VOLUME XXXVII NUMBER 121

BULLETIN

OF THE

CALIFORNIA INSTITUTE

OF

TECHNOLOGY

ANNUAL CATALOGUE

PASADENA, CALIFORNIA

DECEMBER, 1928

Contents

Calendar

1929

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	..	..	..	..
..	..	..	..	..	..	..

1930

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
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	13	..	..
..	..	..	..	..	..	..

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

1929

JANUARY 2.....Registration (9 A. M. to 3 P. M.)

JANUARY 19.....Examinations for Removal of Conditions

MARCH 1....Last Day for Applications for Fellowships and Assistantships

MARCH 13-16.....Term Examinations

MARCH 16.....End of Second Term

MARCH 17-24.....Recess

MARCH 20.....Notifications of Award of Fellowships and Assistantships

MARCH 23.....Meetings of Registration Committees

MARCH 25.....Registration (9 A. M. to 3 P. M.)

APRIL 13.....Examinations for Removal of Conditions

MAY 13.....Last Day for Removing Senior Deficiencies

MAY 23.....Last Day for Examinations and Presenting Theses for the Degree of Doctor of Philosophy

MAY 30.....Memorial Day Recess

MAY 30.....Last Day for Examinations and Presenting Theses for the Degree of Master of Science to be Conferred in June

JUNE 1.....End of Examinations for Seniors

JUNE 4-8.....Term Examinations for all Students except Seniors

JUNE 4.....Departmental Meetings (9 A. M.)

JUNE 4.....Faculty Meeting (1:30 P. M.)

JUNE 6.....Class Day

JUNE 7.....Commencement

JUNE 7.....Annual Meeting of Alumni Association

JUNE 8.....End of College Year

JUNE 6-8.....Examinations for Admission to Upper Classes

JUNE 17.....Meetings of Registration Committees

JULY 1-2.....Examinations for Admission to Freshman Class and for Freshman Scholarships

SEPTEMBER 23-24.....Examinations for Admission to Freshman Class

SEPTEMBER 24-25.....Examinations for Admission to Upper Classes

SEPTEMBER 25.....Examinations for Removal of Conditions

SEPTEMBER 26.....Registration of Freshmen (9 A. M.)

SEPTEMBER 27.....General Registration (9 A. M. to 3 P. M.)

SEPTEMBER 28.....General Registration (9 A. M. to 12 M.)

SEPTEMBER 30.....Beginning of Instruction

NOVEMBER 28-DECEMBER 1.....Thanksgiving Recess

DECEMBER 2....Last Day for Announcing Candidacy for Bachelor's Degree

DECEMBER 18-21.....Term Examinations

DECEMBER 21.....Last Day for Filing Applications for Candidacy for the Degree of Doctor of Philosophy, to be Conferred June, 1930

DECEMBER 21.....End of First Term (12 M.)

JANUARY 4, 1930.....Meetings of Registration Committees

JANUARY 6.....Registration (9 A. M. to 3 P. M.)

The Board of Trustees

(Arranged in the order of seniority of service)

	Term Expires
Hiram W. Wadsworth 716 South El Molino Avenue, Pasadena.	1932
Arthur H. Fleming 1003 South Orange Grove Avenue, Pasadena.	1930
George E. Hale 739 Hermosa Avenue, South Pasadena.	1932
Charles W. Gates Fordyce, Arkansas.	1928
Henry M. Robinson 195 South Grand Avenue, Pasadena.	1931
R. C. Gillis 215 West Ninth Street, Los Angeles.	1932
R. R. Blacker 1177 Hillcrest Avenue, Pasadena.	1929
Harry Chandler The Times, Los Angeles.	1929
Henry W. O'Melveny Title Insurance Building, Los Angeles.	1930
Allan C. Balch Biltmore Hotel, Los Angeles.	1928
Louis D. Ricketts 349 South Grand Avenue, Pasadena.	1930
Joseph B. Dabney 1208 Bank of Italy Building, Los Angeles.	1931
William L. Honnold 523 West Sixth Street, Los Angeles.	1931
William G. Kerckhoff 740 South Broadway, Los Angeles.	1928

OFFICERS

Arthur H. Fleming	President
Allan C. Balch	First Vice-President
Charles W. Gates	Second Vice-President and Treasurer
Hiram W. Wadsworth	Third Vice-President
Edward C. Barrett	Secretary and Assistant Treasurer

FINANCE COMMITTEE

Arthur H. Fleming, Chairman

Allan C. Balch
Charles W. Gates
William L. Honnold
Louis D. Ricketts

Administrative Officers of the Institute

EXECUTIVE COUNCIL

ROBERT A. MILLIKAN, Chairman
ALLAN C. BALCH
ARTHUR H. FLEMING
GEORGE E. HALE
THOMAS H. MORGAN
WILLIAM B. MUNRO
ARTHUR A. NOYES
HENRY M. ROBINSON

EDWARD C. BARRETT, Secretary

CHAIRMEN OF DIVISIONS

ROBERT A. MILLIKAN....Physics, Mathematics, and Electrical Engineering
ARTHUR A. NOYES....Chemistry and Chemical Engineering
FRANKLIN THOMAS....Civil and Mechanical Engineering
JOHN P. BUWALDA....Geology and Paleontology
THOMAS H. MORGAN....Biology
CLINTON K. JUDY....Humanities
ROYAL W. SORENSEN....Physical Education

OTHER OFFICERS

FREDERIC W. HINRICHS, JR....Dean of Upper Classmen
JOHN R. MACARTHUR....Dean of Freshmen
EDWARD C. BARRETT....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, President, Bell Telephone Laboratories, Inc., and Vice-President, American Telephone and Telegraph Company.

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

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

ADVISER IN ATHLETICS

DAVID BLANKENHORN, Pasadena

Officers and Committees of the Faculty

OFFICERS

CHAIRMAN, A. A. Noyes.
SECRETARY, H. C. Van Buskirk.
DEAN OF UPPER CLASSMEN, F. W. Hinrichs, Jr.
DEAN OF FRESHMEN, J. R. Macarthur.

GENERAL COMMITTEES

FACULTY BOARD, Chairman, F. W. Hinrichs, Jr.; Secretary, H. C. Van Buskirk.

The Board consists of the officers of the Faculty, of the chairmen of the Divisions of the Institute, of the chairmen of the Committees named below, and of three members at large.

REGISTRATION, Chairman, H. C. Van Buskirk.
FRESHMAN REGISTRATION, Chairman, J. E. Bell.
COURSE IN ENGINEERING, Chairman, R. L. Daugherty.
COURSE IN SCIENCE, Chairman, W. N. Lacey.
GRADUATE STUDY, Chairman, R. C. Tolman.
ENGINEERING RESEARCH, Chairman, C. C. Thomas.
HONOR STUDENTS, Chairman, I. S. Bowen.
STUDENT RELATIONS, Chairman, F. Thomas.
PHYSICAL EDUCATION, Chairman, R. W. Sorensen.

Research Associates, 1928-1929

SAMUEL JACKSON BARNETT, PH.D.
Research Associate in Physics

GODFREY HAROLD HARDY, SC.D., LL.D.
Associate in Mathematics
Savilian Professor of Geometry, Oxford University

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

ARNOLD SOMMERFELD, PH.D.
Research Associate in Physics
Professor of Physics, University of Munich

HARRY O. WOOD, M.A.
Research Associate in Seismology
Research Associate of Carnegie Institution of Washington

Staff of Instruction and Research

Robert Andrews Millikan, Ph.D., LL.D., Sc.D., Nobel Laureate

Director of the Norman Bridge Laboratory of Physics
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. Sc.D. (hon.), Oberlin College, 1911; Northwestern University, 1913; University of Pennsylvania, 1915; Amherst College, 1917; Columbia University, 1917; University of Dublin, 1924; Yale University, 1925; Leeds University, 1927; Princeton University, 1928. LL.D., University of California, 1924; University of Colorado, 1927. Ph.D. (hon.), King John Casimir University, Lwów, Poland, 1926; University of Ghent, 1927. Vice-President, American Association for the Advancement of Science, 1911; 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; American Representative, Troisiéme Conseil de Physique, Solvay, Brussels, 1921; Exchange Professor, Belgium, 1922; American Representative, Committee on Intellectual Cooperation, League of Nations, 1922-. Member, American Philosophical Society, National Academy of Sciences, American Academy of Arts and Sciences. *Corresponding Member, Société* Batave de Philosophie Expérimentale à Rotterdam, Académie des Sciences de Russie, Institut de France Académie des Sciences. Hon. Member, Royal Institution of Great Britain, La Société Hollandaise des Sciences, Royal Irish Academy, Die Gesellschaft der Wissenschaften zu Göttingen. Recipient of Comstock Prize, National Academy of Sciences, 1913; of Edison Medal of the American Institute of Electrical Engineers, 1922; of the Nobel Prize in Physics of the Royal Swedish Academy, 1923; of the Hughes Medal of the Royal Society of Great Britain, 1923; of the Faraday Medal of the London Chemical Society, 1924; of the Matteucci Medal of the Societa Italana della Scienze, 1925; of the Gold Medal of the American Society of Mechanical Engineers, 1926; and of the Messel Medal of the Society of Chemical Industry of England, 1928. California Institute, 1916-

300 Palmetto Drive

Thomas Hunt Morgan, Ph.D., LL.D., Sc.D.

Chairman of the Division of Biology, William G. Kerckhoff Laboratories of the Biological Sciences
Member of the Executive Council

B.S., State College of Kentucky, 1886; M.S., 1888; Ph.D., Johns Hopkins University, 1890. Professor of Biology, Bryn Mawr College, 1891-1904; Professor of Experimental Zoology, Columbia University, 1904-1928, LL.D., State College of Kentucky, 1916; Johns Hopkins University, 1917; McGill University, 1921; Sc.D., University of Edinburgh, 1922; University of Michigan, 1924. Fellow of American Association for the Advancement of Science; Member, American Philosophical Society; Foreign Member, Royal Society of London; Corresponding Member, Academy of Petrograd; Honorary Member, Royal Irish Academy, Société Biologique de France, Société Zoologique et Malacol de Belge, Société des Sciences Médicales et Naturelles de Bruxelles, Royal Society of Science of Upsala, Zoological Societies of Norway, Denmark, Finland, Moscow, and Munich; President, National Academy of Sciences, 1927-. California Institute, 1928-

1149 San Pasqual Street

WILLIAM BENNETT MUNRO, PH.D., LL.D.

Professor of History and Government
Member of the Executive Council

B.A., Queens University, 1895; M.A., 1896; LL.B., 1898; M.A., Harvard University, 1899; Ph.D., 1900, M.A. (hon.), Williams College, 1904; LL.D., Queens University, 1912; Parker Traveling Fellow, Harvard University, 1900-1901; Instructor in History and Political Science, Williams College, 1901-1904; Instructor in Government, Harvard University, 1904-1906; Assistant Professor of Government, 1906-1912; Professor of Municipal Government, 1912-1925; Jonathan Trumbull Professor of American History and Government, 1925-; Chairman of the Division of History, Economics and Government, Harvard University, 1920-; Weil Foundation Lecturer, University of North Carolina, 1921; McBride Foundation Lecturer, Western Reserve University, 1925; Jacob H. Schiff Foundation Lecturer, Cornell University, 1926; President of the American Political Science Association, 1927; Major, United States Army, 1918-1919; Fellow of the American Academy of Arts and Sciences. California Institute, 1925-

268 Bellefontaine Street

ARTHUR AMOS NOYES, PH.D., LL.D., SC.D.

Director of the Gates Chemical Laboratory
Member of the Executive Council

S.B., Massachusetts Institute of Technology, 1886; S.M., 1887; Ph.D., University of Leipzig, 1890; LL.D., University of Maine, 1908; Clark University, 1909; University of Pittsburg, 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; President, American Association for Advancement of Science, 1927; Honorary Fellow, 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. Davy Medal, Royal Society, 1927. California Institute, 1913-

1025 San Pasqual Street

LEWIS M. ADAMS, LIEUT. COLONEL

Corps of Engineers, U. S. Army (Rtd.)
Professor of Military Science and Tactics

Graduate, U. S. Military Academy, West Point, 1903, with rank of 2nd Lieutenant, Corps of Engineers; Engineer School, 1907; Honor Graduate, Army Field Engineering School, 1914; Graduate, Army Staff College, 1915. Colonel (temporary), Corps of Engineers, 1918-1920; District Engineer (Galveston District, Gulf Division) 1920-1924. California Institute, 1924-

1855 San Pasqual Street

JOHN AUGUST ANDERSON, PH.D.

Executive Officer of the Observatory Council

Research Associate in Astrophysics*

B.S., Valparaiso College, 1900; Ph.D., Johns Hopkins University, 1907. Associate Professor of Astronomy, Johns Hopkins University, 1908-1916; Physicist, Mount Wilson Observatory, 1916-; California Institute, 1928-

642 North El Molino Avenue

EDWARD CECIL BARRETT, B.A.

Secretary of the Institute

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. California Institute, 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. Fellow of the Royal Society of London, 1928. California Institute, 1917-

1101 San Pasqual Street

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; Research Associate in Physical Chemistry, Massachusetts Institute of Technology, 1922-1923 (on leave from California Institute of Technology). California Institute, 1914-

1671 Oakdale Street

ERIC TEMPLE BELL, PH.D.

Professor of Mathematics

A.B., Stanford University, 1904; A.M., University of Washington, 1908; Ph.D., Columbia University, 1912. Instructor, Assistant Professor, Associate Professor, University of Washington, 1912-1922; Professor, 1922-1926. Bôcher Prize, American Mathematical Society, 1924; Vice-President, American Mathematical Society, 1926-; Colloquium Lecturer, American Mathematical Society, 1927. Professor, summer quarters, University of Chicago, 1924-1928; Visiting Lecturer, Harvard University, first half 1926. Member of National Academy of Sciences. California Institute, 1926-

434 South Michigan Avenue

*Member of the staff of the Mount Wilson Observatory of the Carnegie Institution of Washington. Associated with the California Institute by special arrangement with the Carnegie Institution.

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. Instructor in Chemistry, University of Washington, 1910-1911, 1913-1916. California Institute, 1916-

Sierra Madre Villa, R. D. 3, Box 639

C. F. TUCKER BROOKE, M.A., B. LITT.

Associate in English Literature

B.A., University of West Virginia, 1901; M.A., 1902; Rhodes Scholar from West Virginia at Oxford University, 1904-1907; B.A., Oxford University, 1906; B. Litt., 1907. Instructor in English, Cornell University, 1909; Instructor in English, Yale University, 1909-1913; Professor, 1920-; Exchange Professor, University of London, 1920; Research Associate of the Huntington Library, 1928-1929. California Institute, 1928-

700 Ventura Street, Altadena

GILMOR BROWN

Director of Public Speaking and Dramatics

Formerly with Ben Greet Players; Producing Director of Pasadena Community Playhouse since its organization, 1917; Lecturer on Community Drama, Drama League Institute, Chicago, 1921; Summer Art Colony, Pasadena, 1922-1923, University of Southern California, summer of 1923. California Institute, 1925-

695 Herkimer Street

JOHN PETER BUWALDA, PH.D.

Professor of Geology

B.S., University of California, 1912; Ph.D., 1915. Instructor, University of California, 1915-1917; Assistant Professor of Geology, Yale University, 1917-1921; Associate Professor of Geology, University of California, 1921-1925; Professor of Geology, 1925; Dean of the Summer Sessions, 1923-1925. Associate Geologist, U. S. Geological Survey. Member, Federal Advisory Board for Yosemite National Park, 1928-. California Institute, 1925-.

315 South Chester Avenue

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. California Institute, 1911-

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. Member of Council, American Society of Mechanical Engineers, 1925-1928; Vice-President, 1928-; Vice-Chairman, Board of Directors, City of Pasadena, 1927-. California Institute, 1919-

373 South Euclid Avenue

DONALD RYDER DICKEY, M.A.

Research Associate in Vertebrate Zoology

A.B., Yale University, 1910; M.A. (hon.), Occidental College, 1925. California Institute, 1926-

514 Rosemont 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. Member of National Research Council. California Institute, 1921-

1083 Elizabeth Street

MAX FARRAND, PH.D., LL.D.

Associate in American History

A.B., Princeton University, 1892; A.M., 1893; Ph.D., 1896. M.A. (hon.), Wesleyan University, 1900; Yale University, 1908; LL.D., Occidental College, 1928. Instructor, Associate Professor and Professor of History, Wesleyan University, 1896-1901; Professor and Head of the Department of History, Leland Stanford University, 1901-1908; Acting Professor of American History, Cornell University, 1905-1906; Professor of History, Yale University, 1908-1925; Director of Research at the Huntington Library, 1927-. California Institute, 1928-

179 South Orange Grove Avenue

BERNARD FAY, Docteur es lettres

Lecturer in History

Agrégé des Lettres, Sorbonne, 1914; A.M., Harvard University, 1920; Docteur ès Lettres, Sorbonne, 1923. Croix de Leopold II, 1916; Croix de Guerre, 1917. Chapman Fellow, Harvard University, 1920. Lecturer and Acting Professor of History, Columbia University, 1922-1924; Professor of History, Université de Clermont-Ferrand, 1923-; Research Associate, Huntington Library and Art Gallery, 1928-. California Institute, 1928-

Pasadena Athletic Club

FREDERIC W. HINRICHS, JR., M.A.

Professor of Mechanics

Dean of Upper Classmen

A.B., Columbia University, as of 1902. M.A. (hon.), Occidental College, 1926. Graduate of the United States Military Academy, West Point, 1902. Assistant Professor, Professor of Applied Mechanics, University of Rochester, 1910-1919. California Institute, 1920-

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. California Institute, 1909-

1325 Woodstock Road, San Marino

THEODOR VON KARMAN, PH.D.

Associate in Aeronautics

M.E., Budapest, 1902; Ph.D., Göttingen, 1908. Privat docent, Göttingen, 1910-1913; Professor of Mechanics and Aerodynamics, Director of the Aerodynamical Institute, University of Aachen, 1913-. California Institute, 1928-

Faculty Club

GRAHAM ALLAN LAING, M.A.

Professor of Economics and 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. California Institute, 1921-

1081 Elizabeth Street

JOHN ROBERTSON MACARTHUR, PH.D.

Professor of 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. California Institute, 1919-

866 South Pasadena Avenue

FRANCIS GLADHEIM PEASE, D.SC.

Associate in Optics and Instrument Design*

B.S., Armour Institute of Technology, 1901; M.S., 1924, D.Sc., 1927. Optician and Observer, Yerkes Observatory, 1901-1904; Instrument Designer, Mount Wilson Observatory, 1904-1913; Astronomer, 1911; In Charge of Instrument Design, 1913-. Chief Draftsman, National Research Council, 1918. Fellow of Royal Astronomical Society, London. California Institute, 1928-

824 North Holliston Avenue

---

*Member of the staff of the Mount Wilson Observatory of the Carnegie Institution of Washington. Associated with the California Institute by special arrangement with the Carnegie Institution.

Russell Williams Porter, M.S.

Associate in Optics and Instrument Design

M.S. (hon.), Norwich University, 1917. Made eight trips to Arctic Regions with Peary, Fiala-Ziegler, and Baldwin-Ziegler as artist, astronomer, topographer, surveyor, or collector for natural history; three trips into Alaska, British Columbia, and Labrador. Instructor in architecture, Massachusetts Institute of Technology, 1916-1917; optical work, Bureau of Standards, Washington, D. C., 1917-1918; Optical Associate with the Jones & Lamson Machine Co., 1918-1928. California Institute, 1928-

Frederick Leslie Ransome, Ph.D.

Professor of Economic Geology

B.S., University of California, 1893; Ph.D., 1896. Assistant in Mineralogy and Petrography, Harvard University, 1896-1897; Assistant Geologist, U. S. Geological Survey, 1897-1900; Geologist, 1900-1923; in charge of sections of western areal geology, 1912-1916, and of metalliferous deposits, 1912-1923; Professor of Economic Geology, 1923-1927, and Dean of the Graduate College, 1926-1927, University of Arizona. Fellow, Geological Society of America, American Association for the Advancement of Science; Member, National Academy of Sciences, National Research Council; President, Geological Society of Washington, 1913; President, Washington Academy of Sciences, 1918; Corresponding Member, Societe Géologique de Belgique; President, Society of Economic Geologists. California Institute, 1927-

543 South San Marino Avenue

Frank Elmore Ross, Ph.D.

Research Associate in Optics

B.S., University of California, 1896; Ph.D., 1901. Teacher of Mathematics and Physics, Mount Tamalpais Military Academy, 1896-1897; Assistant Professor of Mathematics University of Nevada, 1900; Assistant, Nautical Almanac Office, 1902-1903; Research Assistant, Carnegie Institution, 1903-1905; Director, International Latitude Observatory, Gaithersburg, Maryland, 1905-1915; Physicist, Eastman Kodak Company, 1915-1924; Associate Professor of Astronomy, Yerkes Observatory, 1924-1928; Professor of Astronomy, 1928-. California Institute, 1928-

Theodore Gerald Soares, Ph.D., D.D.

Associate in Philosophy and Ethics

A.B., University of Minnesota, 1891; A.M., 1892; Ph.D., University of Chicago, 1894; D.B., 1897; D.D., Knox College, 1901. Professor of Homiletics, University of Chicago, 1906-1908; Professor of Religious Education and Head of the Department of Practical Theology, 1908-. California Institute, 1927-

1542 Morada Place, Altadena

Royal Wasson Sorensen, E.E.

Professor of Electrical Engineering

B.S., in Electrical Engineering, University of Colorado, 1905; E.E., 1928. Associated with General Electric Co., Schenectady, N. Y., and Pittsfield, Mass., 1905-1910; Consulting Engineer, Pacific Light and Power Corporation, 1913-1917. Consulting Engineer, U. S. Electrical Manufacturing Company, 1917-. California Institute, 1910-

384 South Holliston Avenue

CHESTER STOCK, PH.D.

Professor of Paleontology

B.S., University of California, 1914; Ph.D., 1917; Research Assistant, Department of Paleontology, University of California, 1917-1919; Instructor, 1919-1921; Assistant Professor, Department of Geological Sciences, 1921-1925. Research Associate, Carnegie Institution of Washington. Vertebrate Paleontologist, Los Angeles Museum. California Institute, 1926-

2480 Linda Vista Avenue

ALFRED HENRY STURTEVANT, PH.D.

Professor of Genetics

A.B., Columbia University, 1912; Ph.D., 1914. Research Assistant, Carnegie Institution, 1915-1928. California Institute, 1928-

1171 Steuben Street

CARL CLAPP THOMAS, M.E.

