on the requirements of patterns for metal castings; the necessity for and the determination of the

amount of shrinkage, draft and other allowances; the effects of chilling and other heat treatments on cast metals; study of moulding methods and pattern construction.

4. MACHINE SHOP. COLD WORKING OF METALS.—Experiments in the cutting of metals with shears, files, cold chisels and drills, in lathes and other machine tools, with especial regard to the hardness and other properties of the metals, and the suitability of the tool cutting-edge; effect of speed and feed in machine tool operation; methods of laying out work; experimental determination of necessary accuracy in the fitting of machine parts.

1-4. (Above subjects) Required in all courses, first three weeks of summer, or during the freshman year.

(12 units for the year)

### SHOP EQUIPMENT

The equipment of the Pasadena High School is used for the shop instruction. The shops are easily accessible from the campus, and the Institute has exclusive use of this equipment and the services of the instructors on certain days for Institute students. The wood working, pattern making, forge and machine shops are all amply equipped to carry on the work of the Institute as outlined above.

## SUPPLEMENTARY SUBJECTS

1 a, b, c. ORIENTATION.—A course of lectures to freshmen by men who, by reason of special experience or professional training, are qualified to discuss their several subjects. Such topics as personal hygiene, good manners, how to study, and the obligations of college life are discussed during the first term. During the second and third terms the treatment becomes more objective, aiming to provide a conspectus of the fields of engineering and science, with a special view to preparation for an intelligently chosen professional life. Required in all courses, throughout the freshman year.

(1 unit each term)

10 a, b, c. Engineering Journals.—Recent developments and noteworthy achievements in engineering practice are observed and discussed; the student is required to report in abstract on articles of interest appearing in the successive issues of the particular engineering publication assigned to him; and is expected to keep individual abstract files of such articles as promise to be of value for reference in his later professional career. A short paper covering some notable development, or the year's progress in some line of engineering work, is required of every student at the close of each year's course. Required in Electrical, Mechanical, and Civil Engineering, and Engineering and Economics courses, throughout the junior year. (2 units each term)

## THESIS

100. Thesis or Special Problems.—A thesis will be prepared, or an equivalent amount of work done in solving assigned engineering problems. The thesis may be either an account of some investigation, or an original design accompanied by a complete exposition. Subjects of theses should be selected with the approval of the professor in charge at the close of the junior year, and formal "progress" reports submitted at the end of the first and second terms following. The thesis must be submitted to the faculty for approval at least one month before commencement. Engineering problems will be of a comprehensive nature, selected with a view to correlating various fundamental subjects in their application. All problems and theses, and records of work done in preparation therefor, remain the property of the Institute, and may not be published except by its authority. The amount of credit depends upon the course. See pages 89, 90, and 92.

[For a description of the Thesis Requirements in the Chemistry and Chemical Engineering courses, see page 111.]

# Degrees, Conferred June 8, 1923.

## Master of Science

Albert L. Raymond, B.S.

## Bachelor of Science

Charles Donald Adams
Joseph Rodney Alcock
Max Beeler Alcorn
Willard Ewing Baier
William Larribee Bangham
Harold Arthur Barnett
Loren Ellsworth Blakeley
Lyle Dillon
Arthur Gibson Duncan
Harold Shaylor Endicott
Bernard Gwynne Evans
Charles Edward Fitch
Leland Dean Fowler
Walton Gilbert
Alva Charles Hall
Robert James Hammond
David Griffith Harries, Jr.
George Isbell Hickey
Basil Hopper
Charles Stetson Howard
Douglas Garnett Kendall
L. Merle Kirkpatrick
George Cole Kuffel
Howard Bradbury Lewis
Fred George Little
Donald Holt Loughridge
Forest La Verne Lynn
George Thomas McKee
Lewis Morton Mott-Smith
Henry Todd Nies
John Rainsford North
Clarence Rice Owens
Harold Raymond Preston
John Harold Puls
George Numa Ramseyer
Hubert Alexander Reeves
Frank Fred Roberts
Lamberto Esteban de la Rocha
Lawrence Paul Roth
Stanley Truman Schofield
Robert John Schonborn
Richard Urmy Seares
Richmond Hastings Skinner
Elmer Lewis Smith
Laurance Gardinier South
Charles Arba Storms
Douglas Albert Stromsoe
Charles Perry Walker
Lloyd Andreas Walling
John Paul Walter
Paul Meacham White
Hubert Keating Woods
Robert Ellerston Woods

# Honors, 1923

DUPONT FELLOWSHIP IN CHEMISTRY: GORDON ALBERT ALLES

JUNIOR TRAVEL PRIZE: HOWARD WILLIAM GOODHUE

SOPHOMORE TRAVEL PRIZE: CARL HENRY HEILBRON, JR.

SOPHOMORE SCHOLARS: ALPHEUS BALL, JOHN STUART CAMPBELL, JAMES MAURICE CARTER, WAYNE CLARK, JACK FAHS, ROBERT FREDERICK HEILBRON, WILLIAM ABBETT LEWIS, JR.,* RICHARD POMEROY, SIDNEY ZABARO

FRESHMAN SCHOLARS: CHARLES HEWITT DIX, JAMES CLARENCE HARTWELL, RUSSELL JAMES LOVE, BERNARD NETTLETON MOORE,† FREDERICK GEORGE THEARLE‡

CONGER PEACE PRIZE: JOSEPH HURD WALKER, JR.

*Westinghouse War Memorial Scholarship
†American Chemical Society Scholarship
‡Alumni Scholarship

# Roster of Students

Abbreviations: E., Electrical Engineering; M., Mechanical Engineering; C., Civil Engineering; Ch., Chemistry; Ch.E., Chemical Engineering; Ph., Physics; Ph.E., Physics and Engineering; Eng.Ec., Engineering and Economics; G., General Courses.