Associate in Engineering Research

Stanford University, 1891-1894; M.E., Cornell University, 1895. Engaged in Design and Construction of Marine Machinery for Merchant and Naval Vessels, 1895-1904. Professor of Marine Engineering, Cornell University, 1904-1908. Chairman, Department of Mechanical Engineering, University of Wisconsin, 1908-1913; Head of Department of Mechanical Engineering, Johns Hopkins University, 1913-1920. Manager, Machinery Design and Fabrication, United States Government, Hog Island Shipyard, 1917-1919 (on leave from Johns Hopkins University). Vice-President, Dwight P. Robinson & Company, Inc., Engineers and Constructors, 1923. Member American Engineering Council, 1923-. Longstreth Medalist, Franklin Institute, for work on measurement of gases, 1912. California Institute, 1925-

165 Puente Drive

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. Member and Vice-Chairman, Board of Directors, City of Pasadena, 1921-1927. California Institute, 1913-

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. California Institute, 1921 -

345 South Michigan Avenue

FREDERICK JACKSON TURNER, PH.D., LL.D., LITT. D.

Associate in American History

A.B., University of Wisconsin, 1884; A.M., 1888; Ph.D., Johns Hopkins University, 1890. LL.D., University of Illinois, 1908; Litt. D., Harvard University, 1909; Johns Hopkins University, 1921; Ph.D. (hon.), Royal Frederick University of Norway, 1911. Assistant Professor of History, University of Wisconsin, 1889-1891; Professor, 1891-1892; Professor of American History, 1892-1910; Professor of History, Harvard University, 1910-1924; Professor Emeritus, 1924-. President of the American Historical Association, 1910-1911. Research Associate of the Huntington Library, 1926-. California Institute, 1928-

HARRY CLARK VAN BUSKIRK, PH.B.

Professor of Mathematics

Registrar

Ph.B., Cornell University, 1897. California Institute, 1904-

390 South Holliston Avenue

WENDELL PHILLIPS WOODRING, PH.D.

Professor of Invertebrate Paleontology

A.B., Albright College, 1910; Ph.D., Johns Hopkins University, 1916. Research Assistant, Johns Hopkins University, 1916-1917, 1919; Associate Geologist, Geologist, U. S. Geological Survey, 1919-; Geologist in Charge, Haitian Geological Survey, 1920-1923. California Institute, 1927-

925 South Los Robles Avenue

THOMAS EDWARD BUTTERFIELD, M.E., C.E.

Visiting Professor in Mechanical Engineering

M.E., Stevens Institute of Technology. 1895; C.E., Rensselaer Polytechnic Institute, 1897. In engineering practice, 1897-1911; Lehigh University, 1912-1916; Captain, C. A., U. S. A., 1917; Major, 1918. Associate Professor of Mechanical Engineering, Lehigh University, 1919-1921; Professor of Heat Power Engineering, 1922-. California Institute, 1928-

137 North Rampart Boulevard, Los Angeles

AUBREY CHESTER GRUBB, PH.D.

Visiting Professor in Chemistry

B.A., Iowa State Teachers' College, 1917; M.S., Purdue University, 1919; Ph.D., University of Chicago, 1921. Professor of Chemistry, University of Saskatchewan, 1921-. California Institute, 1928-

256 South Craig Avenue

William Leroy Hart, Ph.D.

Visiting Professor in Mathematics

B.A., University of Chicago, 1913; Ph.D., University of Chicago, 1916. Instructor in Mathematics, Harvard University, 1916-1917; Assistant Professor of Mathematics, University of Minnesota, 1919-1920; Associate Professor, 1920-1925; Professor, 1925-. California Institute, 1928-

1726 North Madison Avenue

Ernest Gustaf Anderson, Ph.D.

Associate Professor of Genetics

B.S., University of Nebraska, 1915; Ph.D., Cornell University, 1920. Research Associate, Carnegie Institution, 1920-1922; Instructor in Biology, College of the City of New York, 1922-1923. Fellow of the National Research Council, University of Michigan, 1923-1928. California Institute, 1928-

Ira Sprague Bowen, Ph.D.

Associate Professor of Physics

A.B., Oberlin College, 1919; Ph.D., California Institute of Technology, 1926. Assistant in Physics, University of Chicago, 1920-1921. California Institute, 1921-

1170 Steuben Street

Roscoe Gilkey Dickinson, Ph.D.

Associate Professor of Physical Chemistry

S.B., Massachusetts Institute of Technology, 1915; Ph.D., California Institute of Technology, 1920. Assistant in Theoretical Chemistry, Massachusetts Institute of Technology, 1915-1916; Research Assistant in Physical Chemistry, 1916-1917. National Research Fellow in Chemistry, 1920-1923. Fellow of the International Education Board in Europe, 1924-1925. California Institute, 1917-

212 South Grand Oaks Avenue

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, 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. California Institute, 1916-

334 Berkeley 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. California Institute, 1913-

97 North Holliston 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. California Institute, 1918-

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. Consulting Engineer on Bridge Design for City of Pasadena, 1921-1924. Representative of Southern California Council on Earthquake Protection at Third Pan-Pacific Science Congress, Tokyo, 1926. California Institute, 1918-

690 South Mentor Avenue

WILLIAM W. 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; Office Engineer with The Power Construction Company of Massachusetts, 1914-1915; in private engineering practice, 1916-1918. Engineer, Palos Verdes Estates, summer of 1922; Associate with County Engineer, Ulster County, N. Y., summers of 1925 and 1928. California Institute, 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; 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, 1919-1921. California Institute, 1921-

515 Manzanita Avenue, Sierra Madre

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. California Institute, 1919-

1124 Mar Vista Avenue

LUTHER EWING WEAR, PH.D.

Associate Professor of Mathematics

A.B., Cumberland University, 1902; Ph.D., Johns Hopkins University, 1913. Instructor in Mathematics, University of Washington, 1913-1918. California Institute, 1918-

68 South Grand Oaks Avenue

GEORGE BICKFORD BRIGHAM, JR.

Assistant Professor of Engineering Drawing

Massachusetts Institute of Technology, 1910-1913. With William L. Mowll, Architect, Boston, Massachusetts, 1913-1916. Instructor in Engineering Drawing, Tufts College, 1918-1919; Instructor in Engineering and Architectural Drawing, Massachusetts Institute of Technology, 1919-1920. California Institute, 1923-

1371 San Pasqual Street

LOUIS J. CLATERBOS, B.S. IN C. E., 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, Field Artillery, 1920. Transferred to Corps of Engineers as Second Lieutenant, 1920. Graduate Engineer School, Fort Humphreys, Virginia, 1921; B.S. in C.E., Rensselaer Polytechnic Institute, 1922. California Institute, 1925-

665 South Mentor Avenue

HARVEY EAGLESON, PH.D.

Assistant Professor of English Language and Literature

B.A., Reed College, 1920; M.A., Leland Stanford University, 1922; Ph.D., Princeton University, 1928. Instructor in English, University of Texas, 1922-1926. California Institute, 1928-

543 South Oakland Avenue

STERLING H. EMERSON, PH.D.

Assistant Professor of Genetics

B.S., Cornell University, 1922; M.S., University of Michigan, 1924; Ph.D., 1928. Instructor in Botany, University of Michigan, 1924-1928. California Institute, 1928-

1132 Constance Street

WILLIAM VERMILLION HOUSTON, PH.D.

Assistant Professor of Physics

B.A. and B.Sc. in Ed., Ohio State University, 1920; M.S., University of Chicago, 1922; Ph.D., Ohio State University, 1925. Instructor in Physics, Ohio State University, 1922-1925. National Research Fellow in Physics, 1925-1927. Foreign Fellow of the John Simon Guggenheim Foundation, 1927-1928. California Institute, 1925-

335 South Parkwood Avenue

SAMUEL STUART MACKEOWN, PH.D.

Assistant Professor of Electrical Engineering

A.B., Cornell University, 1917; Ph.D., 1923. Instructor in Physics, Cornell University, 1920-1923; National Research Fellow in Physics, 1923-1926. California Institute, 1923-

1240 Arden Road

J. ROBERT OPPENHEIMER, PH.D.*

Assistant Professor of Physics

B.A., Harvard University, 1925; Ph.D., University of Göttingen, 1927. California Institute, 1928-

LINUS CARL PAULING, PH.D.

Assistant Professor of Theoretical Chemistry

B.S., Oregon Agricultural College, 1922; Ph.D., California Institute of Technology, 1925. National Research Fellow in Chemistry, 1925-1926. Foreign Fellow of the John Simon Guggenheim Memorial Foundation, 1926-1927. California Institute, 1922-

320 South Wilson Avenue

HOWARD P. ROBERTSON, PH.D.*

Assistant Professor of Mathematics

B.S., University of Washington, 1922; M.S., 1923; Ph.D., California Institute of Technology, 1925. Fellow of the National Research Council, 1925-1928; Acting Assistant Professor of Mathematics, Princeton University, 1928-. California Institute, 1925-

WILLIAM RALPH SMYTHE, PH.D.

Assistant Professor of Physics

A.B., Colorado College, 1916; A.M., Dartmouth College, 1919; Ph.D., University of Chicago, 1921. Professor of Physics, University of the Philippines, 1921-1923. National Research Fellow, California Institute, 1923-1926; Research Fellow, 1926-1927. California Institute, 1923-

426 South Michigan Avenue

ERNEST HAYWOOD SWIFT, PH.D.

Assistant Professor of Analytical Chemistry

B.S. in Chemistry, University of Virginia, 1918; M.S., California Institute of Technology, 1920; Ph.D., 1924. California Institute, 1919-

1131 Lura Street

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. California Institute, 1917-

1947 San Pasqual Street

*On leave of absence, 1928-1929.

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. 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. California Institute, 1920-

401 South Chester Avenue

FRITZ ZWICKY, PH.D.

Assistant Professor of Theoretical Physics

Graduate, Eidg. Technische Hochschule, Zurich, 1920; Ph.D., 1922. Assistant in Physics, Eidg. Technische Hochschule, 1921-1925. Fellow in Physics of the International Education Board, 1925-1927. California Institute, 1925-

27 South Wilson Avenue

ARNOLD ORVILLE BECKMAN, PH.D.

Instructor in Chemistry

B.S., University of Illinois, 1922; M.S., 1923; Ph.D., California Institute of Technology, 1928. California Institute, 1928-

107 South Grand Oaks Avenue

WILLIAM NOEL BIRCHBY, M.A.

Instructor in Mathematics

A.B., Hope College, 1899; M.A., Colorado College, 1905. Instructor, Colorado College, 1905 and 1907; Instructor in Physics, University of Southern California, summer session, 1916. California Institute, 1918-

1500 Sinaloa Avenue

REGINALD BLAND

Director of Orchestra

California Institute, 1926-

609 North Hill Avenue

FRED J. CONVERSE, B.S.

Instructor in Civil Engineering

B.S. in Mechanical Engineering, University of Rochester, 1914. With Cleveland Electric Illuminating Company, Cleveland, Ohio, 1914-1915. With General Electric Company, Lynn, Massachusetts, 1915-1916. Instructor in Applied Mechanics, University of Rochester, 1916-1917. With General Laboratories, Bureau of Aircraft Production, U. S. A., 1917-1918. With Gleason Gear Works, Rochester, New York, 1919. Designer, Bureau of Power and Light, Los Angeles City, 1920. California Institute, 1921-

168 South Craig Avenue

RENE ENGEL, M.S.

Instructor in Geology

B.S., University of Paris, 1909; M.S., 1912; Instructor in Chemistry, Conservatoire des Arts and Metiers, Paris, 1911-1912; Associated with the Anaconda Copper Mining Co., Anaconda and Butte, Montana, 1913-1914 and 1920-1923; Chemical Engineer, Military Research Laboratory, Sorbonne, Paris, 1914-1917; Member, Scientific Commissions, U.S.A. and England, 1917-1918; Geologist, Saar Coal Mines, Saarbrucken, 1918-1919; Professor of Geology, Oklahoma School of Mines, 1923-1924; Assistant Professor of Geology and Mineralogy, New Mexico School of Mines, 1924-1925; California Institute, 1925-

1148 Constance Street

EUSTACE L. FURLONG

Curator in Vertebrate Paleontology

Assistant in Paleontology, 1903-1910; Curator of Vertebrate Paleontology, 1915-1927, University of California. California Institute, 1927-

349 South Mentor Avenue

ARTHUR FREDERICK HALL[1]

Instructor in Pattern Making and Machine Shop Practice (Part Time)

With Sullivan Machine Company, Claremont, N. H., 1891-1894; B. F. Sturdevant Company, Jamaica Plain, Mass., 1894-1897; Union Gas Engine Company, San Francisco, 1898-1899; W. P. Kidder Machine Company, Jamaica Plain, Mass., 1899-1907. California Institute, 1912-

1090 Mar Vista Avenue

FLOYD L. HANES, D.O.

Physical Trainer

D.O., College of Osteopathic Physicians and Surgeons, Los Angeles, 1921. California Institute, 1923-

200 South Madison Avenue

MURRAY W. HAWS, M.A.[1]

Instructor in Pattern Making (Part Time)

A.B., Stanford University, 1906; M.A., University of Southern California, 1928. With Tracy Engineering Company, 1906-1908; Santa Fe Railway Company, 1908-1916; Instructor in Machine Shop and Machine Drawing, Technical High School, Oakland, 1916-1923; Instructor, Manual Arts Department, Pasadena High School, 1923-. California Institute, 1927-

1911 Summit Avenue

OSCAR LESLIE HEALD[1]

Instructor in Forging (Part Time)

Graduate, Normal Arts Department, Throop Polytechnic Institute, 1903. Instructor in Manual Arts, California Polytechnic School, San Luis Obispo, 1903-1906; Superintendent, Construction of Buildings, University Farm, Davis, California, 1909-1910; Instructor, Engineering-Mechanics Department, State Polytechnic School, San Luis Obispo, California, 1910-1918. California Institute, 1918-

2180 Santa Anita Avenue

[1]Associated with Pasadena Junior College.

LOUIS WINCHESTER JONES, A.B.
Instructor in English Language and Literature

A.B., Princeton University, 1922. California Institute, 1925-

351 California Terrace

ROBERT TALBOT KNAPP, B.S.
Instructor in Mechanical Engineering

B.S., Massachusetts Institute of Technology, 1920. Designer with C. M. Gay & Son, Refrigerating Engineers, 1920-1921. California Institute, 1922-

163 South Greenwood Avenue

WALTER WILLIAM MARTIN[1]
Instructor in Wood Working (Part Time)

Graduate, Normal Arts Department, Throop Polytechnic Institute, 1900. Instructor in Shop, Throop Polytechnic Institute, 1900-1911; Head of Department of Mechanic Arts, Pasadena Junior College, 1911-. California Institute, 1911-

1782 Rose Villa Street

FRANCIS WILLIAM MAXSTADT, M.S.
Instructor in Electrical Engineering

M.E., Cornell University, 1916; Certificate of E.E., 1916; M.S., California Institute of Technology, 1925. 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. California Institute, 1919-

3782 Elma Road

ALBERT ADAMS MERRILL
Instructor in Experimental Aeronautics and in Accounting

California Institute, 1918-

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. California Institute, 1921-

834 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. California Institute, 1920-

184 South Oak Avenue

[1]Associated with the Pasadena Junior College.

JOHN L. RIDGWAY

Scientific Illustrator in Vertebrate Paleontology

Chief Illustrator, in charge of Division of Illustrations, United States Geological Survey, 1898-1920; in charge of illustrations, Carnegie Institution of Washington, 1904-1920; Artist, Carnegie Institution, 1921-1925. California Institute, 1926-

501 Fairmont Street, Glendale.

FRANCES HALSEY SPINING

Librarian

California Institute, 1914-

1067 North Catalina Avenue

ALEXANDER J. SMITH

Band Instructor

California Institute, 1924-

1860 West Forty-first Place, Los Angeles

ROGER STANTON, M.A.

Instructor in English Language and Literature

B.S., Colgate University, 1920; M.A., Princeton University, 1924. Instructor in English, Colorado College, 1924-1925. California Institute, 1925-

840 East Del Mar Street

RAY EDWARD UNTEREINER, A.M.

Instructor in Economics and History

A.B., University of Redlands, 1920; A.M., Harvard University, 1921. Instructor in Economics, Harvard University, 1921-1923; Professor of Public Speaking, Huron College, 1923-1924; Instructor in Economics and Social Science, Joliet Junior College, 1924-1925. Member of California Bar. California Institute, 1925-

351 West Marigold Street, Altadena

DON M. YOST, PH.D.*

Instructor in Chemistry

B.S., University of California, 1923; Ph.D., California Institute of Technology, 1926. Instructor in Chemistry, University of Utah, 1923-1924; Research Fellow in Europe, 1928-1929. California Institute, 1924-

---

WILLARD HARRISON BENNETT, PH.D.

National Research Fellow in Physics

A.B., Ohio State College, 1924; M.S., University of Wisconsin, 1926; Ph.D., University of Michigan, 1928. California Institute, 1928-

252 South Catalina Avenue

FRANCIS BITTER, PH.D.

National Research Fellow in Physics

A.B., Columbia University, 1924; University of Berlin, 1925-1926; Ph.D., Columbia University, 1928. National Research Fellow, Princeton University and California Institute, 1928-

*On leave of absence, 1928-1929.

FRANK WOODBRIDGE CONSTANT, PH.D.

National Research Fellow in Physics

B.S., Princeton University, 1925; Ph.D., Yale University, 1928. California Institute, 1928-

676 South El Molino Avenue

GEORGE ALEXANDER CUMMING, PH.D.

Commonwealth Fund Fellow in Geology

B.Sc., University of St. Andrews, Scotland, 1923; Ph.D., 1927. Assistant Lecturer, University College, Dundee, 1923-1927. California Institute, 1928-

238 North Catalina Avenue

ROBERT HENNAH DALTON, PH.D.

Research Fellow in Chemistry

B.S., California Institute of Technology, 1925; M.S., 1926; Ph.D., 1928.

Faculty Club

THEODOSIUS DOBZHANSKY

Research Fellow in Biology of the International Education Board

Diploma, University of Kiev, 1921. Assistant in Zoology, Polytechnic Institute of Kieve, 1921-1924. Lecturer in Genetics, University of Leningrad, 1924; Research Fellow, Bureau of Genetics, Russian Academy of Sciences, 1926.

1134 Cordova Street

JESSE WILLIAM MONROE DUMOND, M.S.

Research Fellow in Physics

B.S., California Institute of Technology, 1916; M.S. in E.E., Union College, 1918.

615 South Mentor Avenue

JOHN GEORGE FRAYNE, PH.D.

National Research Fellow in Physics

A.B., Ripon College, 1918; Ph.D., University of Minnesota, 1922. Instructor in Physics, University of Minnesota, 1919-1922; Professor of Physics, Antioch College, 1922-1928. California Institute, 1928-

1766 Las Lunas Street

ALEXANDER GOETZ, PH.D.

Research Fellow in Physics

Ph.D., University of Göttingen, 1921; Habilitation, 1923. Assistant Professor of Physics, University of Göttingen, 1923-1927. Fellow in Physics of the International Education Board, 1927-1928. California Institute, 1927-

721 Calaveras Street

LOUIS ARMAND MARTIAL HENRY, Sc.D.

Fellow in Physics of the C. R. B. Educational Foundation

Science Candidate of the Science Faculty of Namur, 1924; Sc.D., University of Brussels, 1927. Research Fellow of the International Institute of Chemistry, Solvay, Brussels University, 1927-1928. California Institute, 1928-

Faculty Club

YOSHITAKA IMAI, PH.D.

Fellow of the International Education Board in Biology and Research Scholar of the Department of Education of Japan

Graduate, Tokyo Imperial University, 1916; Ng.H. (Ph.D.), 1928. California Institute, 1928-

1147 Lura Street

LOUIS STEVENSON KASSEL, PH.D.

National Research Fellow in Chemistry

B.S., University of Chicago, 1924; S.M., 1926; Ph.D., 1927. Assistant, University of Chicago, 1925-1927. California Institute, 1927-

Faculty Club

ROY JAMES KENNEDY, PH.D.

Fellow in Physics of the John Simon Guggenheim Memorial Fund

A.B., Cornell University, 1921; Ph.D., Johns Hopkins University, 1924. California Institute, 1924-

150 South Orange Grove Avenue

ARTHUR LOUIS KLEIN, PH.D.

Research Fellow in Aeronautics

B.S., California Institute of Technology, 1921; M.S., 1924; Ph.D., 1925. California Institute, 1921-

125 Fremont Place, Los Angeles

JOSEPH BLAKE KOEPFLI, D. PHIL.

Research Fellow in Organic Chemistry

A.B., Leland Stanford, Junior, University, 1924; M.A., 1925; D.Phil., Oxford University, 1928. California Institute, 1928-

342 South Mariposa Avenue, Los Angeles

ADOLF HENRY KUNZ, PH.D.

National Research Fellow in Chemistry

A.B., William Jewell College, 1923; M.S., University of Iowa, 1926; Ph.D., 1928. California Institute, 1928-

1100 East Del Mar Street

CLARK BLANCHARD MILLIKAN, PH.D.

Research Fellow in Aeronautics

A.B., Yale University, 1924; Ph.D., California Institute of Technology, 1928. California Institute, 1925-

700 Laguna Road

WILLIAM RICHARD MORGANS, M.Sc.

Commonwealth Fund Fellow in Physics

B.Sc., University College, Wales, 1925; M.Sc., 1927. Garrod Thomas Fellow, University of Wales, 1926-1927. Diploma in Education, 1928. California Institute, 1928-

238 North Catalina Avenue

MARTIN EMERY NORDBERG, PH.D.

Research Fellow in Chemistry

B.S., Iowa State College, 1924; M.S., 1925; Ph.D., California Institute of Technology, 1928. California Institute, 1928-

Faculty Club

GLENN H. PALMER, M.S., FIRST LIEUTENANT

Signal Corps, U. S. Army

Research Fellow in Physics (Signal Corps)

Graduate U. S. Military Academy, with rank of Second Lieutenant, Signal Corps, 1923; M.S., Yale University, 1924. Instructor, Signal School, U. S. Army, 1925. California Institute, 1926-

501 Rio Grande Street

FRANCO RASETTI, PH.D.

Fellow in Physics of the International Education Board

Ph.D., University of Pisa, 1922. Assistant in Physics, University of Florence, 1922-1927; Habilitation, University of Rome, 1927-1928. California Institute, 1928-

1122 Cordova Street

HERMAN C. RAMSPERGER, PH.D.

National Research Fellow in Chemistry

B.S., Utah Agricultural College, 1919; M.S., University of California, 1923; Ph.D., 1925. Instructor in Chemistry, University of California, 1925-1927. *National Research Fellow in Chemistry, 1927-. California Institute, 1929-*

OSCAR KNEFLER RICE, PH.D.

National Research Fellow in Chemistry

B.S., University of California, 1924; Ph.D., 1926. Fellow in Chemistry, University of California, 1924-1926; Associate in Chemistry, 1926-1927. California Institute, 1927-

1371 San Pasqual Street

MORGAN WARD, PH.D.