## GRADUATE STUDENTS

| Name | Course | Home Address |
|---|---|---|
| ALLES, GORDON ALBERT<br>B.S., California Institute of Technology, 1922 | Ch. | Alhambra |
| ALTER, DINSMORE<br>B.S., Westminster College, 1909<br>M.S., Univ. of Pittsburgh, 1911<br>Ph.D., Univ. of California, 1916 | Ph. | Lawrence, Kansas |
| BADGER, RICHARD MCLEAN<br>B.S., California Institute of Technology, 1921 | Ch. | Monrovia, California |
| BECKMAN, ARNOLD ORVILLE<br>B.S., University of Illinois, 1922; M.S., 1923 | Ch. | Bloomington, Illinois |
| BJORKESON, ALBERT<br>Fil. Mag., University of Upsala, 1915; Fil. Lic., 1919; Ph.D., 1923 | Ph. | Upsala, Sweden |
| BRODE, ROBERT BIGHAM<br>B.S., Whitman College, 1921 | Ph. | Walla Walla, Washington |
| BURT, ROBERT CADY<br>E.E., Cornell University, 1921 | Ph. | Battle Creek, Michigan |
| CAMERON, GEORGE HARVEY<br>B.S., University of Saskatchewan, 1922 | Ph. | Saskatoon, Saskatchewan, Canada |

GRADUATE STUDENTS—Continued

| Name | Course | Home Address |
|---|---|---|
| CARROLL, JOHN<br>B.A., Univ. of Cambridge, 1921 | Ph. | Cambridge, England |
| DENIS, ARMOND G.<br>B.A., Oxford, 1920 | Ch. | Antwerp, Belgium |
| DUMOND, JESSE WM. MONROE<br>B.S., California Institute of Technology, 1916.<br>M.S., in E.E., Union College, 1918 | Ph. | Pasadena |
| DUNN, HUGH KENNETH<br>A.B., Miami University, 1918 | Ph. | Oxford, Ohio |
| EMMETT, PAUL HUGH<br>B.S., Oregon Agricultural College, 1922 | Ch. | Pasadena |
| GREENLEES, ALEC LLOYD<br>M.A., Queen's University, 1920 | Ph. | Kingston, Ontario |
| HINCKE, WILLIAM BERRARD<br>B.S., University of Illinois, 1923 | Ch. | Pinckneyville, Illinois |
| HOLTON, WILLIAM BULTMAN<br>B.S., University of Illinois, 1921; M.S., 1923 | Ch. | Olmsted Falls, Ohio |
| HOUSE, HARVEY WALTER<br>B.S., California Institute of Technology, 1920 | Ch.E. | Pasadena |
| HUTCHINSON, ARTHUR J. L.<br>A.B., Stanford University, 1919 | Ph. | Palo Alto, California |
| KIRKPATRICK, L. MERLE<br>B.S., California Institute of Technology, 1923 | Ch. | Pasadena |
| KLEIN, ARTHUR LOUIS<br>B.S., California Institute of Technology, 1921 | Ph. | Los Angeles, California |

GRADUATE STUDENTS—Continued

| Name | Course | Home Address |
|---|---|---|
| KNAPP, ROBERT TALBOT<br>B.S., Massachusetts Institute of Technology, 1920 | G. | Los Angeles, California |
| LANGER, RUDOLPH MEYER<br>B.S., College of the City of New York, 1920<br>M.A., Columbia University, 1921 | Ch. | New York City |
| LOUGHRIDGE, DONALD HOLT<br>B.S., California Institute of Technology, 1923 | Ph. | Pasadena |
| MANCHEE, VINCENT TAYLOR<br>B.S., Princeton University, 1917 | Ch. | Santa Barbara, California |
| MCKEE, GEORGE THOMAS<br>B.S., California Institute of Technology, 1923 | C. | Los Angeles, California |
| MAXSTADT, FRANCIS WILLIAM<br>M.E., Cornell University, 1916 | G. | Pasadena |
| MENDENHALL, HALLAM EVANS<br>B.S., Whitman College, 1921. | Ph. | Deer Park, Washington |
| MOTT-SMITH, LEWIS MORTON<br>B.S., California Institute of Technology, 1923 | Ph. | Los Angeles, California |
| MUYLAERT, MAURICE<br>C.M.E., Univ. of Louvain, 1922 | Ph. | Brussels, Belgium |
| NIES, HENRY TODD<br>B.S., California Institute of Technology, 1923 | E. | Pasadena |

GRADUATE STUDENTS—Continued

| Name | Course | Home Address |
|---|---|---|
| OTIS, RUSSELL MORLEY<br>B.S., California Institute of Technology, 1920 | Ph. | Pasadena |
| PAULING, LINUS CARL<br>B.S., Oregon Agricultural College, 1922 | Ch. | Portland, Oregon |
| PRESCOTT, CHARLES HOLDEN, JR.<br>A.B., Yale, 1922 | Ch. | Cleveland, Ohio |
| RAYMOND, ALBERT L.<br>B.S., California Institute of Technology, 1921; M.S., 1923 | Ch. | Pasadena |
| ROBERTSON, HOWARD P.<br>B.S., University of Washington, 1922; M.S., 1923 | Math. | Montesano, Washington |
| ROSE, EDWIN LAWRENCE<br>S.B., Massachusetts Institute of Technology, 1921 | Ph. | Pasadena |
| SCHUHMANN, REINHARDT<br>B.A., University of Texas, 1910, M.A., 1921 | Ch. | Pasadena |
| SMITH, SINCLAIR<br>B.S., California Institute of Technology, 1921 | Ph. | Pasadena |
| WARNER, ARTHUR HOWARD<br>A.B., University of Colorado, 1917; B.S., 1920 | Ph. | Carr, Colorado |
| WHITE, ERNEST CROEL<br>A.B., Randolph Macon College, 1910<br>M.S., George Washington University, 1922 | Ch. | Norfolk, Virginia |

GRADUATE STUDENTS—Continued

| Name | Course | Home Address |
|---|---|---|
| WINGER, RALPH EDGAR<br>B.A., Baker University, 1914 | Ph. | Marshfield, Oregon |
| WISE, WILLIS HOWARD<br>B.S., Montana State College, 1921; M.A., University of Oregon, 1923 | Ph. | Sherman, Colorado |
| WULF, OLIVER REYNOLDS<br>B.S., Worcester Polytechnic Institute, 1920; M.S., The American University, 1922 | Ch. | Putnam, Connecticut |

## SENIOR CLASS

| Name | Course | Home Address |
|---|---|---|
| Albright, Harold Lewis | E. | Santa Ana |
| Anderson, Kenneth Briggs | M. | Coronado |
| Baker, Floyd Arthur | E. | Anaheim |
| Barcus, Everett Dale | E. | Los Angeles |
| Baxter, Warren Phelps | Ch. | Pasadena |
| Beck, Harold Rudolph | Ph.E. | Oxnard |
| Beeson, Martin Lynn | E. | Pasadena |
| Carlson, Roy Washington | Ph. | San Jose |
| Coffey, Jule Hubert | E. | San Gabriel |
| Cornelison, Edward | C. | South Pasadena |
| Dreyer, William Conklin | E. | Glendale |
| Duncan, Sydney Ford | M. | Pasadena |
| Eckermann, Carlton Herman | G. | Covina |
| Elmore, Roy Ovid | E. | Santa Monica |
| Farnham, Harold Hurst | Ch.E. | South Pasadena |
| Forbes, Charles Leonard | M. | Glendale |
| Freeman, Hugh Barton | Ph.E. | Glendale |
| Gandy, Elmer Harold | Eng.Ec. | Pasadena |
| Goldsmith, Morris | C. | Hollywood |
| Golikoff, Boris Arkadiavitch | E. | Russia |
| Goodhue, Howard William | C. | Hemet |
| Gould, Albert Sumner | E. | Pasadena |

SENIOR CLASS—Continued

| Name | Course | Home Address |
|---|---|---|
| Gridley, Horace Velsey | C. | Pasadena |
| Griswold, Loys | E. | Glendale |
| Groat, Fred Jeremiah | E. | Whittier |
| Hall, Lawrence William | E. | Pasadena |
| Hastings, Robert Clinton | Ch.E. | Pasadena |
| Hayman, Earl Spencer | E. | Milwaukee, Wisconsin |
| Holladay, William Lee | E. | Los Angeles |
| Honn, Harry Thomas | E. | Los Angeles |
| Hopkins, George Harold | M. | Pasadena |
| Hough, Frederic Allen | Ch. | Pasadena |
| Irwin, Emmett MacDonald | E. | Riverside |
| Jameson, Archibald Yule | Ch. E. | Hollywood |
| Jenkins, Grant Vincent | G. | Yucaipa |
| Kalichevsky, Vladimir Anatole | Ch.E. | Pasadena |
| Kiesling, Louis | Eng. Ec. | Los Angeles |
| Kilham, Oliver William | M. | Pasadena |
| Landau, Maurice | E. | Los Angeles |
| Layton, Edgar Nelson | E. | Pasadena |
| Leavitt, Warren Burton | M. | Ontario |
| Liddell, Orval Eugene | M. | Los Angeles |
| Lovering, Russell Frank | C. | Pasadena |
| Lownes, Edward Datesman | Eng.Ec. | Redlands |
| Lukens, Mitchell Clark | Eng. Ec. | Pasadena |
| Magill, Paul LaFrone | Ch. | Nampa, Idaho |
| Maltby, Clifford William | E. | Hueneme |
| Mayer, Joseph Edward | Ch. | Pasadena |
| McClung, Frederick James | E. | Huntington Park |
| McKaig, Archie | G. | San Diego |
| Mercereau, James Timothy | E. | Holtville |
| Michael, Arthur Franklin | E. | Los Angeles |
| Miller, Palmer | Ch. | Portland, Oregon |
| Miller, Roy Elmer | M. | Anaheim |
| Moody, Max Washington | C. | Santa Monica |
| Morrell, Donald Francis | Eng.Ec. | Los Angeles |
| Moyse, Hollis Weaver | Ch.E. | Glendale |
| Parker, Cecil Nelson | E. | Pomona |

SENIOR CLASS—Continued

| Name | Course | Home Address |
|---|---|---|
| Peffer, Robert Ellwood | Ph.E. | Los Angeles |
| Piper, John William | C. | Los Angeles |
| Pope, Harold Frank | C. | Yucaipa |
| Ridgway, Robert Styles | M. | Pasadena |
| Ross, Maurice Bursk | Ph.E. | San Diego |
| Simpson, Thomas Patrick | Ch.E. | Fresno |
| Smith, Eugene Wood | M. | Fallbrook |
| Springer, Harold Ormiston | C. | Pasadena |
| Squires, Willis Leslie | Eng.Ec. | Pasadena |
| Stearns, Charles Fordham | Eng.Ec. | Pasadena |
| Stoker, Lyman Paul | M. | Long Beach |
| Stone, George Bagdasar | E. | Pasadena |
| Tellwright, Frank Douglas | Ph.E. | Los Angeles |
| Thayer, Edwin Force | G. | Pasadena |
| Thomas, Rolland Shields | Eng.Ec. | Long Beach |
| Tracy, Willard Harmon | Ch. | Hollywood |
| Warren, Harry L. | C. | Arcadia |
| Weinbaum, Sidney | Ph.E. | Los Angeles |
| Weitekamp, Elmer John | G. | San Diego |
| Whiting, Robert Mackenzie | M. | South Pasadena |
| Wilson, Edward Arthur | M. | Orange |
| Wilson, Ralph Chalmers | E. | Los Angeles |
| Wolochow, David | Ch.E. | Los Angeles |
| Yang, Kai Jin | Ch.E. | China |
| Young, David Robert | Eng.Ec. | Fallon, Nevada |