Research Fellow in Mathematics

A.B., University of California, 1924; Ph.D., California Institute of Technology, 1928. California Institute, 1925-

1391 Linda Vista Avenue

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. California Institute, 1923-

346 South Michigan Avenue

ANDREW P. ALFORD, A.B.

Teaching Fellow in Physics

A.B., University of California, 1924.

Faculty Club

CARL DAVID ANDERSON, B.S.

Assistant in Physics

B.S., California Institute of Technology, 1927.

897 Granite Drive

WARREN NELSON ARNQUIST, B.S.

Assistant in Physics

B.S., Whitman College, 1927.

435 South Lake Avenue

DONALD PORTER BARNES, B.S.

Teaching Fellow in Engineering

B.S., Oregon State Agricultural College, 1928.

314 South Allen Avenue

MIGUEL ANTONIO BASOCO, M.S.

Teaching Fellow in Mathematics

B.A., University of California, 1924; M.S., University of Chicago, 1926.

129 West Forty-third Street, Los Angeles

RUSSELL LEE BIDDLE, M.A.

Teaching Fellow in Biology

B.S., University of Pittsburg, 1925; M.A., Columbia University, 1928.

1163 Steuben Street

ALBERT CONSTANT BILICKE, M.S.

Research Assistant in Organic Chemistry

A.B., Williams College, 1924; M.S., California Institute of Technology, 1927.

363 South McCadden Place, Los Angeles

LEE REED BRANTLEY, A.B

Assistant in Chemistry

A.B., University of California at Los Angeles, 1927.

411¼ East Avenue Twenty-eight, Los Angeles

WILLARD CHARLES BRUCE
Assistant in Physics
B.A., University of Minnesota, 1926.
130 North Mentor Avenue

JOHN STUART CAMPBELL, B.S.
Assistant in Physics
B.S., California Institute of Technology, 1926. Rice Institute, 1927-1928.
873 North Chester Avenue

CHARLES HAWLEY CARTWRIGHT, B.S.
Teaching Fellow in Engineering
B.S., California Institute of Technology, 1926.
R.F.D. Box 485-6, San Gabriel

BENEDICT CASSEN, M.S.
Assistant in Physics
A.R.C.S., Imperial College of Science and Technology, London, 1927; M.S., California Institute of Technology, 1928.
1156 Constance Street

GUY LEWIS CHILBERG, B.S.
Assistant in Engineering
B.S., California Institute of Technology, 1928.
289 South Madison Avenue

ALEXANDER CLARK, B.S.
Assistant in Paleontology
B.S., California Institute of Technology, 1928.
522 North Newlin Avenue, Whittier

THOMAS CLEMENTS, E.M.
Teaching Fellow in Mineralogy
Mining Eng., University of Texas, 1922.
1308 North Wilcox Avenue, Hollywood

FRANK CUTSHAW CROXTON
Assistant in Chemistry
B.A., Ohio State University, 1927; M.A., 1928.
940 Del Mar Street

RALPH WALDO CUTLER, B.S.
Teaching Fellow in Engineering
B.S., California Institute of Technology, 1928.
6341 Seville Avenue, Huntington Park

CHARLES ROBERT DAILY, A.B.
Teaching Fellow in Physics
A.B., Colorado College, 1925.
670 South Lake Avenue

RALPH KOHLRAUSCH DAY, PH.B.
Research Assistant in Physics (American Petroleum Institute)
Ph.B., Yale University, 1925.
Faculty Club

ROBERT TROUTMAN DILLON, B.S.
Teaching Fellow in Chemistry
B.S., California Institute of Technology, 1925.
97 North Holliston Avenue

ROLLIN POLLARD ECKIS, B.A.
Teaching Fellow in Geology and Paleontology
B.A., Pomona College, 1927.
104 North Holliston Avenue

JOHN DYER ELDER, B.S.
Teaching Fellow in Mathematics
B.S., University of Chicago, 1925.
1122 Cordova Street

ROBLEY DUNGLISON EVANS, B.S.
Reader in English
B.S., California Institute of Technology, 1928.
973 Del Mar Street

FREDERICK JUNIOR EWING, B.S.
Teaching Fellow in Chemistry
B.S., California Institute of Technology, 1927.
354 South Chester Avenue

ALFRED BOSWORTH FOCKE, B.S.
Assistant in Physics
B.S., Case School of Applied Science, 1928.
2926 Nina Street

RICHARD GILMAN FOLSOM, B.S.
Assistant in Engineering
B.S., California Institute of Technology, 1928.
399 South Mentor Avenue

CHARLES LEWIS GAZIN, M.S.
Assistant in Paleontology
B.S., California Institute of Technology, 1927; M.S., 1928.
672 South Mentor Avenue

FERDINAND GUNNER GRAMATKY, B.S.
Assistant in Engineering
B.S., California Institute of Technology, 1928.
501 East Whitmore Street, Wilmar

GEORGE THOMAS HARNESS, JR., B.S.
Assistant in Electrical Engineering
B.S., California Institute of Technology, 1928.
473 Riverdale Drive, Glendale

CLAUDE DEWAYNE HAYWARD, M.S.
Teaching Fellow in Electrical Engineering
B.S., California Institute of Technology, 1926; M.S., 1927.
79 South Wilson Avenue

WILLIAM ALFORD HETHERINGTON, M.A.
Teaching Fellow in Biology
A.B., Columbia College, 1926; M.A., Columbia University, 1927. Assistant in Biology, New York University, 1925-1926; Fellow in Biology, College of the City of New York, 1926-1927; Assistant in Zoology, Columbia University, 1927-1928.
Faculty Club

HOWARD BYINGTON HOLROYD, B.S.
Assistant in Physics (American Petroleum Institute)
B.S. in M. Eng., Iowa State College, 1924.
323 South Chester Avenue

LOZELL CHARLES HOOKWAY, B.S.
Assistant in Paleontology
B.S., California Institute of Technology, 1928.
810 North Michigan Avenue

VAINO ALEXANDER HOOVER, M.S.
Assistant in Physical Education and in Electrical Engineering
B.S., California Institute of Technology, 1927; M.S., 1928.
406 South Chester Avenue

LYNN GORMAN HOWELL, M.A.
Assistant in Physics (American Petroleum Institute)
B.A., University of Texas, 1925; M.A., 1926.
Faculty Club

ARCHER HOYT, B.A.
Assistant in Physics
B.A., Whitman College, 1927.
435 South Lake Avenue

LORENZ DITMAN HUFF, M.S.
Assistant in Physics
A.B., University of Oklahoma, 1927; M.S., 1928.
191 South Lake Avenue

KENNETH KNIGHT ILLINGWORTH, M.A.
Assistant in Physics
A.B., Colorado College, 1924; M.A., Dartmouth College, 1926.
902½ East California Street

CECIL EDWARD PRUITT JEFFREYS, M.A.
Teaching Fellow in Chemistry
B.A., University of Texas, 1925; M.A., 1927.
196 South Sierra Bonita Avenue

NORRIS JOHNSTON, S.M.
Research Assistant in Physics (American Petroleum Institute)
S.B., Massachusetts Institute of Technology, 1924; S.M., 1925.
1124 East Mountain Street

LAWRENCE SANFORD KENNISON, A.M.
Assistant in Mathematics
A.B., Dartmouth College, 1926; A.M., Brown University, 1928.
1122 Cordova Street

DOUGLAS G. KINGMAN, B.S.
Assistant in Engineering
B.S., California Institute of Technology, 1928.
900 Bushnell Avenue, Alhambra

CHARLES COYLE LASH, B.S.
Assistant in Physics
B.S., California Institute of Technology, 1928.
248 South Michigan Avenue

CHARLES CHRISTIAN LAURITSEN
Teaching Fellow in Physics
Odense Tekniske Skole, 1911.
352 South Chester Avenue

WILLIAM ABBETT LEWIS, JR., M.S.
Teaching Fellow in Electrical Engineering
B.S., California Institute of Technology, 1926; M.S., 1927.
664 South Lake Avenue

CARL CLARENCE LINDEGREN, M.S.
Assistant in Biology
B.S., University of Wisconsin, 1922; M.S., 1923.
929 Chapman Avenue

ALBERT EATON LOMBARD, JR., B.S.
Assistant in Aeronautics
B.S., California Institute of Technology, 1928.
1277 San Pasqual Street

RALPH LEONARD LUPHER, M.A.
Research Assistant in Geology and Paleontology
B.A., University of Oregon, 1926; M.A., 1927.
1673 Locust Street

JOHN HAVILAND MAXSON, M.S.
Teaching Fellow in Geology and Reader in History
B.S., California Institute of Technology, 1927; M.S., 1928.
488 North Marengo Avenue

EDWIN MATTISON MCMILLAN, B.S.
Assistant in Physics (Standard Oil Company of California)
B.S., California Institute of Technology, 1928.
387 South Los Robles Avenue

DANIEL BRENT MCRAE, B.S.
Assistant in Chemistry
B.S., University of Utah, 1926.
461 South Hudson Avenue

WALTER CHRISTIAN MICHELS, E.E.
Assistant in Physics
E.E., Rensselaer Polytechnic Institute, 1927.
1455 North Marengo Avenue

BERNARD NETTLETON MOORE, B.S.
Teaching Fellow in Geology
B.S., California Institute of Technology, 1927.
1026 West Twentieth Street, Los Angeles

MORRIS MUSKAT, M.A.
Teaching Fellow in Mathematics
B.A., Ohio State University, 1926; M.A., 1926.
1124 Del Mar Street

HENRY VICTOR NEHER, B.A.
Assistant in Physics
B.A., Pomona College, 1926.
1122 Cordova Street

FRANK ANDREW NICKELL, M.S.
Assistant in Languages
B.S., California Institute of Technology, 1927; M.S., 1928.
104 North Holliston Avenue

JOHN WILFRED PATTERSON, M.A.
Research Assistant in Geology and Paleontology
E.Met., Colorado School of Mines, 1925; M.A., University of Wyoming, 1926.
434 North Holliston Avenue

JOHN MAGNUS PEARSON, B.S.
Teaching Fellow in Physics
B.S., University of Chicago, 1925.
Faculty Club

ROBERT IRVING PIPER, B.A.
Assistant in Mathematics
B.A., University of Montana, 1928.
373 South Wilson Avenue

RICHARD DURANT POMEROY, B.S.
Research Assistant in Chemistry (American Petroleum Institute)
B.S., California Institute of Technology, 1926; M.S., 1927.
173 South Meredith Avenue

EMERSON MARTINDALE PUGH, M.S.
Assistant in Physics (American Petroleum Institute)
B.S., Carnegie Institute of Technology, 1918; M.S., University of Pittsburgh, 1927.
115 South Mentor Avenue

SOL FREDERICK RAVITZ, M.A.
Teaching Fellow in Chemistry
B.A., University of Utah, 1927; M.A., 1928.
461 South Hudson Avenue

BURT RICHARDSON, PH.B.
Assistant in Physical Education
Ph.B., Yale University, 1919.
Faculty Club

KENNETH H. ROBINSON, B.S.
Assistant in Engineering
B.S., California Institute of Technology, 1928.
735 North Lake Avenue

LYNN HAMILTON RUMBAUGH, A.B.
Assistant in Physics
A.B., Miami University, 1928.
1122 Cordova Street

NORWOOD KORTER SCHAFFER, M.S.
Assistant in Biology
B.S., University of Washington, 1926; M.S., 1927.
Faculty Club

JOSEPH WILLIAM SCHWEINFEST, B.S.
Assistant in Mathematics and in Languages
B.S., California Institute of Technology, 1928.
593 East California Street

NATHAN FROST SCUDDER, M.S.
Research Assistant in Chemistry (American Petroleum Institute)
B.S., California Institute of Technology, 1926; M.S., 1928.
225 South Holliston Avenue

ERNEST EDWIN SECHLER, B.S.
Assistant in Engineering
B.S., California Institute of Technology, 1928.
804 Santa Barbara Street

JOHN EGON SKAFTE, B.S.
Assistant in Engineering
B.S., California Institute of Technology, 1928.
259¼ Isabel Street, Los Angeles

HAMPTON SMITH, B.S.
Assistant in Languages
B.S., California Institute of Technology, 1928.
248 East Orange Avenue, Monrovia

VADIM MICHOVITCH SOKOLOFF, B.S.
Research Assistant in Physics (American Petroleum Institute)
B.S., California Institute of Technology, 1926.
240 South Chester Avenue

KENNETH A. SOLOMON, B.S.
Research Assistant in Physics (American Petroleum Institute)
Reader in History
B.S., California Institute of Technology, 1928.
1605 North Pacific Avenue, Glendale

WILLIAM LAYTON STANTON, B.S.
Assistant in Physical Education
B.S., California Institute of Technology, 1927.
515 Manzanita Avenue, Sierra Madre

JAMES HOLMES STURDIVANT, M.A.
Teaching Fellow in Chemistry
B.A., University of Texas, 1926; M.A., 1927.
1164 Steuben Street

RICHARD MANLIFFE SUTTON, B.S.
Teaching Fellow in Physics
B.S., Haverford College, 1922.
406 South Chester Avenue

CHARLES ALBERT SWARTZ, B.S.
Research Assistant in Physics (American Petroleum Institute)
B.S., California Institute of Technology, 1927.
135 North San Marino Avenue

DANIEL DWIGHT TAYLOR, A.B.
Research Assistant in Physics (American Petroleum Institute)
A.B., Colorado College, 1924.
189 North Oakland Avenue

JOHN WILLIAM THATCHER, B.S.
Assistant in Electrical Engineering
B.S., California Institute of Technology, 1928.
236 Greenwood Avenue, Montebello

EDWARD MOULTON THORNDIKE, A.M.
Assistant in Physics
B.S., Wesleyan University, 1926; A.M., Columbia University, 1927.
902½ East California Street

ALBERT TITLEBAUM, A.M.
Teaching Fellow in Biology
A.B., Columbia University, 1926; A.M., 1927. Assistant in Zoology, Columbia University, 1926-1928.
1145 Steuben Street

JOHANNES ARCHIBALD VAN DEN AKKER, B.S.
Teaching Fellow in Physics
B.S., California Institute of Technology, 1926.
660 North St. Andrews Place, Los Angeles

ADRIAAN JOSEPH VAN ROSSEM
Assistant in Vertebrate Zoology
2656 Foothill Boulevard

HOMER BIGELOW WELLMAN, M.A.
Teaching Fellow in Chemistry
B.A., Carleton College, 1926; M.A., University of Michigan, 1927.
290 South Michigan Avenue

RALPH RICHTER WENNER, M.S.
Assistant in Chemistry
B.S., Cooper Union Institute of Technology, 1926; M.S., Northwestern University, 1927.
325 South Wilson Avenue

RALPH EDGAR WINGER, A.B.
Teaching Fellow in Physics
A.B., Baker University, 1914.
358 South Euclid Avenue

KARL MORGAN WOLFE, B.S.
Assistant in Electrical Engineering
B.S., West Virginia University, 1925.
Faculty Club

WILLIAM GOULD YOUNG, M.A.
Du Pont Fellow in Chemistry
A.B., Colorado College, 1924; M.A., 1925. Assistant Research Chemist, Coastal Laboratory, Carmel, Carnegie Institution, 1925-1927.
353 North Holliston Avenue

LOUIS H. BAILEY, FIRST SERGEANT, D. E. M. L., U. S. ARMY, RETIRED
Assistant, Department of Military Science and Tactics
California Institute, 1920-
686 South Lake Avenue

JOSEPH LARACY, MASTER SERGEANT, ENGINEERS, U. S. ARMY, RETIRED
Assistant, Department of Military Science and Tactics
California Institute, 1920-
1084 Mar Vista Avenue

Technical Assistants

BURT BEVERLY.....Biology
1645 Rose Villa Street

THOMAS H. BOLTER.....Mechanic, Mechanical Engineering and Hydraulics
929 South Marengo Avenue

WILLIAM H. BRESLER.....Instrument Maker, Physics
1680 Locust Street

WILLIAM CLANCY.....Glass Blower, Physics
123 North Wilson Avenue

ELIZABETH L. GRIFFITHS.....Technician, Biology
1147 Lura Street

HERMAN KNAPP.....Storekeeper, Physics
1177 Copeland Place, Los Angeles

SHEPARD MACALLISTER.....Instrument Maker, Physics
1504 E. Walnut Street

BRUNO E. MERKEL.....Instrument Maker, Physics
515 N. Michigan Avenue

S. E. PARKER.....Storekeeper, Chemistry
152 Sacramento Street, Altadena

JULIUS PEARSON.....Head Instrument Maker, Physics
1115 Attica Street, Altadena

LOYD ROYER.....Mechanic, Aeronautics
255 Terrace Avenue, Altadena

A. SANDALL.....Instrument Maker, Physics
451 LeRoy Avenue, Arcadia

ELBERT H. SEARLE.....Instrument Maker, Chemistry
1009 Tipton Terrace, Los Angeles

BERNHARD M. SWANSON.....Instrument Maker, Physics
621 Indiana Street, Los Angeles

Assistants in Administration

ELLA BEYER.....Geology and Paleontology
1785 North Garfield Avenue

RUAMA M. COIT.....Library
801 West Burchett Avenue, Glendale

THERESA DIERKES.....Registrar's Office
362 South Hudson Avenue

ALICE GAZIN.....Engineering
672 South Mentor Avenue

MARGARET A. GANSSLE.....Registrar's Office
336 South San Gabriel Blvd.

LILLIAN C. GRUNDY.....Physics
1531 North Michigan Avenue

ALICE HAWKINS.....Secretary's Office
1008 North El Molino Avenue

JOSEPHINE HERMANN.....Humanities Library
937 East California Street

INGA HOWARD.....Office of the Chairman of the Executive Council
1126 Cordova Street

LOUISE HUGENTOBLER.....Assistant and Secretary, Biology
1067 San Pasqual Street

HELEN LEPREVOST.....Secretary's Office
107½ West Tremont Street

A. W. MCCONNELL.....Superintendent of Buildings and Grounds
490 East Delmar Street

HELENA MCFARLIN.....House Director, Dormitory
Dormitory

ADELINE M. MORRILL.....Chemistry
827 North Catalina Avenue

HERBERT H. G. NASH.....Bookkeeper, Secretary's Office
145 South Michigan Avenue

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

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

MARGARET A. SHERIDAN.....Athletic Store
656 South Mentor Avenue

Staff of Instruction and Research
Summary

DIVISION OF PHYSICS, MATHEMATICS, AND ELECTRICAL ENGINEERING

R. A. MILLIKAN, Chairman

PROFESSORS

HARRY BATEMAN, Mathematics, Theoretical Physics, Aeronautics
ERIC T. BELL, Mathematics
PAUL S. EPSTEIN, Theoretical Physics
ROBERT A. MILLIKAN, Physics
ROYAL W. SORENSEN, Electrical Engineering
RICHARD C. TOLMAN, Physical Chemistry, Mathematical Physics
HARRY C. VAN BUSKIRK, Mathematics

ASSOCIATE PROFESSORS

IRA S. BOWEN, Physics
EARNEST C. WATSON, Physics
LUTHER E. WEAR, Mathematics

ASSISTANT PROFESSORS

WILLIAM V. HOUSTON, Physics
SAMUEL S. MACKEOWN, Electrical Engineering
J. ROBERT OPPENHEIMER,* Physics
HOWARD P. ROBERTSON,* Mathematics
WILLIAM R. SMYTHE, Physics
WALTER T. WHITNEY, Physics
CLYDE WOLFE, Mathematics
FRITZ ZWICKY, Theoretical Physics

INSTRUCTORS

WILLIAM N. BIRCHBY, Mathematics
FRANCIS W. MAXSTADT, Electrical Engineering

*On leave of absence.

INTERNATIONAL RESEARCH FELLOWS

Louis A. M. Henry, C. R. B. Educational Foundation
William R. Morgans, Commonwealth Fund
Franco Rasetti, International Education Board

NATIONAL RESEARCH FELLOWS

William H. Bennett
Francis Bitter
Frank W. Constant
John G. Frayne

JOHN SIMON GUGGENHEIM MEMORIAL FUND FELLOW

Roy James Kennedy

RESEARCH FELLOWS

Jesse W. M. DuMond
Alexander Goetz
William L. Hart*
Morgan Ward
Wladimir M. Zaikowsky

TEACHING FELLOWS AND ASSISTANTS

Andrew P. Alford
Carl D. Anderson
Warren N. Arnquist
Miguel A. Basoco
Willard C. Bruce
John S. Campbell
Benedict Cassen
Charles R. Daily
John D. Elder
Alfred B. Focke
George T. Harness, Jr.
Claude D. Hayward
Archer Hoyt
Lorenz D. Huff
Kenneth K. Illingworth
Lawrence S. Kennison
Charles C. Lash
Charles C. Lauritsen
William A. Lewis
Walter C. Michels
Morris Muskat
Henry V. Neher
Glenn H. Palmer
John M. Pearson
Robert I. Piper
Lynn H. Rumbaugh
Joseph W. Schweinfest
Richard M. Sutton
Charles A. Swartz
John W. Thatcher
Edward M. Thorndike
Johannes A. Van den Akker
Ralph E. Winger
Karl M. Wolfe

INDUSTRIAL RESEARCH ASSISTANTS

Ralph K. Day
Howard B. Holroyd
Lynn G. Howell
Norris Johnston
Edwin M. McMillan
Emerson M. Pugh
Vadim M. Sokoloff
Kenneth A. Solomon
D. Dwight Taylor

*Visiting Professor.

DIVISION OF CHEMISTRY AND CHEMICAL ENGINEERING

A. A. Noyes, Chairman

PROFESSORS

Stuart J. Bates, Physical Chemistry
James E. Bell, Chemistry
Arthur A. Noyes, Chemistry
Richard C. Tolman, Physical Chemistry, Mathematical Physics

ASSOCIATE PROFESSORS

Roscoe G. Dickinson, Physical Chemistry
William N. Lacey, Chemical Engineering
Howard J. Lucas, Organic Chemistry

ASSISTANT PROFESSORS

Linus C. Pauling, Theoretical Chemistry
Ernest H. Swift, Analytical Chemistry

INSTRUCTORS

Arnold O. Beckman, Inorganic Chemistry
Don M. Yost, Inorganic Chemistry§

NATIONAL RESEARCH FELLOWS

Louis S. Kassel
Adolf H. Kunz
Herman C. Ramsperger
Oscar K. Rice

RESEARCH FELLOWS

Robert H. Dalton
Aubrey C. Grubb*
Joseph B. Koepfli
Martin E. Nordberg

TEACHING FELLOWS AND ASSISTANTS

Albert C. Bilicke
Lee R. Brantley
Frank C. Croxton
Robert T. Dillon
Fred J. Ewing
Cecil E. P. Jeffreys
Daniel B. McRae
Richard D. Pomeroy†
S. Frederick Ravitz
Nathan F. Scudder†
James H. Sturdivant
Homer B. Wellman
Ralph R. Wenner
William G. Young‡

*Visiting Professor.
†Petroleum Research Institute.
§On leave of absence in Europe.
‡duPont Fellow.