## JUNIOR CLASS

| Name | Course | Home Address |
|---|---|---|
| Adams, Horace Chamberlin | Ch.E. | Glendora |
| Aggeler, William Ford | E. | Los Angeles |
| Alderman, Raymond Ellis | C. | Santa Ana |
| Allen, William Head | Ch.E. | Altadena |
| Anderson, Clarence Travis | Ch.E. | Garden Grove |
| Atherton, Tracy Leon | C. | Los Angeles |

JUNIOR CLASS—Continued

| Name | Course | Home Address |
|---|---|---|
| Bailey, Emerson Dudley | Ph.E. | Los Angeles |
| Beed, Carl Frederick | C. | Encanto |
| Beed, Sterling Westman | M. | Encanto |
| Blackburn, Duncan Arnold | C. | Pasadena |
| Blackman, Ralph Villamil | Ph.E. | Los Angeles |
| Blunt, Allyn Willis | E. | Eagle Rock |
| Borschell, Edson Jaynes | E. | Pasadena |
| Bowman, Robert Barclay | Ph. | Monrovia |
| Bravender, Norris Franklin | Eng.Ec. | Hermosa Beach |
| Brunner, Michael Charles | C. | Los Angeles |
| Bryant, Walter Lowell | E. | San Diego |
| Burmister, Clarence Amandus | C. | Needles |
| Carr, John | Ph.E. | South Pasadena |
| Cartwright, Eugene Ewing | Ch.E. | Salt Lake City, Utah |
| Chapman, Albert | E. | Gardena |
| Childs, Raymond Frank | M. | Los Angeles |
| Clayton, Frank Charles Ashton | E. | Los Angeles |
| Crocker, George | E. | El Cajon |
| Dalton, Robert Hennah | Ch. | Pasadena |
| Dent, William Ulm | Ph.E. | Hollywood |
| De Remer, Edgar Merton | M. | San Fernando |
| Diack, Samuel Latta | Ch.E. | Ann Arbor, Michigan |
| Dillon, Robert Troutman | Ch. | Modesto |
| Erickson, Alfred Louis | M. | Burbank |
| Ericsson, Carl Gustav | E. | Kingsburg |
| Farman, Ivan Lonsdale | Ph.E. | Los Angeles |
| Fenner, Lawrence Gilbert | E. | Long Beach |
| Ferkel, Albert Jefferson | Ch.E. | Los Angeles |
| Flick, Holland Mills | E. | Huntington Park |
| Foster, Frank Murray | C. | Sierra Madre |
| Fowle, Royal Edgar | C. | Bellefontaine, Ohio |
| Fulwider, Robert William | M. | Pasadena |
| Gockley, Roscoe | E. | El Toro |
| Hahn, Carl Kwan | C. | Korea |
| Hamilton, James Hugh | E. | Los Angeles |

JUNIOR CLASS—Continued

| Name | Course | Home Address |
|---|---|---|
| Hansen, Raymond John | E. | Los Angeles |
| Hart, Edward Whipple | Ch.E. | Los Angeles |
| Heilbron, Carl Henry, Jr. | C. | San Diego |
| Helms, Jack Harold | Eng.Ec. | Glendale |
| Henderson, Lawrence Pelton | M. | Pasadena |
| Henderson, William Gilmore | Ph.E. | Tornillo, Texas |
| Herner, Ernest Paul | C. | Claremont |
| Hertenstein, Wesley Charles | C. | Azusa |
| Hess, Ben Ewart | Ch.E. | Huntington Park |
| Hill, Byron Arthur | C. | Barstow |
| Hotchkiss, Thomas Myron | E. | Monrovia |
| Jones, David Thomas | E. | Hollywood |
| Jones, Herbert James | E. | Coronado |
| Jones, Walter Bond | E. | Santa Barbara |
| Karelitz, Michael Boris | E. | Pasadena |
| Kniaseff, Vasily | Ch.E. | China |
| Knox, Carl Bradford | M. | Huntington Par |
| Krouser, Caryl | E. | Oxnard |
| Larabee, Oscar Seymour | E. | Los Angeles |
| Larson, Frans August | E. | Altadena |
| Laws, Allen Lee | E. | Ontario |
| Leonard, Leonid Vladimirovich | M. | Russia |
| Losey, Theodore Chapin | Eng.Ec. | South Pasadena |
| Maag, Ernst | E. | Monrovia |
| Martin, Harold Judson | E. | Pasadena |
| Maurer, John Edward | Eng.Ec. | Los Angeles |
| McProud, Charles Gilbert | E. | Long Beach |
| Melnikoff, Demitry Nicholas | E. | Pasadena |
| Merrill, Richard Henry | E. | Oceanside |
| Merrill, Robert Arthur | C. | Maywood, Illinois |
| Miller, Leo Marco | C. | Los Angeles |
| Moore, James Edward | Eng.Ec. | El Cajon |
| Morikawa, Fred Masato | E. | Japan |
| Newcomb, Leroy | E. | San Bernardino |
| Newton, Alfred Arthur | Eng.Ec. | Venice |
| Noll, Paul Edward | M. | Pasadena |

JUNIOR CLASS—Continued

| Name | Course | Home Address |
|---|---|---|
| Palmer, Richard Walter | Ph.E. | Pasadena |
| Pearson, Rolland Robert | E. | Burbank |
| Peterson, Earl Randolph | C. | Yucaipa |
| Pompeo, Domenick Joseph | Ph.E. | Jersey City, New Jersey |
| Prentice, Leland Busby | Ch.E. | Los Angeles |
| Ranney, Kenneth Wyckoff | Ch.E. | Santa Ana |
| Rapp, Clinton | C. | Long Beach |
| Rivinius, Paul Clifton | Eng.Ec. | Pasadena |
| Salsbury, Markham Elmer | C. | Santa Barbara |
| Schlegel, Glenn Marcus | C. | Los Angeles |
| Schumacher, Karl Fritz | C. | San Diego |
| Schumaker, Halsey Rhees | E. | Pasadena |
| Scott, Percival Thomas Walter | E. | Fullerton |
| Scudder, Nathan Frost | Ch. | Pasadena |
| Sellers, Douglas William | E. | Pasadena |
| Seymour, Stuart Lewis | E. | Pasadena |
| Shafer, Edgar Esterly, Jr. | Ch.E. | Alhambra |
| Sheffield, Harold Clough | Ch.E. | South Pasadena |
| Smith, Dwight Olney | M. | Long Beach |
| Smith, Neal Deffebach | Ph.E. | Reedley |
| Sonnabend, Max Leo | E. | Los Angeles |
| Spelman, George Curtiss | M. | Santa Monica |
| Stewart, Earl Deloris | Ch. | Huntington Park |
| Tackabury, Howard Stevely | M. | Los Angeles |
| Tanaka, Masaru | G. | Lihue, Hawaii |
| Templeton, John Dickson | Eng.Ec. | Casper, Wyoming |
| Templin, Newton Henry | C. | Pasadena |
| Thacker, Gerald | C. | Los Angeles |
| Thompson, Wilfred Gregg | M. | Hemet |
| Walker, Joseph Hurd, Jr. | E. | Los Angeles |
| Waller, Conrad Judson | Eng.Ec. | Pasadena |
| Watkins, Robie Thomas | E. | San Bernardino |
| Wilson, Keith Maple | E. | Colton |
| Winckel, Edmond Emile | C. | Hollywood |
| Wrestler, Ora Lorenzo | Ch.E. | San Pedro |

## SOPHOMORE CLASS

| Name | Course | Home Address |
|---|---|---|
| Allyn, Arthur Barnard | Ch.E. | Pasadena |
| Anissimoff, Constantin Ivanovitch | E. | Los Angeles |
| Austin, Henry Carter | E. | San Bernardino |
| Bailey, Bennett Preble | Ch.E. | Altadena |
| Baker, Jack Correll | E. | Santa Monica |
| Ball, Alpheus | Ch.E. | Los Angeles |
| Barker, Forrest West | M. | Los Angeles |
| Bawbell, Robert Clark | C. | Hollywood |
| Baxter, Ellery Read | Ch.E. | Pasadena |
| Baylin, Meyer | E. | Los Angeles |
| Beverly, Burt, Jr. | Ph.E. | Pasadena |
| Bidwell, Charles Hawley | E. | Pasadena |
| Bogen, Robert | C. | Los Angeles |
| Bryan, Roger Bates | Ch.E. | San Diego |
| Bull, Alvah Stanley | C. | Riverside |
| Buxton, John | Ch.E. | Douglas, Arizona |
| Byler, Albert Elliott | E. | Santa Ana |
| Byrne, Hugh Joseph | M. | Anaheim |
| Campbell, John Stuart | Ph.E. | Pasadena |
| Carter, James Maurice | Ch. | Beverly Hills |
| Cartwright, Charles Hawley | Ph.E. | San Gabriel |
| Catey, Raymond | M. | Redondo Beach |
| Chaffee, Hugh LeRoy | E. | Pasadena |
| Cheney, Lyle Howard | Ch. | Pasadena |
| Clapp, George Wirt | Ph. | Pasadena |
| Clark, Wayne | Ph.E. | Los Angeles |
| Coleman, Theodore Cleaveland | C. | Pasadena |
| Copeland, Ralph Ehrnman | C. | Los Angeles |
| Copeland, Ray Edwin | C. | Los Angeles |
| Crowley, Homer Lawrence | E. | Los Angeles |
| Cruzan, Walter | E. | Los Angeles |
| Cunningham, Harry Earl | E. | Terminal |
| Darling, Mortimer Dick, Jr. | Eng.Ec. | Los Angeles |
| Degnan, Dwight Alexander | Eng.Ec. | Lorain, Ohio |

SOPHOMORE CLASS—Continued

| Name | Course | Home Address |
|---|---|---|
| Detzer, Stephen | Eng.Ec. | Hollywood |
| Dinsmore, Daniel George | E. | Riverside |
| Dixon, LeRoy | Eng.Ec. | Los Angeles |
| Doane, Edwin Addison | E. | Eureka |
| Doane, Walter Carleton | Eng.Ec. | Eureka |
| Dunlap, Philip Tyler | C. | Los Angeles |
| Edwards, Manley Warren | E. | Pasadena |
| Erickson, Richard Gordon | Ch.E. | El Centro |
| Fahs, John Louis | Ch.E. | Fullerton |
| Ficklen, Joseph Borwell, III | Ch.E. | Fredericksburg, Virginia |
| Forsyth, John Norman | E. | Santa Rosa |
| Freeman, Henry Ross | C. | South Pasadena |
| Freeman, Ralph Allen | C. | Visalia |
| Fricker, Felix Oscar | E. | Los Angeles |
| Garnett, Ernest Edwin, Jr. | C. | San Diego |
| Gilbert, Riley Llewellyn | M. | Victoria, B. C., Canada |
| Graham, Glenn | C. | Elsinore |
| Granger, Wayne E. | E. | Long Beach |
| Gulick, Frank Martin | E. | Orange |
| Hale, Frank Sherman | C. | Moneta |
| Halik, Glen | M. | La Crosse, Wisconsin |
| Hall, Ray Irvin | C. | Los Angeles |
| Hamburger, Frey | E. | Pasadena |
| Hanes, Mason Day | M. | Fort Dodge, Iowa |
| Hanson, Victor Frederick | Ph. | Hollywood |
| Hastings, James Wilbert | Ch.E. | Pasadena |
| Hayward, Claude Dewayne | E. | Santa Ana |
| Heilbron, Robert Frederick | Ph.E. | San Diego |
| Henderson, Henry Phillips | M. | Glendale |
| Herrington, William Charles | E. | San Pedro |
| Higman, Arch | Ph.E. | Pasadena |
| Hinkston, Donald Robert | Ph.E. | Battle Lake, Minnesota |
| Holod, George P. | E. | Pasadena |
| Houda, Milton | E. | Banning |
| Huggins, Harold Ferris | M. | Tacoma, Washington |
| Humphrey, Charles, II | C. | Los Angeles |