DIVISION OF CIVIL AND MECHANICAL ENGINEERING

FRANKLIN THOMAS, Chairman

PROFESSORS

LEWIS M. ADAMS, Military Science and Tactics
HARRY BATEMAN, Mathematics, Theoretical Physics, Aeronautics
W. HOWARD CLAPP, Mechanism and Machine Design
ROBERT L. DAUGHERTY, Mechanical and Hydraulic Engineering
FREDERIC W. HINRICHS, JR., Mechanics
FRANKLIN THOMAS, Civil Engineering

ASSOCIATES

THEODOR VON KARMAN, Aeronautics
CARL C. THOMAS, Engineering Research

ASSOCIATE PROFESSORS

R. R. MARTEL, Civil Engineering
WILLIAM W. MICHAEL, Civil Engineering

ASSISTANT PROFESSORS

GEORGE B. BRIGHAM, Engineering Drawing
LOUIS J. CLATERBOS, Military Science and Tactics

INSTRUCTORS

FRED J. CONVERSE, Civil Engineering
ARTHUR F. HALL, Pattern Making and Machine Shop
MURRAY W. HAWS, Pattern Making
OSCAR L. HEALD, Forging
ROBERT T. KNAPP, Mechanical Engineering
WILLIAM W. MARTIN, Wood Working
ALBERT A. MERRILL, Experimental Aeronautics
WALTER W. OGIER, Mechanical Engineering

RESEARCH FELLOWS

THOMAS E. BUTTERFIELD* ARTHUR L. KLEIN
CLARK B. MILLIKAN

TEACHING FELLOWS AND ASSISTANTS

DONALD P. BARNES
CHARLES H. CARTWRIGHT
GUY L. CHILBERG
RALPH W. CUTLER
RICHARD G. FOLSOM
FERDINAND G. GRAMATKY
DOUGLAS G. KINGMAN
ALBERT E. LOMBARD
KENNETH H. ROBINSON
ERNEST E. SECHLER
JOHN E. SKAFTE

*Visiting Professor.

DIVISION OF GEOLOGY AND PALEONTOLOGY

J. P. BUWALDA, Chairman

PROFESSORS

J. P. BUWALDA, Geology
F. L. RANSOME, Economic Geology
CHESTER STOCK, Paleontology
WENDELL P. WOODRING, Invertebrate Paleontology

RESEARCH ASSOCIATE

DONALD R. DICKEY, Vertebrate Zoology

INSTRUCTOR

RENE ENGEL, Geology

CURATOR

EUSTACE L. FURLONG, Vertebrate Paleontology

SCIENTIFIC ILLUSTRATOR

JOHN L. RIDGWAY

COMMONWEALTH FUND FELLOW

GEORGE A. CUMMING

TEACHING FELLOWS AND ASSISTANTS

ALEXANDER CLARK
THOMAS CLEMENTS
ROLLIN P. ECKIS
C. LEWIS GAZIN
LOZELL C. HOOKWAY
RALPH L. LUPHER
JOHN H. MAXSON
BERNARD L. MOORE
JOHN W. PATTERSON
ADRIAAN J. VAN ROSSEM

DIVISION OF BIOLOGY

THOMAS H. MORGAN, Chairman

PROFESSORS

THOMAS H. MORGAN, Biology
ALFRED H. STURTEVANT, Genetics

ASSOCIATE PROFESSOR

ERNEST G. ANDERSON, Genetics

ASSISTANT PROFESSOR

STERLING H. EMERSON, Genetics

INTERNATIONAL RESEARCH FELLOW

YOSHITAKA IMAI, International Education Board
THEODOSIUS DOBZHANSKY, International Education Board

TEACHING FELLOWS AND ASSISTANTS

RUSSELL L. BIDDLE
WILLIAM A. *HETHERINGTON*
NORWOOD K. SCHAFFER
CARL C. *LINDEGREN*
ALBERT TITLEBAUM

DIVISION OF ASTROPHYSICS

OBSERVATORY COUNCIL

GEORGE E. HALE, Chairman
ROBERT A. MILLIKAN
ARTHUR A. NOYES
HENRY M. ROBINSON

JOHN A. ANDERSON, Executive Officer
EDWARD C. BARRETT, Secretary

ADVISORY COMMITTEE

WALTER S. ADAMS, Chairman
CHARLES G. ABBOT
IRA S. BOWEN
PAUL S. EPSTEIN
EDWIN HUBBLE
ALBERT A. MICHELSON
HENRY N. RUSSELL
FREDERICK H. SEARES
RICHARD C. TOLMAN

RESEARCH ASSOCIATES

JOHN A. ANDERSON
FRANK E. ROSS

ASSOCIATES IN OPTICS AND INSTRUMENT DESIGN

FRANCIS G. PEASE
RUSSELL W. PORTER

DIVISION OF THE HUMANITIES

C. K. JUDY, Chairman

PROFESSORS

C. K. JUDY, English Language and Literature
GRAHAM A. LAING, Economics and Business Administration
JOHN R. MACARTHUR, Languages
WILLIAM B. MUNRO, History and Government

ASSOCIATES

C. F. TUCKER BROOKE, English Literature
GILMOR BROWN, Director, Public Speaking and Dramatics
MAX FARRAND, American History
BERNARD FAY, Lecturer, History
THEODORE G. SOARES, Philosophy and Ethics
FREDERICK J. TURNER, American History

ASSOCIATE PROFESSOR

GEORGE R. MACMINN, English Language and Literature

ASSISTANT PROFESSOR

HARVEY EAGLESON, English Language and Literature

INSTRUCTORS

LOUIS W. JONES, English Language and Literature
ALBERT A. MERRILL, Accounting
ROGER STANTON, English Language and Literature
RAY E. UNTEREINER, Economics and History

ASSISTANTS

FRANK A. NICKELL — JOSEPH W. SCHWEINFEST
HAMPTON SMITH

READERS

ROBLEY D. EVANS — JOHN H. MAXSON
KENNETH A. SOLOMON

DIVISION OF PHYSICAL EDUCATION

R. W. Sorensen, Chairman

PHYSICAL DIRECTOR

William L. Stanton

INSTRUCTOR

Harold Z. Musselman

PHYSICAL TRAINER

Floyd L. Hanes

ASSISTANTS

Louis J. Claterbos
Arthur Griffith
Vaino A. Hoover
Layton Stanton
Burt Richardson

Historical Sketch

The California Institute, first known as Throop Polytechnic Institute and then as Throop College of Technology, was in its early years an undergraduate and secondary polytechnic school. It owed its origin to a donation made by Amos G. Throop in 1891. In 1910, when the present campus was acquired and the building now known as Throop Hall was erected, its trustees, under the leadership of and with large financial support from the president of the board, Mr. Arthur H. Fleming, adopted the broader policy which led to its development into an institution of university grade devoted not only to undergraduate but also to advanced instruction, in the fundamental sciences as well as in the various branches of engineering, and to research in these fields. It has thereby become a college, graduate school, and research institute of pure and applied science.

During the first ten-year period on the new campus, under the effective presidency of Dr. James A. B. Scherer, there were developed mainly its professional undergraduate courses in civil, mechanical, and electrical engineering, resting on a solid foundation of mathematics, physics, and chemistry, and reinforced on the cultural side by strong departments of English and history.

The progress of the Institute during the last ten years has been especially rapid, owing to the substantial financial support it has received from many individuals and from some of the large national foundations, and owing to the group of scientific men of the first rank who have associated themselves with it.

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. An extension to this laboratory, made possible by a further gift from the same donors, was completed in 1926.

During the years 1920 to 1923, the Norman Bridge Laboratory of Physics, given by the late Dr. Norman Bridge of Chicago, was erected. Dr. Robert A. Millikan became Director of this Laboratory in 1921. In 1922, Culbertson Hall, an auditorium seating 500 persons, was erected. In 1924, the High-Potential Research Laboratory was built and equipped through the cooperation of the Southern California Edison Company. A laboratory of Steam Engineering and an Engineering Research Laboratory, and a Seismological Laboratory were erected in 1927. A building for the Daniel Guggenheim Graduate School of Aeronautics has just been completed; also a new Hall of Humanities, provided by the gift of Mr. and Mrs. Joseph B. Dabney. This includes a commodious lounge used as a social meeting place and reading room for the students and faculty. Additional provision for undergraduate student life on the campus has been made by the erection of a temporary building provided by Mr. and Mrs. Robert Roe Blacker. The first large unit of the William G. Kerckhoff Laboratories of Biology has also been just completed; and Professor Thomas H. Morgan has assumed charge of the development of research and instruction in the various branches of biology. All of this construction has been carried out in the style of Spanish architecture, under the direction of the late well-known architect, Bertram G. Goodhue, and his associates.

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 and a large number of people of this locality interested in the development in Southern California of an important institution of this type. These include Eldridge M. Fowler, Mr. and Mrs. John Wadsworth, M. H. Sherman, R. C. Gillis, Mrs. Marjorie Fleming Lloyd-Smith, Mrs. Van Santvoord Merle-Smith, Mr. and Mrs. James A. Culbertson, Mrs. Mae M. Bridge, Mr. and Mrs. R. R. Blacker, Henry M. Robinson, A. C. Balch, L. D. Ricketts, Wil-

liam G. Kerckhoff, W. L. Honnold, Frank L. Clark, Mr. and Mrs. A. M. Drake, Mr. and Mrs. Arthur Noble, Mrs. Caroline M. Dobbins, Herbert Earlscliffe, Mrs. Emily A. Humphry, Miss Harriet Harvey, and the whole group of Associates of the Institute. The General Education Board has given an endowment of $300,000 to be used for salaries, one of $450,000 for general purposes, and two, aggregating $2,100,000, for enlarging the resources and facilities for graduate instruction and research in the physical sciences and for initiating similar activities in the biological field. The Carnegie Foundation for the Advancement of Teaching has provided an endowment of $40,000 for teachers' insurance and annuities. The Carnegie Institution of Washington has appropriated $30,000 a year for a period of years for the support of researches on the structure of matter and the nature of radiation, under the direction of Dr. R. A. Millikan and Dr. A. A. Noyes, and $12,000 for researches on genetics conducted by Dr. T. H. Morgan. The Carnegie Corporation of New York has given $25,000 for the initiation of a department of instruction and research in geology, $60,000 for the endowment of research in physics and chemistry, and $100,000 for general endowment. The Daniel Guggenheim Fund for the Promotion of Aeronautics, Inc., has appropriated about $350,000 for the erection and equipment of the aeronautics building and for support of the Graduate School through a period of years. The Rockefeller Foundation has, through the National Research Council, provided payments totaling about $20,000 a year to National Research Fellows now working at the Institute.

Educational Policies

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

(1) The Institute shall offer two four-year Undergraduate Courses, one in Engineering and one in Science. Both of these Courses shall lead to the degree of Bachelor of Science and they shall also possess sufficient similarity to make interchange between them not unduly difficult.

(2) The four-year Undergraduate Course in Engineering shall be of a general, fundamental character, with a minimum of specialization in the separate branches of engineering. It 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 technical subjects commonly included in undergraduate engineering courses. It shall include, however, the professional subjects common to all branches of engineering. It is hoped in this way to provide a combination of a fundamental scientific training with a broad human outlook, which will afford students with engineering interests the type of collegiate education endorsed by leading engineers—one which avoids on the one hand the narrowness common among students in technical schools, and on the other the superficiality and the lack of purpose noticeable in many of those taking academic college courses.

(3) Fifth-year Courses leading to the degree of Master of Science shall be offered in the various branches of engineering—for the present in civil, mechanical, electrical, aeronautical, and chemical engineering. In these Courses the instruction in basic engineering subjects shall be maintained at the highest efficiency so that the graduates from them may be prepared with especial

thoroughness for positions as constructing, designing, operating, and managing engineers.

(4) The four-year Undergraduate Course in Science shall afford, even more fully than is possible in the Engineering Course, an intensive training in physics, chemistry, and mathematics. In its third and fourth years groups of optional studies shall be included which will permit either some measure of specialization in one of these basic sciences or in geology, paleontology, biology, or in the various branches of engineering. This Course shall include the same cultural studies as does the Engineering Course, and in addition, instruction in the German and French languages. Its purpose will be to provide a collegiate education which, when followed by one or more years of graduate study, will best train the creative type of scientist or engineer so urgently needed in our educational, governmental, and industrial development, and which will most effectively fit able students for positions in the research and development departments of manufacturing and transportation enterprises.

(5) Fifth-year Courses leading to the degree of Master of Science shall be offered in the sciences, especially in physics, mathematics, chemistry, geology, paleontology, biology, and chemical engineering. A considerable proportion of the time of these Courses shall be devoted to research. These will be supplementary to the Undergraduate Course in Science, and will be intended to continue the training for the types of professional positions referred to in the preceding paragraph.

(6) Throughout the period of undergraduate study every effort shall be made to develop the character, 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; and the weekly assemblies, addressed by leading men in the fields of education, literature, art, science, engineering, public service, commerce, and industry, shall be maintained as effectively as possible. 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. Moderate participation of all students in student activities of a social, literary, or artistic character, such as student publications, debating and dramatic clubs, and musical clubs shall be encouraged; and students shall be required to take regular exercise, preferably in the form of intramural 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 gymnasium and student houses.

(7) In all the scientific and engineering departments of the Institute research shall be strongly emphasized, 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 research work adds vitality to the educational work of the Institute and develops 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.

(8) 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, the registration of students at any period shall be strictly limited to that number which can be satisfactorily

provided for with the facilities and funds available. And students shall be admitted, not on the basis of priority of application, but on that of a careful study of the merits of individual applicants, so that the limitation may have the highly important result of giving a select body of students of more than ordinary ability. A standard of scholarship shall also be 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.

Buildings and Educational Facilities

THROOP HALL

Throop Hall, the central building on the campus, contains the offices of administration, the classrooms and drawing-rooms of the engineering departments, and some of the engineering laboratories.

NORMAN BRIDGE LABORATORY OF PHYSICS

The Norman Bridge Laboratory of Physics, the gift of the late Dr. Norman Bridge of Chicago, consists of two units of five floors each, 128 by 58 feet, connected at the north by a third unit of two floors, 80 by 52 feet, so as to form three sides of a hollow square. One of these units has in addition a special photographic laboratory on a partial sixth floor, and each has on its large flat roof excellent facilities for outdoor experimentation.

The first unit contains a lecture room seating 260 persons, two large undergraduate laboratories with adjoining dark rooms and apparatus rooms, three classrooms, three laboratories for advanced instruction, nine offices, a stock and chemical room, the graduate library of physics, and twelve research rooms, besides shops, machinery, switchboard, and storage battery rooms.

The second unit is used primarily for research. It contains forty-five research rooms as well as a seminar room, photographic dark rooms, a chemical room, fourteen offices, and switchboard, storage-battery, electric furnace and machinery rooms. On the second and third floors of this unit of the Norman Bridge Laboratory, is housed, temporarily, the Division of Geology and Paleontology.

The third unit houses on one floor eight more research rooms, thus bringing the number of rooms devoted exclusively to re-

search up to sixty-five, and on the other the Norman Bridge Library of Physics, to provide for which Dr. Bridge gave $50,000.

Ample funds are also available for the purchase of special apparatus and supplies and for the upkeep of the laboratory. Capital funds for the support of research in physics specifically now amount to approximately $865,000. The income of this sum does not, however, represent the total amount available for work in physics. The Trustees have undertaken to provide for the work of the department of physics an income of $95,000 a year. This includes both teaching and research, although the larger portion of this income is to be expended on research. In addition to the Institute funds available for research, the Carnegie Corporation of New York provided through the Carnegie Institution of Washington $15,000 a year for a period of years to be used in researches in physics to be conducted at the Institute under the direction of Dr. Millikan. This annual appropriation has now been capitalized by the Carnegie Corporation.

The relations of the Institute with the staff of the Mount Wilson Observatory are most cordial and one of the chief assets of the Institute is its associations with the Observatory group both informally and in the joint Astronomy and Physics Club.

THE HIGH-POTENTIAL RESEARCH LABORATORY

A high-potential 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 Professor R. W. Sorensen, which is capable of supplying 1,000 kilovolt amperes at the above potential with one end grounded. It is 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 transmission at high potentials. 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 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.

Ample funds are available for the purchase of special apparatus and supplies. An endowment of $700,000 provides an annual income of $35,000 for chemical research. In addition to the Institute funds available for research the Carnegie Corporation of New York provided, through the Carnegie Institution of Washington, $15,000 a year for a period of years to be used in researches in chemistry to be conducted at the Institute under the direction of Professor A. A. Noyes. This annual appropriation has now been capitalized by the Carnegie Corporation.

An addition to the laboratory, for which funds have been provided by C. W. Gates and his brother, P. G. Gates, since de-

ceased, adjoins the first unit on the west, is approximately 80 feet by 50 feet in area, and is two stories in height. It contains a lecture room, seating 150 and completely equipped for chemical demonstrations of all sorts; a seminar room, a chemistry library, a small lecture room seating about 30 people, class rooms, four research laboratories, professors' studies, a storeroom for inflammable chemicals, and the usual machinery, switchboard, and service rooms. The architects for this unit were the Bertram G. Goodhue Associates, with Clarence S. Stein.

RESEARCH LABORATORY OF APPLIED CHEMISTRY

With the Gates Chemical Laboratory is associated the Research Laboratory of Applied Chemistry, which is located in the new Engineering Research Building. 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.

LABORATORY OF STEAM ENGINEERING AND ENGINEERING RESEARCH

Through funds provided in part by the late Dr. Norman Bridge, and in part from other sources, the Institute has erected an engineering building, designed by the Bertram G. Goodhue Associates, 50 by 140 feet in size. One section of this is occupied by a new steam engineering laboratory, which contains a steam unit consisting of two Babcock and Wilcox Sterling boilers, each of 300 H.P. capacity, with all accessory equipment to provide for comprehensive tests of all portions of the installation.

The other half of the building is devoted to an engineering

research laboratory, in which the research section of chemical engineering has already been installed.

DANIEL GUGGENHEIM AERONAUTICAL LABORATORY

The Daniel Guggenheim Aeronautical Laboratory has recently been completed. Funds for its construction and for its operation for a period of ten years have been provided through a gift of about $350,000 from the Daniel Guggenheim Fund for the Promotion of Aeronautics. The building is 160 feet long by about 55 feet wide, and has five floors. The largest item of equipment is a wind tunnel of the Göttingen closed circuit type with a working section 10 feet in diameter. Provision is made for using the working section either as an open or closed type. A 500 horse-power, direct-current motor drives a 15-foot propeller, and a wind velocity of much more than 100 miles per hour will be produced. A complete set of aerodynamical balances will permit testing and research work of all kinds to be performed in the wind tunnel. At one end of the building a room 50 by 20 feet and four stories high will house a large testing machine capable of taking a specimen 30 feet long. In the sub-basement is a water channel about 140 feet long with a cross-section 10 by 10 feet, above which a light car will run, attaining a speed of about 40 miles per hour. This equipment will permit research to be conducted on seaplane hulls, pontoons, ship models, and various surface phenomena. A group of compressed air tanks capable of sustaining ten atmospheres pressure will give a four-inch jet of air at approximately the velocity of sound for a period of time long enough to allow accurate observations to be made on bodies placed in the jet. On the first floor are the observation room of the wind tunnel, a wood shop large enough for the building of complete airplanes, and an engine-testing laboratory with dynamometers and equipment for the testing of small engines. On the second floor are a machine shop and a group of six small laboratories for research on the various physical problems connected with engine studies. The

third floor contains the balance room in which the wind tunnel measurements are made, a seminar room, library, drafting room, auxiliary equipment room, and five offices.

Attention will be centered for the next year or two on the wind tunnel; the installation of the remaining apparatus will follow as rapidly as time permits.

DABNEY HALL OF THE HUMANITIES

Through the generous gift of Mr. and Mrs. Joseph B. Dabney, a Hall of the Humanities was completed in September, 1928. It is a three-story building, located to the east of the Gates Chemical Laboratory, with its main entrance facing the plaza. The building contains provision for various undergraduate activities, lecture rooms, a treasure room for the exhibition of pictures and other works of art, a library-reading room, conference rooms and studies, and in the east wing a very attractive lounge, on the north side of which a series of windows open out upon a tiled patio and an ornamental garden.

CULBERTSON HALL

Culbertson Hall, a beautiful auditorium seating 500 persons, erected in 1922, provides facilities for the Institute assemblies, lectures, and concerts, as well as for various social functions both of students and faculty. It was named in honor of the late Mr. James A. Culbertson, who was a trustee of the Institute and Vice-President of the Board during the years 1908 to 1915.

SEISMOLOGICAL RESEARCH LABORATORY

A Seismological Research Laboratory, located on a site west of the Arroyo Seco, has recently been completed. In it are carried on studies on earth movements. The general program of research is outlined by the Committee on Seismology of the Carnegie Institution of Washington, of which Dr. Arthur L. Day, director of its Geophysical Laboratory, is chairman. Mr. Harry O. Wood is in immediate charge of the investigations; and

with him cooperate Dr. J. A. Anderson, of the Mt. Wilson Observatory, and Prof. John P. Buwalda, of the geological department of the Institute.

THE WILLIAM G. KERCKHOFF LABORATORIES OF THE BIOLOGICAL SCIENCES

The first unit of the William G. Kerckhoff Laboratories of the Biological Sciences was completed and occupied in the fall of 1928. This building, designed by the Bertram G. Goodhue Associates, is located on the western end of the campus north of its main axis and parallel to it. It is approximately 50 by 160 feet in size, four stories in height, and contains over fifty rooms.

The basement includes two workshops, chemical room, switchboards, and five special laboratory rooms. The first floor is given over largely to undergraduate instruction. It includes two lecture rooms each seating about fifty students, four large laboratories, and six small instructors' rooms. On the second and third floors are the research laboratories, including the private laboratories of the staff, offices, and laboratories for graduate and more advanced work and research. The library is temporarily housed on the second floor.

On each floor of the building there is a large cold storage room. These rooms can be individually regulated within a wide range of temperatures, and should suffice for carrying on experimental work in which temperature measurements are required.

Land has been purchased in the vicinity for the erection of greenhouses for genetic work.

LIBRARIES

The library of the Institute comprises the General Library and five departmental libraries: for Physics, Chemistry, Geology, Biology, and the Humanities. The General Library, situated in the central unit of the Norman Bridge Laboratory of Physics, contains the books, periodicals, and society papers on engineering, general science, and other general subjects. With it is

incorporated the Webb Library, which is a collection of some 3,000 volumes largely in French and German and in popular science. This library, together with an endowment of $30,000, is the gift of the late William E. Webb of New York.

The Physics Library is situated in the east wing of the Norman Bridge Laboratory of Physics, and contains all books and periodicals required for the advanced study of physics and mathematics. An endowment of $40,000 for books for this library is the gift of the late Dr. Norman Bridge.

The Chemistry Library is located on the first floor of the new unit of the Gates Chemical Laboratory. This library contains the books and periodicals on chemistry and chemical engineering.

The Geology Library is situated on the second floor of the west wing of the Norman Bridge Laboratory of Physics. Dr. Ralph Arnold has recently given his valuable geological library to the Institute.

The biological library is located on the second floor of the William G. Kerckhoff Laboratories of the Biological Sciences.

The Humanities Library is situated on the first floor of the Dabney Hall of the Humanities, and contains books and periodicals on economics, history, literature, and philosophy.

OTHER BUILDINGS

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

Extra-Curriculum Opportunities

LECTURE AND CONCERT COURSES

Under the auspices of the Pasadena Lecture Course Committee there are given each year a number of public lectures on science, literature, and other subjects of general interest, to which the members of the Institute are admitted. Weekly public lectures in science, illustrated by experiments, are given by the members of the Institute faculty in the lecture room of the Norman Bridge Laboratory of Physics. Special opportunities are made available to students for attendance at concerts given by noted artists under the auspices of the Pasadena Music and Art Association. Lectures given from time to time at the Institute under the auspices of Sigma Xi and of the Astronomical Society of the Pacific are open to the students. They may also arrange to visit the Huntington Library and Art Gallery, and members of the Institute staff give occasional talks to small groups of students at the art gallery on the pictures there exhibited.

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 with such matters as may be delegated 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 and a Geology Club include men interested in these particular fields. Other organizations are the Dramatic Club, the Economics Club, the Press Club, the Radio Club, and the Aeronautics Club.

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.

Sigma Xi is represented at the Institute by an active chapter. Graduate students who have demonstrated their ability to prosecute research are eligible for membership. Undergraduate students who have shown particular interest and aptitude in research are elected to associate membership.

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.

A chapter of Pi Kappa Delta, national forensic honor society, elects to membership students who have represented the Institute in intercollegiate debate, oratorical or extempore speaking contests. At the national conventions held every even-numbered

year, the Institute speakers have an opportunity to compete for national honors in the forensic field. On the odd-numbered years they enter the competition for the trophies offered by the Pacific Province of the order.

The forensic interests of the Institute include also membership in the Southern California Public Speaking Association. Under the auspices of this association the Institute debaters engage in an annual schedule of six debates with other Southern California colleges, and in annual oratorical and extempore contests. Debates are also scheduled with other nearby colleges, and frequently with eastern teams traveling through California. On the Pi Kappa Delta trips to the National Conventions, debates are scheduled with the best of the institutions that can be met en route. Institute orators also compete in the annual contest of the Peace Association, and the Better America League contest on the Constitution.

To train the Institute speakers for these various intercollegiate contests, a debate course is offered by the English department, and much individual coaching is given the members of the teams. During the second and third terms a special class for freshmen gives the members of that class an opportunity to prepare for the freshman debates, in which the first-year men of six other colleges are met. A number of intramural practice debates, and the annual contest for the Conger Peace Prize, afford all men interested in public speaking an opportunity to develop their abilities.

Exceptional facilities in dramatic work are afforded the student. Each year a classical play, Greek or Roman, is presented under the auspices of Pi Kappa Delta, participation in it, however, being open to the whole student body. A modern play is given under the auspices of the English Department, open likewise to all students. Both of these plays are produced under the direction of Mr. Gilmor Brown, Director of the internation-

ally famous Pasadena Community Playhouse. Mr. Brown also supervises the delivery of the students taking part in forensic contests.

A thriving Young Men's Christian Association with a full time Secretary has its office in Dabney Hall and performs many valuable services. Receptions for new students, hikes, meetings, classes for the study of life and other problems are conducted by this organization. Under its auspices has been formed a Cosmopolitan Club, membership in which is evenly divided between foreign and American students.

Requirements for Admission to Undergraduate Standing

ADMISSION TO THE FRESHMAN CLASS

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 rest 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, Shop (up to 1 unit); additional English, Mathematics, Laboratory Science, or History.	
Group C:	Drawing, Commercial subjects, additional Shop, 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. All 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]

[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

In addition to the above credentials, all applicants for admission to the freshman class are required to take entrance examinations. These examinations do not take the place of the high-school credentials, but serve to supplement them. The subjects covered are those listed in group A. The examinations are 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.

Students planning to enter the Institute in September, 1929, may take the examinations Monday and Tuesday, July 1st and 2nd, or Monday and Tuesday, September 23rd and 24th.

Students living at a distance from Pasadena may, upon request, be allowed to take the spring entrance examinations under the supervision of their local school authorities; or they may, if they prefer, take the College Board examinations in Comprehensive English, Comprehensive Mathematics (Elementary and Advanced), Physics, and Chemistry. The last three examinations must be taken in the summer immediately preceding entrance to the Institute. Each applicant who offers College Board examinations should arrange with the College Entrance Examination Board to have his papers sent to the Institute after they have been graded.

Each applicant must present a physician's certificate showing that he is physically qualified to carry the work of the Institute. All students entering the Institute for the first time are required to be vaccinated or to submit satisfactory evidence of recent vaccination.

---

notebooks at the time of the examination. The schedule for 1929 is as follows: Wednesday, September 25, 9:00 A.M., Mathematics; 2:00 P.M., English. Thursday, September 26, 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 17-22, 1929. Application 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 20, 1929.

Application for admission to the Institute may be made at any time, but there is a distinct advantage in having it on file by the first of May, or even earlier. This enables the Institute to make full use of all information available from high school sources. Applicants whose preparatory work is complete should submit certificates of recommendation from the principals of their high schools, together with their complete scholastic record before taking the entrance examinations. Applicants who wish to take the spring entrance examinations and who have completed their preparatory work but are not able to secure their scholastic records before the examinations, will be admitted to the examinations if such a request is received from their principals. Certificates of recommendation and scholarship records of students who have taken the examinations under the above arrangement should be forwarded to the Institute as soon as possible after the completion of the preparatory work.

No decision can be reached as to the admission of a student until his principal's recommendation and his complete scholastic record are received. Applicants are advised to take the July examinations if possible.

Blanks for the physician's certificate, application for admission to the Institute, and certificate of recommendation will be provided upon request.

Applicants who comply with these conditions not later than July 10th will be notified by the Registrar as to their acceptance on or about July 15th.

Upon receipt of the registration fee of $10.00 (which will be deducted from the first-term tuition) and a satisfactory physician's certificate, each accepted applicant will be sent a registration card which should be presented at the Institute at the time set for freshman registration.

Checks or money orders should be made payable to the California Institute of Technology.

ADMISSION OF UNDERGRADUATES FROM OTHER COLLEGES TO UPPER CLASSES

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. It is well for students planning to transfer to send their credentials to the registrar at an early date; they should arrange for a personal interview, if possible. These students take examinations in Mathematics, Physics, and Chemistry; except that the examinations in Physics and Chemistry are required only of those desiring to pursue the Course in Science. In addition, students desiring credit for work in Science and Engineering Courses taken elsewhere will be required to pass review examinations in these subjects unless both the quality and the extent of their previous work appear to be entirely satisfactory. The examinations in Mathematics, Physics and Chemistry taken by students planning to transfer to the third and fourth-year classes are the review examinations required of all students of the Institute before they undertake the work of the third year, and are taken at the same time by both regular and transfer students. For men planning to enter the sophomore year, similar review examinations covering the work of the freshman year are required. Copies of previous examination papers will be sent to approved applicants upon request.

The examinations may be taken either in June or in September. The schedule for 1929 is as follows: Thursday, June 6, 9:00 A.M., Chemistry; Friday, June 7, 9:00 A.M., Mathematics; Saturday, June 8, 9:00 A.M., Physics; Tuesday, September 24, 9:00 A.M., Mathematics; 1:30 P.M., Physics; Wednesday, September 25, 9:00 A.M., Chemistry.

Applicants residing at a distance may take the June examinations elsewhere than at the Institute, provided arrangements are made in advance.

Applicants for admission to the third and fourth years whose credentials have been approved may take advantage of the review courses in Mathematics and Physics to prepare for their examinations. These courses are offered during the three weeks preceding the opening of the fall term. The fee is $20 for each course.

Physicians' certificates and certificates of vaccination are required as in the case of students entering the freshman class.

Because of the very thorough, intensive study of Physics and Mathematics required in the first two years, students from other colleges, unless of ability above the average of Institute students, can not hope to transfer to the higher years of the Institute Courses without incurring much loss of time and serious difficulty in the pursuit of the more advanced subjects. Students intending to complete the Institute Courses are therefore recommended, as far as possible, to take their freshman and sophomore work also at the Institute.

ADMISSION OF COLLEGE GRADUATES TO UPPER CLASSES

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. They will be admitted without examination, provided their previous scholastic record indicates attainment not inferior to the average of Institute students, and provided they have creditably completed thorough courses in the basic scientific subjects required in the first two years of the Institute's Undergraduate Courses. If these provisos are not fulfilled, examinations are required as in case of non-graduates.

Expenses

TUITION

The tuition is two hundred and fifty dollars ($250.00) a year for undergraduate students, payable $90 at the opening of the first term, and $80 at the opening of each of the other terms. (For graduate students, see pages 112 and 122.)

The Associated Student Body fee, payable by all undergraduate 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. Deposits are also required to cover the expense of inspection trips taken by students in various courses.

The cost of supplies and of books 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.

LOAN FUNDS

The Cleveland Loan Fund was established by Miss Olive Cleveland for the purpose of aiding students to obtain an education. The income is lent without interest to worthy students who may need such assistance.

In 1923, Mr. Howard R. Hughes, of Galveston, Texas, gave $5,000 to constitute an additional fund for loans to students. Mr. Raphael Herman, of Los Angeles, has provided a like sum to establish the Raphael Herman Loan Fund, which may be used for loans or for scholarships at the discretion of the Institute. Additional gifts of $5,000 and $1,000 have been made by anonymous donors for the same general purpose.

Applications for loans may be made to the Secretary of the Institute.

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 about sixty students. Several of the rooms have sleeping porches, and there are attractive living and recreation rooms. Accommodations in the dormitory are limited to first-year students, and students entering the Institute are expected to live in the dormitory during their first year unless they live at home or for other satisfactory reasons are permitted to live off the campus.

The present minimum rate for room rent and dinner five nights in the week is $160, the maximum is $210 for the year. The

rates are subject to modification by the Institute prior to the opening of any college year. A cafeteria conducted in connection with the dormitory provides breakfast and luncheon to occupants of the dormitory and any other students who may wish to take these meals there.

Registration and General Regulations

Registration for the second term, 1928-1929, will take place January 2, 1929 (9 A.M. to 3 P.M.); for the third term, March 25, 1929 (9 A.M., to 3 P.M.). Registration for the first term, 1929-1930, will take place, for freshmen, September 26, 1929 (9 A.M.), and for other students September 27, 1929 (9 A.M. to 3 P.M.), and September 28, 1929 (9 A.M. to 12 M.). A special fee of two dollars is charged for registration after these dates.

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 from the Registrar's office.

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.

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 Institute property.

It is taken for granted that students enter the Institute with serious purpose. The moral tone is exceptionally good; and the honor system prevails in examinations, and in all student affairs.

Scholastic Grading and Requirements

SCHOLASTIC GRADING

The following system of grades is used to indicate the character of the student's work in his various subjects of study:

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

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 will 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 record 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. A grade of 1 is given when the work is completed.

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 from examinations may be obtained only from the Deans, and will be granted only in the case of sickness or other emergency.

Special examinations may be arranged by the instructor for students who have been allowed to postpone the regular examina-

tions. But these special examinations must be taken within four weeks from the beginning of the following term; or, if in work of the third term, during the week preceding the next year's registration.

A condition in any term's work must be removed during the next term in residence on the date fixed for the removal of conditions. Any condition not so removed automatically becomes a failure, unless otherwise recommended by the instructor at the time the condition is given.

SCHOLASTIC REQUIREMENTS

The number of credits allowed for any subject is the number of units multiplied by the grade received. The number of units assigned to any subject in any term corresponds to the total number of hours per week devoted to that subject, including (1) classwork, (2) laboratory, drawing, or field work, and (3) estimated outside preparation. Subjects are of two classes, those of the one class being distinguished from those of the other by having their subject numbers printed in italics, both as given in the Course Schedules and in the Description of Subjects. For fulfilling scholastic requirements set forth in the following paragraphs, *not less than 90 per cent of the credits required must be received in non-italicized subjects, after December, 1928.*

1. A student will be *placed on probation,* if, at the end of any term, he does not receive at least 80 credits.*

Any student placed on probation must withdraw from student activities or from outside employment, or must reduce the number of subjects he is taking, to a sufficient extent to enable him to meet the requirements. Any such student must report to the Dean of Freshmen in case he is a member of the freshman class, or to the Dean of Upper Classmen in case he is a member of a

*At the end of the first term of his first year at the Institute a student who has failed to secure 80 credits may be refused registration (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.

higher class, before entering upon the work of the ensuing term, and must arrange his schedule of studies and limit his outside activities in accordance with the advice of his Dean.

2. A student is *ineligible for registration:* (a) if in the preceding term he did not receive at least 60 credits; (b) if he has already been on probation in any preceding term and did not receive at least 80 credits in the term just completed; (c) if during the preceding school year he did not receive 300 credits (corresponding to an average of 100 credits per term).

3. A student ineligible for registration because of failure to meet the requirements stated in the preceding paragraph may, if he desires, submit immediately to the Registrar a petition for reinstatement, giving any reasons that may exist for his previous unsatisfactory work and stating any new conditions that may lead to better results. Each such application will be considered on its merits. From a student so reinstated who again fails to fulfil the scholastic requirements for registration, a second petition for reinstatement will not be entertained.

4. For *graduation* a total of 1,200 credits is required (corresponding to an average of 100 credits per term), as well as the satisfactory completion of the work of some one Option of the Course in Engineering or of the Course in Science, amounting to approximately 655 units.

5. 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.

6. A student will be given *honor standing* in any term if he received during the preceding term 145 credits,*130 of which result from grades of 3 and 4 in non-italicized subjects; such honor standing to entitle him to special privileges and opportunities, such as relief from some of the more routine study and labora-

*For the class of 1929, honor standing is determined on the basis of 140 credits.

tory work, and admittance to more advanced subjects and research work. But a student in honor standing may not be admitted to an honor section pursuing any particular subject (other than those of the freshman year) unless he has also obtained a grade of 3 or better in the work prerequisite to that subject.

7. A student will be *graduated with honor* who has received on the average throughout his Course the credits required for honor standing, and who maintains average honor standing through the three terms of the senior year.

SPECIAL REGULATIONS

With the permission of the Registration Committee, a student of ability who must support himself wholly or in part by outside work and consequently would be unable to meet the scholarship requirements in four years may be admitted at the beginning of his sophomore year to a part-time schedule allowing an extra year for the completion of his course. The scholastic standing of students in these part-time courses shall be determined on the basis of seventy-five per cent of the credits mentioned in scholastic requirements 1, and 2, and 3 above. Tuition shall be at the rate of $200 per year.

If for any other reason a student is carrying less than 40 units, the credits required (as stated in paragraphs 1 and 2 on pages 79-80) shall be prorated on the basis of 40 as a maximum. For example, a man carrying 32 units of work shall be expected to obtain four-fifths of 80, or 64 credits, to remain off probation.

Applications for registration in excess of the prescribed number of units 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.

Freshmen should make application, shortly before the close of the school year, for admission to the second year of the Course in Engineering or of the Course in Science.

CANDIDACY FOR THE BACHELOR'S DEGREE

A student must file with the Registrar a declaration of his candidacy for the degree of Bachelor of Science on or before the first Monday of December preceding the date at which he expects to receive the degree. His record at the end of that term must show that he is not more than 21 units and not more than 40 credits 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.

Scholarships and Prizes

FRESHMAN PRIZE SCHOLARSHIPS

A number of freshman scholarships will be awarded by the Institute, and a further 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 classes of the high schools or college preparatory schools. The Institute Scholarships will carry a payment sufficient to cover either the whole or half of 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 69-71, and he must, if awarded a scholarship, expect to enter the Institute at the beginning of the next college year. The competitor for the Alumni Scholarship must be elected by vote of the male members of the senior class of his high school. Any competitor for the Alumni Scholarship is eligible for an Institute Scholarship (in case he should fail to receive the Alumni Scholarship).

Each student nominated for the Alumni Scholarship must mail to the Registrar of the Institute not later than June 10th, on forms provided for the purpose, 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 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 ten or twelve 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.

In addition to the foregoing, Mr. and Mrs. A. M. Drake of Pasadena, in 1927, made provision for an annual scholarship available for a graduate of the high schools of St. Paul, Minnesota, and a similar annual scholarship available for a graduate of the high school of Bend, Oregon.

SOPHOMORE AND JUNIOR PRIZE SCHOLARSHIPS

An endowment fund for undergraduate and graduate scholarships and fellowships, known as the Robert Roe Blacker and Nellie Canfield Blacker Scholarship and Research Endowment Fund, has recently been given to the Institute. The income of this fund is used for maintaining scholarships covering a part or the whole of the tuition and known as the Blacker Junior and Sophomore Scholarships. Half of these scholarships are available for the junior year and the other half for the sophomore year. Normally, these scholarships will carry half-tuition; but

the awards may be further subdivided, or combined to afford full tuition, when the qualifications of the contestants make this advisable. They are awarded at the end of each year to students of the freshman and sophomore classes, on the basis of a competition of the character described below.

JUNIOR TRAVEL PRIZES

Two Travel Prizes, each carrying an award of $900, have been established through the liberality of anonymous donors, in order to emphasize the educational value of travel as a means of broadening the student's cultural and professional view-points.

These two travel prizes are awarded, at the end of the second term of each year, to the two most worthy students in the junior class upon the basis of a competition carried out as described below. They are to be used for a trip to Europe during the vacation between the junior and senior years. These tours are planned in consultation with representatives of the Faculty Committee on Honor Students, and include about ten days' sightseeing in the United States on the way to Europe and on the return. The winners of the prizes are expected to keep a diary of their experiences, and upon their return to file with the Institute a summarized report of their travels and expenses; and to present an interesting account of some of their experiences at an Assembly of the student body.

CONDITIONS OF THE COMPETITION FOR THE PRIZE SCHOLARSHIPS AND TRAVEL PRIZES

For the competition for the Sophomore and Junior Scholarships and for the Junior Travel Prizes the faculty have adopted the following regulations:

(1) *Award of the Blacker Prize Scholarships.* These Scholarships will be awarded to those students who receive the largest number of "points" computed as follows:

	Maximum
(a) Rating in scholastic subjects, equal weights being assigned to the total credits received during the three preceding terms (including credits for previous summer reading), and to the ratio of these total credits to total units	300
(b) Originality, ideals, ability, and personality, as rated by members of the Committee on Honor Students and by individual instructors	225
(c) Rating by fellow-students of the first honor section on personal qualities, such as integrity and trustworthiness, morals, native ability, disposition, initiative, efficiency, ability to deal with others, judgment, gentlemanliness, and the like	150
(d) Rating on ability to write	100
(e) General information and breadth of interest as shown by special examination	75
(f) Detailed statement of each student as to his "student activities," participation in outside affairs, general reading, etc.	75
(g) Physical development and attention to health during the preceding year as rated by the Physical Education Department*	75
Total	1,000

(2) *Qualifying for the Travel Prizes.* At the end of each year the Committee on Honor Students will designate not more than six students of the sophomore class as having "qualified" for the competition for the Travel Prize of the ensuing year. The students who receive the largest number of "points" will be so designated.

(3) *Competition for the Travel Prizes.* The competitors qualifying for the Travel Prizes in the way stated above shall report at once (before the summer vacation) to representatives of the Committee on Honor Students; and a plan for summer reading and study and for special work during the first two terms of their junior year to meet the requirements of the competition will be laid out.

(5) *Award of the Travel Prizes.* These prizes will be awarded to those students who, having qualified in the way stated

*Students desiring to compete for the scholarships or travel prizes should report this fact at the beginning of the school year to the Physical Education Department, in order that they may receive special instructions.

above, receive the highest rating by the members of the Committee on Honor Students. This rating will be based upon:

(a) Accomplishment in scholastic subjects, and grades received in the comprehensive examinations given to "high honor" students at the end of the second term of the junior year.

(b) Research and other creative ability as rated by instructors who have had contact on this side.

(c) Power of clear, forceful expression (oral and written), as rated by instructors who have had contact on this side.

(d) Acquaintance with European geography, politics, social problems, and recent history, with art and nature, with German and French, and other knowledge conducive to the success of a European trip as rated by Dean Macarthur on the basis of the seminar on "Europe" which he conducts during the fall and winter terms.

(e) Student activities, physical development, health, as rated at the end of the sophomore year (items d and g of that rating).

(f) Personal qualities as rated by fellow students at end of sophomore year (item b of that rating).

(g) Personal qualities conducive to fullness of life and success in a scientific or engineering career, as rated by Honor Student Committee and instructors who have had close contact.

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.

SCHOLARSHIP AID FOR HONOR STUDENTS

In addition to the prize scholarships described above, certain scholarship funds, limited in amount, are available for students in honor standing whose financial resources might otherwise prevent them from continuing at the Institute. Any such students are requested to consult the Deans.

Developments in the Humanities

One of the distinctive features of the California Institute is its traditional emphasis upon the humanistic side of the curriculum. In the degree and genuineness of this solicitude the Institute has differentiated itself from other American schools of technology, most of which give little more than a gesture of recognition to the liberal arts. As a rule, in schools of engineering, the professional studies monopolize nearly all the available time and money, leaving the humanities to take what is left, which usually turns out to be very little. Here and there, in most specialized institutions, a lonely course in literature, history, or philosophy is tucked into some corner of the crowded professional programs as a concession to the academic amenities.

This has been particularly unfortunate. It has recruited into the engineering profession large numbers of young men with inadequate cultural backgrounds, lacking in social sympathy, in breadth of outlook, and in their acquaintance with those imponderable forces which even engineers have to take into account. It has crowded into the lower ranks of the engineering vocation too many unimaginative routineers who get no farther than the drafting-room. That should not be the case, for there is no good reason why engineers should be more limited in their intellectual versatility, or in the range of their human interests, than men of any other profession. Many of them are not. On the contrary, there are those who have shown, time and again, that scientific erudition can be illuminated by humanism, and technical skill vivified by imagination. It is to men of this type that the world must continue to look for leadership in all branches of technology, and it is to the training of such men that the energies of the California Institute is primarily directed.

Hence the Institute, from the very outset, has recognized the urgent desirability of making a place in its undergraduate curriculum for a generous amount of instruction in the humanities.