SOPHOMORE CLASS—Continued

| Name | Course | Home Address |
|---|---|---|
| Ingersoll, Herbert Victor | E. | Pasadena |
| Jaffray, George Robert | Ch.E. | Los Angeles |
| Johnson, Walter Stuart | E. | Santa Monica |
| Jones, Maurice Townley | E. | Santa Barbara |
| Kagan, Jacob Aaron | M. | Pasadena |
| Kagiwada, Frank Eiho | E. | Japan |
| Kaye, George Robert | Ch. | Los Angeles |
| Kibort, Leon | E. | Pasadena |
| Kiernan, Earl Franklin | Ph.E. | Pasadena |
| Kinsey, John Edward | Ch.E. | Los Angeles |
| Knupp, Seerley Gnagy | E. | Whittier |
| Kroneberg, Alex A. | E. | Riverside |
| Lewis, William Abbett, Jr. | E. | Los Angeles |
| Lord, Harold Wilbur | E. | Pasadena |
| Lutes, Arnold Stevens | E. | Duluth, Minnesota |
| Macfarlane, Donald Peter | E. | Pasadena |
| Maechtlen, Lawrence George | M. | Los Angeles |
| Margison, Leslie Wills | E | Iron Mountain, Michigan |
| Matson, Joseph, Jr. | E | Altadena |
| McClain, Lewis Smith | M. | Pasadena |
| Michelmore, John Elwert | C. | Pasadena |
| Mills, Albert Kuhn | C. | Long Beach |
| Mills, Bruce Hopf | C. | Pasadena |
| Minkler, William Annin | E. | Pasadena |
| Moodie, Robert Wardwell | C. | Pasadena |
| Moore, George Edward | E. | Los Angeles |
| Neil, William Harvey | Ch.E. | Long Beach |
| Nordquist, Carroll Oscar | Ch.E. | Los Angeles |
| Parker, Howard Allen | Eng.Ec. | Long Beach |
| Parker, Percy Edwin | E. | Fullerton |
| Parnall, Sam | M. | Hollywood |
| Payne, Leonard Bailey | Eng.Ec. | Chino |
| Penfield, Wallace Clay | M. | South Pasadena |
| Phillips, Harry Merton | Ph.E. | Phoenix, Arizona |
| Pomeroy, Richard | Ch. | Burbank |
| Porush, Vladimir | C. | Los Angeles |

SOPHOMORE CLASS—Continued

| Name | Course | Home Address |
|---|---|---|
| Pyle, Merle Ivan | E. | Pasadena |
| Rathaus, Arthur | C. | Hollywood |
| Reed, Jack Switzer | E. | Pasadena |
| Remington, Harry Leslie | M. | San Diego |
| Riggs, Eugene Howard | Eng.Ec. | Pasadena |
| Rodgers, Vincent Wayne | Ch.E. | Los Angeles |
| Ross, Paul Kenneth | G. | Pasadena |
| Russell, George Wesley | E. | Los Angeles |
| Sammer, Boris Nicholas | M. | Harbin, China |
| Sawyer, John Junior | Ph.E. | Long Beach |
| Schabarum, Bruno Rudolph | M. | Los Angeles |
| Schmid, George Christian | Ch. | Pasadena |
| Schott, Hermann Franz | Ch.E. | Santa Barbara |
| Schueler, Alfred Edward | E. | Pasadena |
| Schultz, Murray Navarre | Ch.E. | Los Angeles |
| Serrurier, Mark Usona | C. | Altadena |
| Sinram, William Melville | Ph.E. | Hollywood |
| Sokoloff, Vladimir Petrovich | Ch.E. | Harbin, China |
| Sokoloff, Vadim | Ch.E. | Pasadena |
| Spassky, Gleb Alexander | E. | Harbin, China |
| Stanton, Robert James | M. | Los Angeles |
| Stein, Robert Oliver | C. | Alhambra |
| Stewart, George Shearer | C. | Hollywood |
| Stewart, Robert Moore | E. | McMinnville, Oregon |
| Streit, Frank Hershey | E. | South Pasadena |
| Thacker, Ralph Scott | Ch.E. | Riverside |
| Triggs, Ira Ellis | M. | Rivera |
| Valby, Edgar | Ch.E. | Long Beach |
| VandenAkker, Joy | Ph.E. | Los Angeles |
| Vanoni, Vito August | C. | Somis |
| Voelker, Joachim | Ch.E. | Oxnard |
| Walker, Reginald Christian | E. | San Gabriel |
| Ward, Edward C. | Ch.E. | Hemet |
| Weber, Willis Waldo | M. | Los Angeles |
| Werden, Arthur Clinton, Jr. | E. | Eagle Rock |
| West, Lloyd E. | Eng.Ec. | Riverside |

SOPHOMORE CLASS—Continued

| Name | Course | Home Address |
|---|---|---|
| West, Myron Eldo | E. | Yorba Linda |
| Wiegand, Frank Hale | E. | Hollywood |
| Williams, Horton Carr | E. | Pasadena |
| Williamson, William E. | E. | Gilman, Iowa |
| Wingfield, Baker | Ch. | Pasadena |
| Wisegarver, Burnett Blanchard | Ch.E. | Huntington Park |
| Wulff, Norman Herbert | Ch.E. | Pasadena |
| Zabaro, Sidney | Ch. | Los Angeles |
| Zbradovsky, Boris | M. | Harbin, China |

## FRESHMAN CLASS

| Name | Course | Home Address |
|---|---|---|
| Adrian, James, Jr. | Ch. | Pasadena |
| Anderson, Arthur Baker | C. | Los Angeles |
| Anderson, Carl | E. | Los Angeles |
| Anderson, Elvin Edward | Ch. | Templeton |
| Anderson, Henry Pierce | C. | Los Angeles |
| Andrews, Wendell Lofton | G. | Los Angeles |
| Armstrong, Fred | Ph. | Kansas City, Missouri |
| Arnold, William A. | E. | Van Nuys |
| Baird, James Charles | M. | Los Angeles |
| Bauer, Paul Harold | E. | Santa Monica |
| Belknap, Kenneth Albert | Ch.E. | Los Angeles |
| Berg, Lawrence Everett | E. | San Gabriel |
| Bidwell, Edwin Lindsley | M. | Pasadena |
| Blankenburg, Rudolph Carter | E. | San Diego |
| Bloom, Carl | Ch. | Hutchinson, Kansas |
| Bogen, David | Ph.E. | Los Angeles |
| Bower, Maxwell | E. | Los Angeles |
| Boyd, James | E. | Hollywood |
| Bradley, Charles, Jr. | Ch. | Long Beach |
| Brown, Townsend | E. | Zanesville, Ohio |
| Burke, Maxwell Follansbee | E. | Los Angeles |
| Burrell, George Sumney | C. | Hollywood |
| Capon, Alan Edmonds | E. | Eagle Rock |

FRESHMAN CLASS—Continued

| Name | Course | Home Address |
|---|---|---|
| Case, John Gideon | C. | Pasadena |
| Clark, Donald | Ph. | Van Nuys |
| Clark, William Dolph | C. | Long Beach |
| Cloyes, Frank Harris | Ch.E. | Santa Ana |
| Coffee, Garfield Clinton | E. | Pasadena |
| Coffey, George William | G. | Riverside |
| Combs, Theodore Carlos | Ch.E. | Ontario |
| Cox, Raymond Edward | Ch. | South Pasadena |
| Crowther, Dexter Paul | C. | Pasadena |
| Cutler, Ralph Waldo | C. | Douglas, Arizona |
| Datin, Richard | E. | Los Angeles |
| Dix, Charles Hewitt | Ph. | Pasadena |
| Drasdo, Albert | Ch. | San Diego |
| Dresser, Harold Albert | M. | Santa Ana |
| Ewing, Fred Junior | Ch. | Pasadena |
| Farrar, Harry King | E. | Tustin |
| Feely, Glenn | Ch. | Bakersfield |
| Fenwick, Kenneth Macdonald | C. | Los Angeles |
| Fisher, Elmer Howard | E. | Penticton, B. C., Canada |
| Foster, Alfred Leon | Ch. | Los Angeles |
| Foster, Charles Bullock | C. | Pasadena |
| Fowlkes, William Belmont | Ch.E. | Pasadena |
| Francis, Willard Hall | Ph. | Ventura |
| Froggatt, William Ellsorth | E. | Covina |
| Fry, Donald Hume, Jr. | Ch. | South Pasadena |
| Galban, John | E. | Los Angeles |
| Gale, Herbert Austin | C. | Santa Monica |
| Gardner, David Z., Jr. | E. | South Pasadena |
| Gazin, Lewis | E. | Los Angeles |
| Gilmore, Edward Raymond | C. | Dover, New Jersey |
| Gleason, Frederick Thomas | C. | Glendale |
| Gordon, Ernest Alfred | Eng.Ec. | Tacoma, Washington |
| Gottier, Thomas Larimer | E. | Los Angeles |
| Green, Robert Norton | C. | Pasadena |
| Gubser, Regis Samuel | E. | Los Angeles |
| Gunning, J. Henry | C. | Los Angeles |

FRESHMAN CLASS—Continued

| Name | Course | Home Address |
|---|---|---|
| Hallett, Percy Shaul | E. | Pasadena |
| Harrison, Ercell Burton | E. | Pasadena |
| Hartwell, Charles Edward | E. | Pasadena |
| Hartwell, James Clarence | Ch. | Simi |
| Haserot, Clarence Lewis | Ch. | Los Angeles |
| Haydon, L. Albert | G. | Taft |
| Hertz, John Dickinson | E. | Vancouver, Wisconsin |
| Hodel, George Hill | G. | Los Angeles |
| Holland, James Edward | E. | Napa |
| Hook, George Walter | M. | Los Angeles |
| Hookway, Lozell Charles | C. | Pasadena |
| Hoover, Vaino | E. | Los Angeles |
| Hossack, Hugh Alger | Ph. | Ventura |
| Houghton, William Mixer | C. | South Pasadena |
| Hudson, Frank Martin | E. | Los Angeles |
| Hume, Norman Bridge | M. | Pasadena |
| Jackson, William D'Aguilar | Eng.Ec. | Los Angeles |
| Jaeger, Vernon Paul | E. | Turlock |
| James, Jerome Buster | E. | Pasadena |
| Jones, Edward Palmer, Jr. | C. | Alhambra |
| Kaneko, George Shinichiro | E. | Riverside |
| Kasperowicz, Stephen Thomas | Ch. | Vernon |
| Ketcham, Charles Foster | E. | Banning |
| Kiech, Clarence Frank | E. | Riverside |
| Kienly, Harold Theodore | E. | Pasadena |
| King, Archie Paul | Ph.E. | Altadena |
| Kirkwood, John Gamble | Ch. | Wichita, Kansas |
| Kondrashoff, Sergei E. | M. | Harbin, China |
| Krelle, William Hay | M. | Los Angeles |
| Kreutzer, Leslie | E. | Ellis, South Dakota |
| Lambert, Dale Clifton | E. | Eagle Rock |
| Larson, Hilmer Edwin | E. | Pasadena |
| Levine, Edward Morris | M. | Covina |
| Lilly, Forrest James | M. | Los Angeles |
| Logan, Mason Arnold | E. | Pasadena |