The faculty, in thorough sympathy with this aim, has cooperated by eliminating some of the more specialized technical subjects commonly included in undergraduate engineering courses. As a result, it has been found possible to require every student to take, in each of his four undergraduate years, at least one course of a humanistic character. So far as is known, the California Institute is the only engineering school in the United States that maintains and enforces this requirement. These courses in the Division of the Humanities cover the field of English and Foreign Literatures, European and American History, Philosophy and Social Ethics, Economics and Government. All of them are so planned and articulated that the student obtains a solid grounding, and not merely the superficial acquaintance which is too often the outcome of a free elective system. The standards of intellectual performance in these studies are maintained on exactly the same plane as in the professional subjects, so far as this is humanly possible. Every effort is made to impress upon undergraduates the fact that there is an essential unity to all knowledge, and that no man can master science if he sets out to master science only. The history of human achievement has but a single page.

One of the largest and most attractive buildings on the Institute campus is devoted to the work in Literature, Languages, Philosophy, Economics, History, and Government. This new Hall of the Humanities, erected in 1928, was given by Mr. and Mrs. Joseph B. Dabney, of Los Angeles. In connection with the acceptance of this gift, a special endowment fund of $400,000 was raised for the support of instruction in the humanistic fields, this amount being subscribed by several friends of the Institute.

In addition to the regular staff of the Institute, several scholars from other institutions are giving instruction in the Division of the Humanities during the current year. Among these are Dr. Max Farrand, formerly of Yale University and now Director of the Huntington Library; Professor Bernard Fay, of the

University of Clermont-Ferrand in France; Professor Frederick J. Turner, formerly of Harvard University and now Associate at the Huntington Library; and Professor Tucker Brooke, of Yale University. With the opportunities for research in English Literature and American History which are afforded by the proximity of the Huntington Library, it is anticipated that the instruction given at the Institute in these fields will be steadily strengthened by the association of visiting scholars. It is the endeavor of the Trustees and Faculty to make the social sciences, in no less degree than the natural sciences, contribute towards the development of originality, intellectual versatility, and breadth of human interest among the undergraduates.

Study and Research in Mathematics

The Institute is now prepared to offer competent students advanced study and research in pure mathematics. Owing to the exceptional status of the Institute in theoretical and mathematical physics, it is expected that students specializing in mathematics will desire to devote some of their attention to the modern applications of mathematics, even when their first interest is in pure mathematics, in order that they may acquire a well-rounded view of the entire field. On the other hand, specialists in theoretical physics will find much that is useful for their work in the advanced courses in mathematics. It is one of the aims of the mathematical department of the Institute to provide definitely for such a liaison between pure and applied mathematics by the addition of instructors whose training and interests have been in both fields.

An effort will be made to guide research students in the direction of their own interests and abilities. As enrollment at the Institute is limited, it is possible for the staff to take an individual interest in the research students. In particular, students wishing to pursue a line of research chosen by themselves will be encouraged, and all will be advised to find the problem which they wish to attack, since the discovery of significant solvable problems is the initial difficulty in mathematical research. Those who are not far enough advanced to find their own problems will be assigned to investigation in the fields of work of members of the staff. Teaching fellows and research associates in mathematics will be appointed, so that a considerable nucleus of research workers may be built up as in the other sections of the Institute.

The Savilian Professor of Geometry in the University of Oxford, Dr. Godfrey Harold Hardy, a man who has shown extraordinary skill in the use and development of advanced mathematical analysis, will lecture at the Institute during the winter

term of 1928-1929; and it is expected that other mathematicians of similar attainment will be brought to the Institute from time to time.

Upon the completion of the prescribed graduate work in mathematics, the degree of Doctor of Philosophy is awarded, and the graduate may look forward to a career of teaching or of research. In the larger universities teaching and research are ordinarily combined, but academic advancement and freedom for research usually depend upon demonstrated ability to do original work. Positions as mathematicians with engineering corporations maintaining research departments are available from time to time; and the United States Civil Service frequently announces positions for trained mathematicians.

The opportunities for research work in mathematical physics include such basic subjects as aerodynamics, atomic structure, cosmogony, crystal structure, elasticity, the new quantum mechanics, relativity, and statistical mechanics.

The Seminar in Theoretical Physics brings the research men together and enables each one to get the views of other workers on recent important advances in mathematical physics. The lectures which are given each year by some eminent foreign mathematician or physicist, are particularly helpful and inspiring. This year, Professor Arnold Sommerfeld, of Munich, will lecture during the winter term.

Study and Research in Geology and Paleontology

The Institute has recently added Geology and Paleontology to its major branches of instruction and research.

As in the older science departments of physics, chemistry, and mathematics at the Institute, emphasis is being placed primarily on the development of graduate study and research in geological directions; but provision has also been made for a four-year course of undergraduate study. This will afford an unusually broad and thorough preparation in the basic sciences on which geology depends and an introduction to the fundamental principles of geology itself. This is supplemented, for students desiring to specialize in the subject, by Fifth-Year Courses in Geology and in Paleontology leading to the degree of Master of Science.

These Graduate Courses may be taken either by students who have completed the four-year Course at the Institute, or by students from other colleges who have substantially the same preparation. Properly qualified graduates from other colleges may also pursue as graduate students the geological studies of the senior year of the Undergraduate Course.

During the senior year of the Undergraduate Course and throughout the Fifth-Year Courses in Geology and in Paleontology much time will be devoted to investigation; but students desiring to become research men or professional geologists or paleontologists will naturally continue their work at least two years more for the degree of Doctor of Philosophy.

PROFESSIONAL OPPORTUNITIES FOR GEOLOGISTS

Geology affords exceptional opportunities for an attractive professional career, both on the scientific and industrial sides.

There is a real demand, very inadequately met, for well-trained geologists for teaching and research positions in colleges and universities, for government posts in connection with geological and mining surveys, and for places as directors and field explorers in connection with museums, and, above all, for positions in the oil and mining industries.

Aside from these professional opportunities, the work of the geologist is attractive because it constantly offers new problems to be solved, affords special opportunity for research and expert work, and gives close contact with nature and outdoor life.

THE INSTRUCTION IN GEOLOGY AND PALEONTOLOGY

The elementary geological subjects are given with a threefold purpose. First, they serve to convey a broad concept of the constitution and structure of the earth, of its origin and history, and of the evolution of life upon it; for it is assumed 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 evolution. Secondly, the elementary courses afford to engineering students geological knowledge which will often be required by them in their professional practice. Thirdly, the undergraduate subjects give to those who are to specialize in geological sciences the preparation required for advanced work and research.

The courses in Economic Geology are intended particularly for those who expect to become professional geologists or mining engineers. Although economic geology is closely linked with utility, the subject is taught at the Institute with the full conviction that the best work in economic geology can be done only by those who have a thorough preparation in the fundamental sciences and in general geology. All instruction in economic geology is given with the realization that this branch of geology offers ample opportunity for scientific investigation of the highest order.

The advanced subjects afford training for the profession of geologist or paleontologist. Students who complete the Fifth-Year Course in Geology are prepared for geological positions with oil and mining companies and on government and state geological surveys; but further graduate work (leading to the Doctor's degree) is very desirable for those who are preparing themselves for university positions in geology or paleontology and for service as professional geologists.

The thorough grounding in physics and chemistry afforded in the freshman, sophomore, and junior years is a most advantageous preparation for geologic studies; for geology is essentially the application of the principles of physics and chemistry to the Earth's crust.

OPPORTUNITIES FOR RESEARCH IN GEOLOGY

No better field for geologic training exists than the region around Pasadena. Within convenient reach is an almost unrivaled variety of rock types, geologic structures, and physiographic forms. Field studies can be carried on comfortably throughout the entire year; and this constitutes an important part of the department program.

Stratigraphic studies may be pursued in the Cenozoic and Mesozoic sedimentary rocks of the southern Coast Ranges, in which the oil fields are located, and in the Mojave Desert region. Thick sections of Paleozoic sediments in the desert region of southeastern California remain almost unexplored.

Within easy reach of Pasadena a great variety of geologic structures is exemplified. Folding and faulting on a large scale have occurred in the Coast Ranges; and these same structural phenomena in somewhat different form may be studied in their clear development in the higher ranges of Southern California and in neighboring parts of the Great Basin.

Magnificent examples of a large variety of physiographic forms await study; these range from coastal features resulting

from recent uplift and subsidence to forms due to recent folding, faulting, and erosion of different rock structures. The effects of humid, glacial, and desert climates can be seen in closely adjacent areas.

Although Pasadena is not a mining center, it is adjacent to some of the most productive and geologically interesting oil fields in the world, to large Portland cement plants, and to the gem-producing districts of San Diego County. Moreover, the gold, silver, quicksilver, and copper deposits of the Sierra Nevada and Coast Ranges of California are within comparatively easy reach, and the varied metalliferous deposits of Arizona and southern Nevada are also available for visit and research.

The region likewise offers excellent opportunity for studies in physical and geological seismology (in connection with the laboratory mentioned below), and in other branches of geology.

OPPORTUNITIES FOR RESEARCH IN PALEONTOLOGY

Students in both vertebrate and invertebrate paleontology find in Southern California and adjacent regions splendid opportunities for investigational work. Much research remains to be conducted in the phylogenetic history of organisms and in the succession and relationship of faunas.

Within the Pacific Coast province occur many marine formations, having invertebrate assemblages at numerous horizons. Many important problems are presented in the field of invertebrate paleontology relating to the evolution of specific types of invertebrates, to oil and its formation, to the age and relationship of marine deposits and faunas of the western border of North America and the correlation of these accumulations and assemblages with those occurring in the Pacific Basin and elsewhere. The determination of environmental conditions in which invertebrate faunas of the past have maintained themselves, the significance of invertebrates in problems of sedimentation, and

the special studies of the micro-organisms furnish additional fields attractive to the investigator.

Important contributions in vertebrate paleontology remain to be made in monographic studies of many groups of fossil vertebrates treating of the structure, relationships, and evolution of these forms. Opportunities for studies leading toward contributions of this type are afforded particularly by the extensive collections of excellently preserved materials from the asphalt deposits of Rancho La Brea and McKittrick, California, available at the Los Angeles Museum and at the California Institute.

Within the Great Basin province of western North America occur many continental deposits of Tertiary and Pleistocene age yielding mammalian remains. Valuable collections from several Tertiary horizons in the John Day region of eastern Oregon are available for study. Studies of the extinct faunas not only bring to light the existence of new forms in these assemblages with suggestions as to the environmental conditions under which the groups existed, but they also yield important data relating to the time correlation of the faunas with assemblages occurring outside the Great Basin province.

Land-laid deposits intercalated in the Cenozoic marine sections of the Pacific Coast province furnish mammalian remains of considerable importance in establishing the time relationship between the marine record and the continental record of western North America. Remains of marine mammals are also frequently encountered in Tertiary and Pleistocene marine formations of this region, revealing important stages in the evolution of the group and affording a means of establishing world-wide correlation between marine formations.

SEISMOLOGICAL RESEARCH LABORATORY

A Seismological Research Laboratory has recently been completed and equipped on a site west of the Arroyo Seco. It is largely devoted to researches conducted by the Carnegie Insti-

tution of Washington; but graduate students in the Division of Geology and Paleontology will be received in the laboratory for the purpose of taking part in the researches or of becoming familiar with seismological methods.

TEACHING AND RESEARCH FELLOWSHIPS

Fellowships are available for properly qualified students who desire to pursue advanced work in geology or paleontology, as in other branches of science; see page 123.

Study and Research in Biology

The Trustees of the Institute have recently established a department of biology, and a new biological laboratory—the first unit of the William G. Kerckhoff Laboratories of the Biological Sciences—has just been completed. Funds were provided for the endowment, construction, and equipment of the laboratories by members of the Board of Trustees of the Institute and by the General Education Board. Professor Thomas Hunt Morgan, formerly Professor of Experimental Zoology at Columbia University, has accepted the position of Chairman of the new Division of Biology, and is organizing its various branches. Dr. Alfred H. Sturdevant has been appointed Professor of Genetics; Dr. Ernest G. Anderson, Professor of Genetics; and Sterling H. Emerson, Assistant Professor of Genetics.

As in the other departments of the Institute, emphasis will be placed primarily on research and graduate study; and, even in these directions, no attempt will be made to cover at once the whole science of biology, but rather efforts will be concentrated on the development of those of its branches which seem to offer the greatest promise as fields of research. As rapidly as leaders can be found, it is proposed to organize groups of investigators in general physiology, genetics, biophysics, biochemistry, developmental mechanics, and perhaps later experimental psychology. The choice of these fields of modern research implies that emphasis will be laid on the intimate relations of biology to the physical sciences. That a closer association of these sciences with biology is imperative is becoming more and more apparent as indicated by the development of special institutes for such work. In England, Germany, Russia, Scandinavia, and France, research institutes, specializing in different biological fields, yet primarily concerned with the application of mathematical, physical and chemical methods to biological subjects, have developed in recent years. The latest example is a gift of thirty million

francs to the Paris Academy of Sciences to organize an Institute of Physico-Chemical Biology for the purpose of studying "the physico-chemical mechanism of the phenomena of life."

The California Institute is undertaking this development of biological research by the application of physical and chemical methods not only because of its intrinsic importance, but also because the close association with the strong research departments of physics and physical chemistry of the Institute cannot fail to contribute greatly to its success. Most physiological laboratories have in the past, for practical reasons, been associated with medical schools; and few of them have been in intimate contact with the research staffs, and had the use of the research facilities, of laboratories which are primarily devoted to fundamental investigations in the physical sciences.

The establishment of a Department of Biology, rather than the traditional departments of Botany and Zoology, calls for a word of explanation. It is with a desire to lay emphasis on the fundamental principles underlying the life processes in animals and plants that an effort will be made to bring together, in a single group, men whose common interests are in the discovery of the unity of the phenomena of living organisms rather than in the investigation of their manifold diversities. That there are many properties common to the two great branches of the living world is becoming almost daily more manifest, as shown, for example, in the discoveries that the same principles of heredity that obtain among flowering plants apply also to human traits, and that, in their response to light, animals and plants conform to a common law of physics. It is true that, at what may be called the biological level, an immense diversity of form and function manifests itself, but enough insight has already been gained to make evident that this diversity is in large part due to permutations and combinations of relatively few fundamental and common properties. It is in the search for these properties that the zoologist and botanist may profitably pool their interests.

The animal physiologist today, who wishes to have a broad outlook over his field, can as little neglect the physiology of bacteria, yeast and higher plants as the bacteriologist and plant physiologist can ignore the modern discoveries in animal physiology. The geneticist who works with animals will know only half his subject if he ignores the work on plants, and both plant and animal geneticists will fail to make the most of their opportunities if they overlook the advances in cytology and embryology. It is, then, to bring together in sympathetic union a group of investigators and teachers whose interests lie in the fundamental aspects of their subjects, that a department of Biology will be organized.

For the study of biology, the Institute will, in 1929 and thereafter, make the following provision: It will introduce into its four-year undergraduate Course in Science, which in its last two years now has options in physics, chemistry, mathematics, and geology, a new option in biology. This option will include those fundamental biological subjects that are an essential preparation for work in any special field of pure or applied biology; and the four-year course as a whole will in addition afford a far more thorough training in the basic sciences of physics, chemistry, and mathematics than students of biology, medicine, or agriculture commonly receive. This undergraduate course will be supplemented by a fifth-year course, leading to the degree of Master of Science in Biology, in which students may specialize in study and research in various branches of the science. Special opportunities will also be offered for the pursuit of more advanced courses and extended researches leading to the degree of Doctor of Philosophy, to students desiring to become college teachers, research men, or professional experts.

UNDERGRADUATE COURSES

It is planned to introduce into the four-year Course in Science, if there is sufficient demand for them, three kinds of options in elementary biology that will meet the needs of three classes of

students: (1) Students of superior ability preparing to become investigators and teachers; (2) Students expecting to go into medicine; (3) Students desiring a general or cultural course which will serve to impart an intelligent understanding of man and living things in general from a biological standpoint. The details of these courses will be announced later, but the following is a preliminary outline:

1. *Option Preparing for Biological Research and Teaching:* By accepting for this work only those students who have had chemical, physical, and mathematical courses, it will be possible to emphasize from the beginning the physiological side of biology, starting with the more general aspects and leading through consecutively planned courses to the more difficult applications of physical and chemical methods. These courses will be articulated with the more advanced courses for graduates.

2. *Pre-Medical Option:* Preliminary medical students taking a regular college course, with emphasis on the sciences, will be given an opportunity to fulfil the entrance requirements of the Medical Board. This course will not be planned to cover the ground subsequently covered by the medical schools, but will attempt to give a broad outlook on the animal and plant worlds. The course will be supplemented by other courses more specialized in character that will insure a thorough training in the technical methods of the biological sciences.

3. *General Biological Option:* Arrangements will be made for a general course designed especially for students in chemistry and physics who desire to know, not only the phenomena of living things in their relation to physics and chemistry, but also something of their special characteristics resulting from their highly complex organization. There will be included some laboratory work, consisting largely of demonstrations; and every encouragement will be given to individuals to carry out supervised work, both in the laboratory and in the field, on any special prob-

lems in which the student's interest may have been aroused by the lectures and demonstrations.

ADVANCED COURSES

Instruction will be given by lectures and seminars; and research will be forwarded by intimate contact between students and instructors in the laboratories. In view of the great expense of modern research along physiological lines, the Institute will make careful selection of students of exceptional ability and aptitude, in order to avoid the formal instruction that large numbers entail, and in order that the time of experienced investigators on the staff be not dissipated by administration and unprofitable instruction.

It is not possible to announce specific courses until the staff has been selected, but it may be stated that advanced instruction will be given in the following subjects:

General Physiology: General physiology differs in its aims from the traditional physiology which relates more particularly to man and the higher vertebrates in so far as it encompasses the whole field of living things, selecting those for investigation that are particularly suited to solve specific problems. To cover a field so broad, a number of investigators having special training and interests are to be selected. Such a group will include some men who are particularly interested in the chemical constitution of living matter (biochemists); others in its physical aspects (biophysicists); and others whose interests lie in the reactions taking place in the sense organs and central nervous system (physiological psychologists).

Genetics: The study of heredity, under the more modern name of Genetics, has replaced the older vague treatment of questions of inheritance, and has not only placed in our hands methods of exact investigation, by means of which the processes involved have come under control, but has furnished one of the most re-

fined instruments as yet discovered for penetrating into the invisible structure of living cells.

Developmental Mechanics: Developmental Mechanics has come to mean the experimental investigation of problems of development from the standpoint of the physical sciences. The proximity of the ocean, which furnishes in California during the winter an abundance of breeding animals, gives a unique opportunity for intensive work in embryology. The egg furnishes, also, one of the best opportunities for the study of intracellular phenomena, since an abundance of individual cells is assured, each about to pass rapidly through a series of changes, during which the process of differentiation of the future organs is gradually wrought out.

Other Professional Courses: While emphasis will be placed on the study of those topics in which the investigators of the staff are specially interested, care will be taken that students who expect to work for a higher degree will have an opportunity to become familiar with a wide enough range of information and technical training to insure a broad outlook. Special courses with these ends in view will be organized.

The Division of Biology proposes to offer in the third term of the current year (1928-29) an introductory course in biology, which is intended to give a general survey of the field. It will be devoted largely to discussion of present-day problems, with emphasis on the relation of biology to other experimental sciences. This course will be open this year to all juniors, and to those sophomores who intend to take the Biology Option of the Science Course. Other undergraduate subjects will be arranged later for the two following years for students in the Biology Option. Graduate courses will be announced later. For the year 1928-29, the graduate work will consist of seminars, journal club, and research work.

The Astrophysical Observatory and Laboratory

The International Education Board has provided for the construction by the Institute of an Astrophysical Observatory, equipped with a 200-inch reflecting telescope and many auxiliary instruments. A prime purpose of the gift is to secure for the new Observatory the advantage, in its design, construction, and operation, of the combined knowledge and experience of the strong group of investigators in the research laboratories of the Institute and in the neighboring Mount Wilson Observatory of the Carnegie Institution of Washington. Such cooperation has been cordially promised by the President of the Carnegie Institution with the approval of its Executive Committee and of the director of the Mount Wilson Observatory and his associates. Formal approval was thus given to the continuation and extension of the cooperation which has been in progress between the California Institute and the Mount Wilson Observatory for several years, especially in the study of the astronomical, physical, and chemical aspects of the constitution of matter.

The purpose of the Astrophysical Observatory is thus to supplement, not to duplicate, the Mount Wilson Observatory. The increased light-collecting power of the 200-inch telescope will permit further studies of the size and structure of the galactic system; of the distance, radiation, and evolution of stars; of the spectra of the brighter stars under very high dispersion; of the distance and nature of the spiral nebulæ; and of many phenomena bearing directly on the constitution of matter.

The new observatory will consist of two main features. One of these will be the 200-inch telescope, with its building, dome, and auxiliary equipment, to be erected on the most favorable high-altitude site that can be found within effective working distance of the associated groups of investigators and their ex-

tensive scientific equipment. The other will be an Astrophysical Laboratory located on the Institute campus, which will serve as the headquarters in Pasadena of the Observatory Staff and of the Graduate School of Astrophysics. Its equipment will include instruments and apparatus for the measurement of photographs, the reduction and discussion of observations, and for such astrophysical investigations as can be made there to the best advantage. Its instruments for the interpretation of astrophysical phenomena will be designed to supplement those of the laboratories of the Institute and the Pasadena laboratory of the Mount Wilson Observatory. A shop will also be built for the construction of instruments and optical apparatus.

The value of a telescope depends as much upon the efficiency of the instruments and apparatus used to receive, record, and interpret celestial images as upon its optical and mechanical perfection and its light-collecting power. In the present plan, especial emphasis is therefore laid upon the development of all forms of auxiliary apparatus, such as spectrographs and their optical parts; photographic plates of the various types required for astrophysical and spectroscopic research; radiometers, thermocouples, and photoelectric cells; recording microphotometers and other forms of measuring machines; and laboratory apparatus for reproducing or interpreting celestial phenomena.

An Observatory Council, consisting of four members of the Executive Council of the Institute, has been placed by the trustees in full charge of the design, construction, and operation of the Astrophysical Observatory and Laboratory. With the approval of the Carnegie Institution of Washington, Dr. John A. Anderson, of the Mount Wilson Observatory, has been appointed by the Observatory Council as its Executive Officer, in direct charge of design and construction. An Advisory Committee, including the Director and Assistant Director of the Mount Wilson Observatory and many other prominent astronomers and physicists, will aid the Observatory Council in determining matters of

policy. The organization of the Observatory Council and the personnel of its Advisory Committee are shown on page 47 of this Catalogue.

The Observatory Council, supported by the unanimous opinion of the Advisory Committee and of others consulted, decided to use fused silica for the 200-inch mirror and other mirrors of the large telescope. President Gerard Swope and Dr. Elihu Thomson of the General Electric Company promised the full cooperation of that company in this undertaking; and much progress has already been made in the preliminary work.

The extensive investigation of auxiliary instruments, which forms a prime feature of the general scheme, has been begun. The Research Laboratory of the Eastman Kodak Company has generously agreed to deal with many of the special photographic problems. A Zeiss recording microphotometer has been ordered, and will be used in a comparative study of various forms of this instrument. The radiometer recently used very successfully by Dr. C. G. Abbot, of the Smithsonian Institution, in measuring the distribution of energy in the spectra of stars of several types will be developed and improved.

It is expected that, as soon as the Astrophysical Laboratory on the campus has been built and equipped, the Institute will offer to competent students the opportunity of pursuing advanced courses of study and research in astrophysics, leading to the degrees of Master of Science and Doctor of Philosophy. Undergraduate students who desire to prepare themselves for such graduate work should take the Physics Option of the Course in Science, in which electives in astronomy will be offered in the senior year.

Owing to the rapid development of astronomical and spectroscopic research throughout the country, there are now more professional positions in universities, endowed observatories, and the

Government service than can be satisfactorily filled, for able young men well trained in optics, astrophysics, and subatomic physics. The number of such positions, however, is not large; and only those well qualified for such work should undertake graduate study and research.

Daniel Guggenheim Graduate School of Aeronautics

The Institute has recently added to its major branches of instruction and research new work in aeronautics. This development was made possible through a gift of about $300,000 from the Daniel Guggenheim Fund for the Promotion of Aeronautics. With the aid of this gift, the Institute established the Daniel Guggenheim Graduate School of Aeronautics, and has constructed a new Aeronautics Laboratory containing a ten-foot, high-speed wind tunnel, at an expense of approximately $200,000. (See page 61.)

The following program of instruction and research is being undertaken:

1. Extension of the Institute's theoretical courses in aerodynamics and hydrodynamics, with the underlying mathematics and mechanics, taught by Professors Harry Bateman, Eric T. Bell, Paul S. Epstein, and Theodor von Karman. Professor von Karman, one of the leading authorities in Europe in the field of aerodynamics, has associated himself permanently with the Institute staff on a part-time basis.

2. Initiation of a group of practical courses conducted by the Institute's experimental staff in cooperation with the engineering staff of the Douglas Company, with the aid of the facilities now being provided at the Institute combined with those of the Douglas plant.

3. Initiation of a comprehensive program of research on airplane and motor design, as well as on the theoretical basis of aeronautics.

4. Immediate perfection of the new stagger-decalage, tailless airplane recently developed at the Institute by one of its instructors in aeronautics, A. A. Merrill, a radical departure from

standard aeronautical design, which in recent tests has shown promise of adding greatly to the safety of flying.

5. Establishment of a number of research fellowships in aeronautics at the Institute.

6. Building and testing not only of models for wind-tunnel work, but also of full-size experimental gliders and power planes for free flight.

As in the older departments of physics, chemistry, and mathematics, emphasis will be placed primarily upon the development of graduate study and research in the different branches of aeronautical engineering; but provision has also been made in the Four-Year Undergraduate Course in Engineering for a definite option leading to such graduate study and research. This will afford a broad and thorough preparation in the basic science and engineering upon which aeronautics rests, and will include an introductory survey course in aeronautics in the senior year.

As in the other branches, there are offered in aeronautics definite graduate courses leading to the degree of Master of Science. Since not less than two years of graduate work are required to attain reasonable proficiency in aeronautic design, there is awarded at the end of the first year the degree of "Master of Science for the completion of a Course in Mechanical Engineering" and at the end of the second year, the degree of "Master of Science for the completion of a Course in Aeronautical Engineering."

The graduate courses may be taken either by students who have completed a four-year course at the Institute, or by students from other colleges who have had substantially the same preparation. The field of aeronautical engineering is so many-sided that a student who has completed the Undergraduate Course either in Engineering or in Science will be admitted to the Fifth-Year Course. The sixth-year work, however, may be taken only by students who have completed the Fifth-Year Course at the Insti-

tute or who have had substantially the same preparation elsewhere.

Still more advanced study and research is offered for the Degree of Doctor of Philosophy. This degree is given under the same general conditions as those that obtain in the other courses offered at the Institute.

Information and Regulations for the Guidance of Graduate Students

I. ADMISSION TO GRADUATE STANDING

1. To be admitted to graduate standing at the Institute an applicant must in general have received a Bachelor's degree representing the completion of an undergraduate course in science or engineering substantially equivalent to one of those offered by the Institute. He must, moreover, have attained such a scholastic record and must present such recommendations as indicate that he is fitted to pursue with distinction advanced study and research.

2. If the applicant's preliminary training in science, mathematics, and engineering has not been substantially that given by the four-year undergraduate courses at the Institute, he must pursue such undergraduate subjects as may be assigned by the Division in which he is to pursue graduate work. If the time required for such subjects is small, he may be at once provisionally admitted to graduate standing. If the time required constitutes the major part of a year's work, he may enter upon a two-year course for the degree of Master of Science, with the expectation of being admitted to graduate standing when he has substantially completed the assigned undergraduate studies.

3. Men of exceptional attainments who are not graduates of a college or university of good standing may, in each case by special vote of the Committee on Graduate Study, be admitted to graduate standing.

4. Application for admission to graduate standing at the Institute should be made upon a form which can be obtained from the Registrar. Since admission to graduate work will be granted only to a limited number of students of superior ability, applications should be made as long as possible before the opening of the school year, preferably by the first of March. Students

applying for assistantships or fellowships do not need to make separate application for admission to graduate standing. See Section IX.

5. Admission to graduate standing does not of itself admit to candidacy for the degree of Master of Science or Doctor of Philosophy. As to this, see pages 114-122.

II. FEES

1. Tuition for graduate students is in general $250 a year, payable in three installments, $90 at the beginning of the first term and $80 at the beginning of the second and third terms, the same as for undergraduate students (except that holders of Institute Fellowships and Assistantships pay only $180 a year, payable in three installments of $60 each). For graduate students who have been admitted to candidacy for the Doctor's degree, the tuition will thereafter be at one-half the above rates. Graduate students who are permitted to carry on research during the summer will not be required to pay tuition fees; but, in order to obtain credit for such summer work, they must register for it in advance.

2. No other fees except for breakage are required of graduate students. Students in chemistry are required to make a deposit of $15 at the beginning of the school year to cover their breakage charges.

3. No degrees will be granted until all bills due the Institute have been met.

III. REGISTRATION

1. Application for admission should be made well in advance of the time of registration (see page 112).

2. All graduate students are required to register and file a program card in the Registrar's office at the beginning of each term of residence whether they are attending regular courses of study, or only carrying on research or independent reading, or writing a thesis or other dissertation.

3. Before registering the graduate student should consult with members of the department in which he is taking his major work to determine the studies which he can pursue to the best advantage.

4. A student will not receive credit for a course unless he is properly registered, and at the first meeting of each class should furnish the instructor with a regular assignment card for the course, obtained from the Registrar's office.

5. One term of residence shall consist of one term's work of not less than 45 units in which a passing grade is recorded. If less than 45 units are successfully carried the residence will be regarded as shortened in the same ratio, but the completion of a larger number of units in any one term will not be regarded as increasing the residence. Students who are permitted to carry on research during the summer will be allowed credit therefor. *The student himself is charged with the responsibility of making certain that all grades have been recorded to which he is entitled.*

6. The number of units allowed for a course of study or for research is figured on the basis that one unit corresponds roughly to one hour a week of work in the laboratory throughout the term, or a somewhat shorter number of hours of intensive study.

7. In registering for research, students should indicate on their program card the name of the instructor in charge, and should consult with him to determine the number of units to which the proposed work corresponds. At the end of the term the instructor in charge shall decrease the number of units for which credit is given, in case he feels that the progress of the research does not justify the full number originally registered.

8. Graduate students who are devoting their whole time to their studies will be allowed to register for not more than 60 units in any one term. Students on part time teaching appointments will not be allowed to register for so many units. Teaching fellows will be allowed to register for not more than 45 units.

9. Research Associates, National Research Fellows, Travelling Fellows from other institutions, and other guests of the Institute are requested to file a card in the Registrar's office at the beginning of their work, giving Institute and home address, degrees, nature of work planned, etc.

IV. EXAMINATIONS AND GRADES

1. Term examinations are held in all graduate courses unless the instructor shall, after consultation with the chairman of the division, arrange otherwise. No student taking a course for credit shall be exempt from these examinations when held.

2. Grades for all graduate work are turned in to the Registrar's office at the close of each term.

3. The following system of grades is used to indicate class standing in graduate courses: 4 denotes marked distinction, 3 denotes above average, 2 denotes average, 1 denotes below average, C denotes conditioned, F denotes failed. In addition to these grades which are to be interpreted as having the same significance as for undergraduate courses, the grade P, which denotes passed, may be used at the discretion of the instructor, in the case of seminar, research, or other work which does not lend itself to more specific grading. Undergraduates, when allowed to carry graduate work, may be graded P in any graduate course, in which case the grade P carries the same credit as grade 2.

4. The Master's degree is awarded with the designation "with honor," or without designation.

5. The Doctor's degree is awarded with the designations *"summa cum laude," "magna cum laude," "cum laude,"* or without designation.

V. REQUIREMENTS FOR HIGHER DEGREES

The Institute gives two higher degrees, the degree of Master of Science, and the degree of Doctor of Philosophy.

Members of the permanent Institute staff of rank higher than

that of Assistant Professor are not admitted to candidacy for a higher degree.

The course of study of each candidate will be in charge of the department in which the student is pursuing his major work, which will exercise general oversight over his work.

Each student should consult his departmental adviser, concerning special divisional and departmental requirements. See Section VI for special requirements for the Doctor's degree in Mathematics, Physics and Electrical Engineering, and Section VII for special requirements in Chemistry.

A. MASTER OF SCIENCE

To receive the degree of Master of Science, the student must complete in a satisfactory way the work indicated in the schedule of one of the Fifth-Year Courses, as well as in the schedule of the Four-Year Course in Science or in Engineering (see pages 143-144, 148-154), except that in the case of students transferring from other institutions equivalents will be accepted in subjects in which the student shows by examination or otherwise that he is proficient, and except in so far as substitutions may be approved by special vote of the Committee in charge.

A student before entering upon work for the degree of Master of Science should, after consultation with the department concerned, submit a plan of study (together with his previous record if he transfers from another institution), and make application to the Committee in charge for acceptance as a candidate for that degree. Application forms for admission to candidacy for the degree of Master of Science may be obtained from the Registrar, and must be submitted not later than the end of the first week of the first term of the year in which the degree is to be granted.

All programs of study, and applications for candidacy for the degree of Master of Science, shall be in charge of the Committee on Courses in Science (in case the advanced work is to be in

Physics, Chemistry, Chemical Engineering, Mathematics, Geology, Paleontology, or Biology), and of the Committee on the Courses in Engineering (in case the work is to be in Civil, Mechanical, Electrical, or Aeronautical Engineering); and recommendations to the Faculty of the award of that degree shall be made by one of these Committees; all such actions being taken in general after consideration and recommendation by the Department concerned.

B. DOCTOR OF PHILOSOPHY

1. *General Requirements:* The degree of Doctor of Philosophy is conferred by the Institute in recognition of breadth of scientific attainment and of 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 academic 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.

The work for the degree must consist of scientific research and the preparation of a thesis describing it and of systematic studies of an advanced character in some branch of science or engineering, which will be termed the "major subject" of the candidate. In addition as "minor subject" (or subjects) studies such as will give a fundamental knowledge and research point-of-view 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 an examination, which may be written or oral or both, at the discretion of the departments concerned.

2. *Technical Requirements.* (a) *Residence:* At least three years of work in residence subsequent to a baccalaureate degree equivalent to that given by the Institute is required for the Doctor's degree. Of this at least one year must be in residence at the Institute; but it should be understood that this is a minimum requirement, and students must usually count on spending a somewhat longer time in residence.

Graduate students are encouraged to continue their research during the whole or a part of the summer, but in order that such work may count in fulfillment of the residence requirements, the student must comply with the above regulations and file a registration card for this summer work in the office of the Registrar.

A student whose undergraduate work has been insufficient in amount or too narrowly specialized, or whose preparation in his special field is inadequate must count upon spending increased time in work for the degree.

(b) *Admission to Candidacy:* Any student in graduate standing who has been in residence one term or more, who has satisfied the several departments concerned by written or oral examination or otherwise that he has a comprehensive grasp of his major and minor subjects as well as of subjects fundamental to them, who has satisfied the department of modern languages that he can read scientific German and French with reasonable facility, who has shown ability in carrying on research and whose research subject has been approved by the chairman of the division concerned, and whose program of study has been approved by both his major and minor departments may on recommenda-

tion of the chairman of the division in which he is working be admitted by the Committee on Graduate Study to candidacy for the degree of Doctor of Philosophy.

Examinations in French and German, prerequisite to admission to candidacy for the degree of Doctor of Philosophy, will be given on the fourth Friday of September and on the first Friday of December. Students expecting to file application for candidacy in December are advised to take the September examination, so that, if they have had inadequate preparation, they may enroll for the fall term in one of the regular language classes of the Institute. Students having taken regular language classes in the Institute, and having passed the examinations, may be exempted from further requirement. Graduate students may, in lieu of the examinations offered in September or December, take the regular final examinations given at the end of any one of the three terms.

A regular blank is provided for making application for admission to candidacy. This blank may be obtained from the chairman of the Committee on Graduate Study, and the application must be on file in the office of the Registrar before the close of the first term of the year in which the degree is to be conferred. *The student himself is responsible for seeing that admission is secured at the proper time.*

(c) *Examinations:* A final examination is required of all candidates for the Doctor's degree. This examination, subject to the approval of the Committee on Graduate Study, may be taken at such time after admission to candidacy as the candidate is prepared, except that it must take place at least two weeks before the degree is to be conferred. The examination may be written or oral or both, and may be divided in parts or given all at one time at the discretion of the departments concerned.

The student must petition for examination on a form obtained from the chairman of the Committee on Graduate Study after consultation with the division chairman.

(d) *Thesis:* The candidate is required to submit to the Chairman of the Committee on Graduate Study two weeks before the degree is to be conferred two copies of a satisfactory thesis describing his research, including a one-page digest or summary of the main results obtained.

The thesis must be typewritten on paper of good quality 8½ by 11 inches, leaving a margin for binding of not less than one inch, or may consist in part of pages taken from a published article and pasted on paper of the above size. It should be preceded by a title page containing the following items: Title, Thesis by (*name of candidate*), In Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy, California Institute of Technology, Pasadena, California, Date (*year only*).

Before submitting his thesis to the Chairman of the Committee on Graduate Study, the candidate must obtain approval of it by the chairman of his division, and the members of his examining committee. This approval must be obtained in writing on a form which will be furnished at the office of the Chairman of the Committee on Graduate Study. *The candidate himself is responsible for allowing sufficient time for the members of his committee to examine his thesis.*

VI. SPECIAL REGULATIONS RELATING TO CANDIDACY FOR THE DOCTOR'S DEGREE FOR STUDENTS MAJORING IN MATHEMATICS, PHYSICS, AND ELECTRICAL ENGINEERING

In agreement with the general requirements for higher degrees adopted by the Committee on Graduate Study, as set forth in Section V, the Division of Mathematics, Physics and Electrical Engineering has adopted the following supplementary regulations:

1, a. To be recommended for candidacy for the Doctor's degree in Mathematics the applicant must pass the following courses with a grade of 2 or better:

Modern Algebra, Ma. 123 a, b, c, including the Galois Theory; Modern Geometry, Ma. 109 a, b, c, including Metric Differential Geometry and Tensor Analysis; Theory of Functions of Real and Complex Variables; any one of the courses, other than the purely mathematical, listed under 1, b, preferably Ph. 15 a, b, c, or Ph. 8 a, b, c.

b. To be recommended for candidacy for the Doctor's degree in Physics the applicant must pass the following courses with a grade of 2 or better: Analytical Mechanics, Ph. 12 a, b, c, Electricity and Magnetism, Ph. 8 a, b, c, Physical Optics, Ph. 22 a, b, c, and Introduction to Mathematical Physics, Ph. 15 a, b, c. In case the applicant is minoring in Mathematics he must also pass with a grade of 2 or better the following courses: Advanced Calculus, Ma. 8 a, b, and Differential Equations, Ma. 10. In case the applicant is minoring in Chemistry he must also pass with a grade of 2 or better: Chemical Principles, Ch. 21 a, b, c.

c. To be recommended for candidacy for the Doctor's degree in Electrical Engineering the applicant must pass the following courses with a grade of 2 or better: Analytical Mechanics, Ph. 12, a, b, c, or Applied Mechanics, AM. 1 a, b, and Strength of Materials, AM. 1 c; Electricity and Magnetism, Ph. 8 a, b, c, or Electricity and Magnetism, Ph. 7 a, b, and Theory of Electricity and Magnetism, Ph. 122; Advanced Calculus, Ma. 8 a, b, and Differential Equations, Ma. 10; Alternating Current Analysis, EE. 20; Induction Machinery, EE. 22; Transmission Lines, EE. 44; Dielectrics, EE. 52.

2. An applicant who has had a course equivalent to any of the above may satisfy the requirement by taking an examination in the subject with the instructor in charge.

Students are advised to satisfy the conditions for admission to candidacy in their respective departments as rapidly as possible. In general at least one-half of the requirements should be met by the end of the first year of graduate work. Failure

to do this raises grave doubts as to the advisability of the student continuing graduate study and he should not register for further work until after consultation with his department.

3. In general a student will find it necessary to continue his graduate study and research for two years after admission to candidacy.

A student in Electrical Engineering will, in general, be expected to have had six months or more of practical work in manufacturing, operating, or engineering research, in addition to the time required for college residence.

VII. SPECIAL REGULATIONS RELATING TO CANDIDACY FOR THE DOCTOR'S DEGREE FOR STUDENTS MAJORING IN CHEMISTRY

In agreement with the general requirements for higher degrees adopted by the Committee on Graduate Study, as set forth in Section V, the Division of Chemistry has adopted the following special supplementary regulations:

1. To be recommended for candidacy for the Doctor's degree the applicant must pass satisfactorily an examination in chemistry of the character described in paragraph 2. This examination, which will be mainly written but may be partly oral, may be taken at one of four stated dates, namely, just before the opening of the school year, and at end of each term.

2. The examination in chemistry will cover physical chemistry (as treated in Noyes and Sherrill's "Chemical Principles") and inorganic and organic chemistry to the extent that these are treated in the Undergraduate Chemistry Course of the Institute, also atomic structure (a general descriptive knowledge), colloid and surface chemistry, and history of chemistry. In all these subjects a detailed informational knowledge is not so much desired as power to apply general principles to concrete problems.

3. Applicants must also show by examination or otherwise that they are reasonably proficient in mathematics and physics.

The requirement in these subjects includes a thorough working knowledge of all the topics covered in the first two years of the Institute Undergraduate Courses.

4. With his application for admission to candidacy the applicant must also submit a carefully prepared complete report on the progress of his research up to the date of his application. By this report and his laboratory work the applicant must have given evidence of his industry and ability in research, and of his power to present his results in clear, forceful language and with discrimination as to what is essential in scientific papers.

5. Applicants may in some cases be recommended as candidates, but still be required to complete within a specified time their preparation in special subjects in which they have shown themselves to be deficient.

6. After admission to candidacy students must in general pursue advanced study and research not less than 5 terms (counting equivalent summer work) before they will be recommended by the Division of Chemistry for the final examination for the Doctor's degree.

VIII. GRADUATE LIFE

The Faculty Club of the Institute is open to graduate students and affords the advantage of intimate associations with fellow students and with members of the Faculty. A few rooms are available to graduate students at a cost which is less than would ordinarily be paid elsewhere and dining privileges are furnished at cost.

IX. FELLOWSHIPS AND ASSISTANTSHIPS

The Institute offers a number of Fellowships and Assistantships, carrying salaries ranging from $500 to $1,000 for ten months' service. (The tuition of such fellows and assistants is $180 until admitted to candidacy for the Doctor's degree, when it becomes $90.)

The primary object of these appointments is to give a group of well-qualified men a training in 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 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 classroom 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 teaching. Advanced courses of study may also be pursued as 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 Doctor's 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 Teaching Fellowships the second year.

Blanks for making application for Fellowships or Assistantships may be obtained on request from the chairman of the Committee on Graduate Study. When possible, these applications should reach the Institute before March 1st, and notices of awards will be mailed to successful applicants on March 20th. Appointments to Fellowships and Assistantships are for one year only; and a new application must be filed before March 1st

of each year by all who desire appointments for the following year regardless of whether they are already holders of such appointments or not.

X. RESEARCH FELLOWSHIPS

1. Institute Research Fellowships: 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.

2. The National Research Fellowships in Physics, Chemistry, and Mathematics established by the Rockefeller Foundation are awarded by the National Research Council to men who have their Doctor's degree. Fellows may choose the institution in which they desire to pursue research. Applications should be made to the National Research Council, Washington, D. C.

3. The Research Fellowship of the Standard Oil Company: A special fund has been given to the Institute by the Standard Oil Company (New Jersey) for maintaining a fellowship on internal combustion engines.

4. The Petroleum Institute has, through the National Research Council, inaugurated researches at the Institute which call, in 1928-1929, for an expenditure of $18,000. These funds are used mainly for supporting the work of research fellows who are carrying on fundamental researches connected with the physics or chemistry of petroleum or of the hydrocarbons of which it is composed.

5. The Standard Oil Company of California has provided a fund for a research fellowship on the radio-active content of oil bearing materials and other geological structures.

6. The Inspiration Consolidated Copper Company has provided a fund for research on the flotation process.

XI. INSTITUTE GUESTS

Members of the Faculties of other educational institutions who have already received their Doctor's degree and desire to carry on special investigations may be granted the privileges of the facilities of the Institute without payment of fees. Arrangement should be made in advance with the Chairman of the Executive Council of the Institute. Such guests are requested to file a card in the Registrar's office at the beginning of their work, giving Institute and home address, degrees, nature of work planned, etc.

Publications

From October 1, 1927, to October 1, 1928

NORMAN BRIDGE LABORATORY OF PHYSICS

REFLECTED AND SECONDARY ELECTRONS FROM AN ALUMINUM TARGET.
J. B. BRINSMADE, *Phys. Rev., 30,* 494-500 (1927).

EVAPORATION FROM LAKES.
N. W. CUMMINGS and BURT RICHARDSON, *Phys. Rev., 30,* 527-534 (1927).

THE VELOCITY AND NUMBER OF THE PHOTO-ELECTRONS EJECTED BY X-RAYS AS A FUNCTION OF THE ANGLE OF EMISSION.
E. C. WATSON, *Phys. Rev., 30,* 479-487 (1927).

DIRECTION OF PHOTO-ELECTRON EMISSION.
DONALD H. LOUGHRIDGE, *Phys. Rev., 30,* 488-493 (1927).

THE ORIGIN OF THE NEBULIUM SPECTRUM.
I. S. BOWEN, *Nature, 120,* 473 (1927).

THE ORIGIN OF THE NEBULAR SPECTRUM.
I. S. BOWEN, *Pub. A. S. P., 39,* 295-297 (1927).

THE SYMMETRY OF THE STRESS-TENSOR OBTAINED BY SCHROEDINGER'S RULE.
H. BATEMAN, *Proc. Nat. Acad Sci., 13,* 771-773 (1927).

A SPECTROSCOPIC DETERMINATION OF E/M.
WILLIAM V. HOUSTON, *Phys. Rev., 30,* 608-613 (1927).

A REPETITION OF THE MICHELSON-MORLEY EXPERIMENT USING KENNEDY'S REFINEMENT.
K. K. ILLINGWORTH, *Phys. Rev., 30,* 692-696 (1927).

RECENT DEVELOPMENTS IN SPECTROSCOPY.
R. A. MILLIKAN, *Bicentenary Number of the American Philosophical Society's Proceedings, 66,* 211-230 (1927).

THE ELECTROSTATICS OF THE THUNDERSTORM
A. W. SIMON, *Journal of the Franklin Institute, 204,* 617-647 (1927).

TWO DEVICES FACILITATING SPECTROMETRY IN THE FAR INFRARED.
RICHARD M. BADGER, *J. O. S. A. and R. S. I., 15,* 370-373 (1927).

SERIES SPECTRA OF CHLORINE, ClII, ClIII, ClIV, ClV, AND OF SiII, PiII, AND SiV.
I. S. BOWEN, *Phys. Rev., 31,* 34-38 (1928).

THE LIFE OF ATOMIC STATES AND THE INTENSITY OF SPECTRAL LINES.
I. S. BOWEN, *Proc. Nat. Acad. Sci., 14,* 30-32 (1928).

RELATIONS OF FIELD-CURRENTS TO THERMIONIC-CURRENTS.
R. A. MILLIKAN and C. C. LAURITSEN, *Proc. Nat. Acad. Sci., 14,* 45-49 (1928).

THE ORIGIN OF THE NEBULAR LINES AND THE STRUCTURE OF THE PLANETARY NEBULÆ.
I. S. BOWEN, *Astrophys. J., 67,* 1-15 (1928).

NEW RESULTS ON COSMIC RAYS.
R. A. MILLIKAN and G. H. CAMERON, *Nature, 121,* 19-26 (1928).

HIGH ALTITUDE TESTS ON THE GEOGRAPHICAL, DIRECTIONAL AND SPECTRAL DISTRIBUTION OF COSMIC RAYS.
R. A. MILLIKAN and G. H. CAMERON, *Phys. Rev., 31,* 163-173 (1928).

THE PHOTOELECTRIC AND THERMIONIC WORK FUNCTIONS OF OUTGASSED PLATINUM.
LEE A. DUBRIDGE, *Phys. Rev., 31,* 236-243 (1928).

A MODIFICATION OF THE MICHELSON INTERFEROMETER.
R. M. LANGER, *J. O. S. A. and R. S. I., 16,* 134-136 (1928).

THE DISPERSION BY HYDROGEN-LIKE ATOMS IN UNDULATORY MECHANICS.
BORIS PODOLSKY, *Proc. Nat. Acad. Sci., 14,* 253-258 (1928).

ON THE QUANTUM THEORY OF THE RAMSAUER EFFECT.
J. R. OPPENHEIMER, *Proc. Nat. Acad. Sci., 14,* 261-262 (1928).

ON THE EXTENSION OF THERMODYNAMICS TO GENERAL RELATIVITY.
RICHARD C. TOLMAN, *Proc. Nat. Acad. Sci., 14,* 268-272 (1928).

TRANSMISSION AND REFLECTION OF GOLD AND SILVER FILMS.
W. V. HOUSTON and GEORGE MOORE, *J. O. S. A. and R. S. I., 16,* 174-176 (1928).

SERIES SPECTRA OF POTASSIUM AND CALCIUM.
I. S. BOWEN, *Phys. Rev., 31,* 497-502 (1928).

SOME EXPERIMENTS IN POSITIVE ION KINETICS.
GAYLORD P. HARNWELL, *Phys. Rev., 31,* 634-642 (1928).

ON THE ENERGY AND ENTROPY OF EINSTEIN'S CLOSED UNIVERSE.
RICHARD C. TOLMAN, *Proc. Nat. Acad. Sci., 14,* 348-353 (1928)

ON THE EQUILIBRIUM BETWEEN RADIATION AND MATTER IN EINSTEIN'S CLOSED UNIVERSE.
RICHARD C. TOLMAN, *Proc. Nat. Acad. Sci., 14,* 353-356 (1928).

THE SPACE-DISTRIBUTION OF THE PHOTO-ELECTRONS EJECTED BY X-RAYS.
E. C. WATSON, *Phys. Rev., 31,* 728-741 (1928).

FIELD CURRENTS FROM POINTS.
C. F. EYRING, S. S. MACKEOWN, and R. A. MILLIKAN, *Phys. Rev., 31,* 900-909 (1928).

ON THE QUANTUM THEORY OF THE AUTOELECTRIC FIELD CURRENTS.
J. R. OPPENHEIMER, *Proc. Nat. Acad. Sci., 14,* 363-365 (1928).

TEMPERATURES OF STARS IN PLANETARY NEBULAE.
H. ZANSTRA, *Nature, 121,* 790-791 (1928).

NEW PRECISION IN COSMIC RAY MEASUREMENTS; YIELDING EXTENSION OF SPECTRUM AND INDICATIONS OF BANDS.
R. A. MILLIKAN and G. H. CAMERON, *Phys. Rev., 31,* 921-930 (1928).

SERIES SPECTRUM OF SODIUM, NaII.
I. S. BOWEN, *Phys. Rev., 31,* 967-968 (1928).

IONIZATION IN POSITIVE ION SHEATHS.
PHILIP M. MORSE and W. UYTERHOEVEN, *Phys. Rev., 31,* 827-832 (1928).

EVIDENCE FOR THE CONTINUOUS CREATION OF THE COMMON ELEMENTS OUT OF POSITIVE AND NEGATIVE ELECTRONS.
R. A. MILLIKAN and G. H. CAMERON, *Proc. Nat. Acad. Sci., 14,* 445-450 (1928).

THE PURE ROTATION SPECTRUM OF AMMONIA.
RICHARD M. BADGER, *Nature, 121,* 942 (1928).

EVIDENCE OBTAINED BY X-RAY ANALYSIS OF FILMS OF IRON IN MAGNETIC FIELDS AS TO THE ULTIMATE NATURE OF MAGNETISM.
T. D. YENSEN, *Phys. Rev., 32,* 114-123 (1928).

ANGULAR SCATTERING OF ELECTRONS IN HYDROGEN AND HELIUM.
GAYLORD P. HARNWELL, *Proc. Nat. Acad. Sci., 14,* 564-569 (1928).

ON THE THERMODYNAMIC EQUILIBRIUM IN THE UNIVERSE.
F. ZWICKY, *Proc. Nat. Acad. Sci., 14,* 592-597 (1928).

THE SPECTRUM OF SULPHUR, SiI
S. B. INGRAM, *Phys. Rev. 32,* 172-178 (1928).

EVIDENCE THAT THE COSMIC RAYS ORIGINATE IN INTERSTELLAR SPACE.
ROBERT A. MILLIKAN and G. HARVEY CAMERON, *Proc. Nat. Acad. Sci., 14,* 637-641 (1928).

ON THE QUANTUM THEORY OF ELECTRONIC IMPACTS.
J. R. OPPENHEIMER, *Phys. Rev., 32,* 361-376 (1928)

AVAILABLE ENERGY.
ROBERT A. MILLIKAN, *Science, 68,* 279-284 (1928).

FURTHER REMARKS ON THE SECOND LAW OF THERMODYNAMICS IN GENERAL RELATIVITY.
R. C. TOLMAN, *Proc. Nat. Acad. Sci., 14,* 701-706 (1928).

THE EQUATION FOR THE TRANSVERSE VIBRATIONS OF THIN RODS.
H. BATEMAN, *Mess. of Math., 57,* 145-154 (1928).

TRANSVERSE SEISMIC WAVES OF THE SURFACE OF A SEMI-INFINITE SOLID COMPOSED OF HETEROGENEOUS MATERIAL.
H. BATEMAN. *Bull. of the Am. Math. Soc., 34,* 343-348 (1928).

ON THE ARITHMETIC OF ABELINA FUNCTIONS.
E. T. BELL, *Proc. Nat. Acad. Sci., 13,* 754-758 (1927).

GENERAL ARITHMETIC.
MORGAN WARD, *Proc. Nat. Acad. Sci., 13,* 748-749 (1927).

NOTE ON THE QUATERNARY QUADRATIC IDENTITY OF HERMITE.
E. T. BELL, *Am. Math. Monthly, 35,* 76 (1928).

GENERAL CLASS NUMBER RELATIONS WHOSE DEGENERATES INVOLVE INFINITE FORMS.
E. T. BELL, *Trans. of International Math. Congress, 1924, published 1928.*

NUMERICAL FUNCTIONS OF MULTIPARTITE INTEGERS AND COMPOUND PARTITIONS.
E. T. BELL, *Am. Jour. of Math., 49,* 489-510 (1927).

PARTITION POLYNOMIALS.
E. T. BELL, *Ann. of Math., 29,* 38-46 (1927).

CERTAIN COMPLETELY SOLVABLE SYSTEMS OF SIMULTANEOUS DIOPHANTINE EQUATIONS.
E. T. BELL, *Am. Math. Monthly, 35,* 239-241 (1928).

TERNARY CHARACTERISTICS OF PRIMES.
E. T. BELL, *Bull. Am. Math. Soc., 34,* 323-328 (1928)

A PROPERTY OF RESULTANTS.
E. T. BELL, *Mess. of Math., 57,* 141-144 (1928).

INTEGRAL BASES.
E. T. BELL, *Am. Math. Monthly, 35,* 304-305 (1928).

A SIMPLIFICATION OF CERTAIN PROBLEMS IN ARITHMETICAL DIVISION.
MORGAN WARD, *Am. Math. Monthly, 35,* 9-14 (1928).

REMARK ON THE NUMBER OF CLASSES OF BINARY QUADRATIC FORMS OF NEGATIVE DETERMINANT.
E. T. BELL, *Proc. Nat. Acad. of Sci., 14,* No. 5, 430-431 (1928).

CERTAIN CLASS NUMBER RELATIONS IMPLIED IN THE NACHLASS OF GAUSS.
E. T. BELL, *Bull. of the Am. Math. Soc., 34,* 490-494 (1928).

NOTE ON THE DIFFERENCE EQUATIONS DEFINING ENUMERATIVE ARITHMETICAL FUNCTIONS.
E. T. BELL, *Bull. Calcutta Math. Soc., 19,* 135-138 (1928).

GATES LABORATORY OF CHEMISTRY

145. THE CRYSTAL STRUCTURE OF MERCURIC AND MERCUROUS IODIDES.
MAURICE L. HUGGINS and P. L. MAGILL, *J. Am. Chem. Soc., 49,* 2357-2367 (1927).

146. A METHOD FOR ACCURATE DETERMINATION OF THE SPECIFIC HEATS OF SALT SOLUTIONS UP TO 80°C; INCLUDING RESULTS FOR POTASSIUM NITRATE AND CHLORIDE SOLUTIONS.
FRANK T. GUCKER, JR., *J. Am. Chem. Soc., 50,* 1005-1017 (1928).

147. FLUORESCENCE IN MIXTURES OF AMMONIA AND MERCURY VAPOR.
ALLEN C. G. MITCHELL, *J. Am. Chem. Soc., 49,* 2699-2703 (1927).

148. THE POTENTIOMETRIC DETERMINATION OF INDIUM.
ULRIC B. BRAY and DARWIN KIRSCHMAN, *J. Am. Chem. Soc., 49,* 2739-2744 (1927).

149. TWO DEVICES FACILITATING SPECTROMETERY IN THE FAR INFRA RED.
RICHARD M. BADGER, *J. Opt. Soc., 15,* 370-372 (1927).

150. THE HIGH TEMPERATURE EQUILIBRIUM BETWEEN THORIUM OXIDE AND CARBON.
C. H. PRESCOTT, JR. and W. B. HINCKE, *J. Am. Chem. Soc., 49,* 2744-2753 (1927).

151. THE HIGH TEMPERATURE EQUILIBRIUM BETWEEN ALUMINUM OXIDE AND CARBON.
C. H. PRESCOTT, JR. and W. B. HINCKE, *J. Am. Chem. Soc., 49,* 2753-2759 (1927).

152. THE TRUE TEMPERATURE SCALE OF CARBON.
C. H. PRESCOTT, JR. and W. B. HINCKE, *Phys. Rev., 31,* 130-134 (1928).

153. THE SHARED-ELECTRON CHEMICAL BOND
LINUS PAULING, *Proc. Nat. Acad. Sci., 14,* 359-362 (1928).

154. A PERIODIC TABLE OF THE STRUCTURE OF ATOMS SHOWING THE NUMBER, QUANTUM-STATES, AND ENERGIES OF REMOVAL OF THEIR ELECTRONS.
ARTHUR A. NOYES and ARNOLD O. BECKMAN, *Proc. Nat. Acad., 13,* 737-743 (1927).

155. THE ACID-FORMING PROPERTIES OF OSMIUM TETROXIDE.
DON M. YOST and ROBERT J. WHITE, *J. Am. Chem. Soc., 50,* 81-84 (1928).

156. THE PREPARATION OF 2-BROMO-P-CRESOL FROM P-NITROTOLUENE.
HOWARD J. LUCAS and NATHAN F. SCUDDER, *J. Am. Chem. Soc., 50,* 244-249 (1928).

157. THE ANALYSIS OF BROMINATED CRESOLS.
JOHN BUXTON and HOWARD J. LUCAS, *J. Am. Chem. Soc., 50,* 249-252 (1928).

158. THE SIZES OF IONS, AND THEIR INFLUENCE ON THE PROPERTIES OF SALT-LIKE COMPOUNDS.
LINUS PAULING, *Z. f. Krist., 67,* 377-404 (1928).

159. THE OXIDATION STATES OF RUTHENIUM AND ITS HALIDE COMPOUNDS.
WILLIAM R. CROWELL and DON M. YOST, *J. Am. Chem. Soc., 50,* 374 (1928).

160. THE INFLUENCE OF RELATIVE IONIC SIZES ON THE PROPERTIES OF IONIC COMPOUNDS.
LINUS PAULING, *J. Am. Chem. Soc., 50,* 1036-1045 (1928).

161. THE DISTRIBUTION OF ENERGY IN MOLECULES.
LOUIS S. KASSEL, *Proc. Nat. Acad. Sci., 14,* 23 (1928).

162. THE REDUCTION-POTENTIAL OF SELENIUM AND THE FREE ENERGY OF AQUEOUS SELENOUS ACID.
HERMAN F. SCHOTT, ERNEST H. SWIFT and DON M. YOST, *J. Am. Chem. Soc., 50,* 721-727 (1928).

163. THE CRYSTAL STRUCTURE OF BETA-BENZENE HEXABROMIDE AND HEXACHLORIDE.
ROSCOE G. DICKINSON and CONSTANT BILICKE, *J. Am. Chem. Soc., 50,* 764-771 (1928).

164. THE QUANTUM YIELD IN THE PHOTOCHEMICAL DECOMPOSITION OF NITROGEN DIOXIDE.
ROSCOE G. DICKINSON and WARREN P. BAXTER, *J. Am. Chem. Soc., 50,* 774-782 (1928).

165. THE QUANTUM THEORY OF QUASI-UNIMOLECULAR GAS REACTIONS.
OSCAR KNEFLER RICE, *Proc. Nat. Acad. Sci., 14,* 113-118 (1928).

166. THE THEORY OF THE DECOMPOSITION OF AZOMETHANE.
OSCAR KNEFLER RICE, *Proc. Nat. Acad. Sci., 14,* 118-124 (1928).

167. THE STRUCTURE OF ATOMS AS A PERIODIC PROPERTY AND ITS RELATION TO VALENCE AND ION-FORMATION.
ARTHUR A. NOYES and ARNOLD O. BECKMAN, *Chem. Rev., 5,* 85-107 (1928).

168. AN IMPROVED QUARTZ FIBER MANOMETER.
ARNOLD O. BECKMAN, *J. Opt. Soc. Am., 16,* 276-278 (1928).

169. STUDIES IN HOMOGENOUS GAS REACTIONS II. INTRODUCTION OF QUANTUM THEORY.
LOUIS S. KASSEL, *J. Phys. Chem., 32,* 1065-1079 (1928).

170. APPLICATION OF THE QUANTUM MECHANICS TO THE STRUCTURE OF THE HYDROGEN MOLECULE AND MOLECULE-ION AND TO RELATED PROBLEMS.
LINUS PAULING, *Chem. Rev., 5,* 173-213 (1928).

171. NOTE: ON MOLECULAR DIAMETERS IN GAS REACTIONS.
RICHARD C. TOLMAN, ROSCOE G. DICKINSON and DON M. YOST, *Science, 67,* 241 (1928).

172. THE SYNTHESIS OF 1-BUTENE.
HOWARD J. LUCAS and ROBERT T. DILLON, *J. Am. Chem. Soc., 50,* 1460-1464 (1928).

173. THE REGION OF EXISTENCE OF UNIMOLECULAR REACTIONS.
LOUIS S. KASSEL, *J. Am. Chem. Soc., 50,* 1344-1352 (1928).

174. SOME DERIVATIVES OF N-HEPTANE.
ROBERT T. DILLON and HOWARD J. LUCAS, *J. Am. Chem. Soc., 50,* 1711-1714 (1928).

175. THE APPLICATION OF THE FERMI STATISTICS TO THE DISTRIBUTION OF ELECTRONS UNDER FIELDS IN METALS AND THE THEORY OF ELECTROCAPILLARITY.
OSCAR KNEFLER RICE, *Phys. Rev., 31,* 1051-1059 (1928).

176. THE CRYSTAL STRUCTURE OF POTASSIUM CHLOROPLATINATE.
F. J. EWING and LINUS PAULING, *Z. f. Krist., 68,* 223-230 (1928).

177. THE CRYSTAL STRUCTURE OF BROOKITE.
LINUS PAULING and J. H. STURDIVANT, *Z. f. Krist., 68,* 239-256 (1928).

178. THE CRYSTAL STRUCTURE OF TOPAZ.

LINUS PAULING, *Proc. Nat. Acad. Sci., 14,* 603-606 (1928).

179. THE PRODUCTS OF THE PHOTOCHEMICAL DECOMPOSITION OF HYDROGEN AZIDE.

ARNOLD O. BECKMAN and ROSCOE G. DICKINSON, *J. Am. Chem. Soc., 50,* 1870-1875 (1928).

180. THE ENERGY DISTRIBUTION OF COMPLEX MOLECULES.

OSCAR KNEFLER RICE, *Phys. Rev., 32,* 142-149 (1928).

181. ON THE THEORY OF UNIMOLECULAR GAS REACTIONS.

OSCAR KNEFLER RICE. Read at the Reunion Internationale de Chimie Physique, Societé de Chimie Physique, Paris, October 8-12, 1928.

GEOLOGY AND PALEONTOLOGY

DIRECTIONS OF PROGRESS IN ECONOMIC GEOLOGY.

F. L. RANSOME. (Presidential address, Society of Economic Geologists, Cleveland meeting, Dec. 30, 1927.) *Economic Geology, 23,* 119-131 (1928).

GEOLOGY OF THE ST. FRANCIS DAM-SITE.

F. L. RANSOME, *Economic Geology, 23,* 553-563 (1928).

REPORT OF THE COMMISSION APPOINTED BY GOVERNOR C. C. YOUNG TO INVESTIGATE THE CAUSES LEADING TO THE FAILURE OF THE ST. FRANCIS DAM.

F. L. RANSOME, with A. J. WILEY, GEORGE D. LOUDERBACK, F. E. BONNER, H. T. CORY and F. H. FOWLER. Sacramento, 1928.

THE GEOLOGY OF THE SOUTHERN PART OF THE SOUTH STAFFORDSHIRE COALFIELD.

F. L. RANSOME (Review), *Economic Geology, 22,* 849-850 (1927).

GEOLOGY IN RELATION TO DAM AND RESERVOIR SITES.

F. L. RANSOME, *Hydraulic Engineering,* October, 1928.

REPORT ON SAFETY OF WATER SUPPLY DAMS AND RESERVOIRS OF THE CITY OF LOS ANGELES.

F. L. RANSOME, A. J. WILEY, F. C. HERRMANN, and CHAS. H. PAUL. Appendix A., Report on Geological Conditions at Mulholland Dam, Los Angeles. 1928.

A FURTHER CONTRIBUTION TO THE MAMMALIAN FAUNA OF THE THOUSAND CREEK PLIOCENE, NORTHWESTERN NEVADA.

JOHN C. MERRIAM and CHESTER STOCK, *Carnegie Institution of Washington, Publ. 393,* Art. II (1928).

A PECCARY FROM THE MCKITTRICK PLEISTOCENE, CALIFORNIA.

CHESTER STOCK, *Carnegie Institution of Washington, Publ. 393,* Art. III (1928).

TANUPOLAMA, A NEW GENUS OF LLAMA FROM THE PLEISTOCENE OF CALIFORNIA.

CHESTER STOCK, *Carnegie Institution of Washington, Publ. 393,* Art. IV (1928).

CANID AND PROBOSCIDEAN REMAINS FROM THE RICARDO DEPOSITS, MOJAVE DESERT, CALIFORNIA.

CHESTER STOCK, *Carnegie Institution of Washington, Publ. 393,* Art. V (1928).

A Tooth of Hipparion Mohavense from the Puente Formation, California.

Chester Stock, *Carnegie Institution of Washington, Publ. 393,* Art. VI (1928).

Merychippus Isonesus (Cope) from the Later Tertiary of the Crooked River Basin, Oregon.

John H. Maxson, *Carnegie Institution of Washington, Publ. 393,* Art. VII (1928).

The Pleistocene Elephants of Santa Rosa Island, California.

Chester Stock and E. L. Furlong, *Science, 68,* 140-141 (1928).

The Occurrence and Phylogenetic Status of Merycodus from the Mojave Desert Tertiary.

E. L. Furlong, *Univ. Calif. Publ., Bull. Dept. Geol. Sci., 17,* No. 4 (1927).

Marine Eocene Deposits on the East Slope of the Venezuelan Andes.

W. P. Woodring, *Bull. Amer. Assoc. Petroleum Geologists, 11,* 992-996 (1927).

ENGINEERING

The Electric Arc. (Discussion.)

R. W. Sorensen, *Trans. A. I. E. E., 46,* 882 (1928).

Lightning Protection for Oil Storage Tanks and Reservoirs.

Royal W. Sorensen, James Hugh Hamilton, and Claude D. Haywood, *Trans. A. I. E. E., 47,