FRESHMAN CLASS—Continued

| Name | Course | Home Address |
|---|---|---|
| Lohse, Raymond Floyd | M. | Pasadena |
| Longaker, Robert Edgar | E. | Los Angeles |
| Love, Russell | E. | Los Angeles |
| Marsland, John Ely | Ch.E. | Venice |
| Mason, William Andrews | E. | Hollywood |
| Matson, Randolph | Ph. | Fellows |
| Maxson, John Haviland | E. | Pasadena |
| Mayhew, Paul Donald | Ch. | Pasadena |
| McComb, Harry Thurlow | E. | Alhambra |
| McGee, Theodore Allen | E. | Pasadena |
| Medlin, Lewis Everett | Eng.Ec. | Morrill, Nebraska |
| Merritt, Will Dockery | M. | Mount Airy, N. C. |
| Meserve, Frank Pierce, Jr. | E. | Redlands |
| Metz, David Radford | Eng.Ec. | Santa Ana |
| Miller, William Brenton | E. | South Pasadena |
| Minkler, Cyrus Gordon | Eng.Ec. | Pasadena |
| Moore, Bernard Nettleton | Ch. | Los Angeles |
| Moore, Robert Merrell | M. | Pasadena |
| Murai, Frank Yoshi | E. | Brawley |
| Muschenheim, Carl | M. | New York, New York |
| Musselman, Weidler Bard, Jr. | M. | Long Beach |
| Myers, James Henry | C. | Fallbrook |
| Netz, Donald Carlisle | Ch. | Alhambra |
| Nickell, Frank Andrew | C. | Los Angeles |
| Olsen, Lewis William | G. | Sierra Madre |
| Orsatti, Louis | M. | Los Angeles |
| Owen, Winthrope Harold | Ch. | Covina |
| Perry, Raymond Carver | Ph.E. | Santa Monica |
| Petersen, Frank Fred | M. | San Diego |
| Peterson, Thurman Stewart | C. | Los Angeles |
| Philleo, Rolland | E. | Covina |
| Powers, Russell William | C. | San Pedro |
| Pugh, Evan Ellis | E. | Pasadena |
| Ralston, Lee Walter | M. | Redlands |
| Randolph, Engle Fitz | E. | Redlands |
| Rees, Philip | Ch. | Los Angeles |

FRESHMAN CLASS—Continued

| Name | Course | Home Address |
|---|---|---|
| Reynolds, Roland William | Ch. | Los Angeles |
| Robinson, Arthur Alan | Ch. | Fresno |
| Robinson, Roger | Ch. | La Verne |
| Ross, Leonard Wikoff | E | San Diego |
| Ross, Robert Trowbridge | M. | Pasadena |
| Roush, Frank Maxwell | C. | Pasadena |
| Runnells, Thomas Raymond | E. | Los Angeles |
| Russell, George Vernon | C. | San Bernardino |
| Scheck, Richard Theodore | Ch. | Los Angeles |
| Schell, Frederick Taylor | E. | Long Beach |
| Scott, Malcolm Leeds | E. | Pasadena |
| Shintani, Kenichi | Ch. | Hollywood |
| Shuster, John Davis | G. | Pasadena |
| Skov, Bunde Bundeson | E. | Pasadena |
| Snider, John Franklin | E. | Terra Bella |
| Snyder, Leonard Leroy | C. | Pasadena |
| Southwick, Thomas Scott | E. | Los Angeles |
| St. Clair, Raymond | Ch. | Atascadero |
| St. Helen, Cecil Dewey | Ch. | Portland, Oregon |
| Stanton, Layton | G. | Lamanda Park |
| Starke, Howard Richard | Ch. | South Pasadena |
| Swartz, Charles Albert | E. | Pasadena |
| Thearle, Frederick George | M. | Pasadena |
| Thompson, Donald Raw | Ch. | South Pasadena |
| Thompson, Russell Edgar | E. | Los Angeles |
| Tolle, Guy | E. | Los Angeles |
| Turner, Francis Earl | E. | Anaheim |
| Upward, Aubrey Bowles | C. | Oakland |
| Vaile, Robert Brainard, Jr. | E. | Alhambra |
| Valdivieso, Alfonso Jose | M. | Central America |
| Van Sickle, William Wallace | M. | Walnut Park |
| Wade, Archie, Jr. | E. | Los Angeles |
| Ward, Roderick Charles | E. | Pasadena |
| Wells, Carlos Kenyon | E. | Pasadena |
| Westlund, Karl | E. | San Fernando |
| White, Albert Huiskamp, Jr. | E. | La Habra |

FRESHMAN CLASS—Continued

| Name | Course | Home Address |
|---|---|---|
| Whittington, Richard Byrne | Ch. | Long Beach |
| Wichman, William Charles | M. | Charles City, Iowa |
| Wyre, Wilbur | C. | Pasadena |
| Zeller, Earl Franklin | Ch. | Erie, Pennsylvania |

## SUMMARY

| | |
|---|---|
| Graduate Students | 43 |
| Seniors | 83 |
| Juniors | 112 |
| Sophomores | 151 |
| Freshmen | 170 |
| Total Registration | 559 |

# Index

CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA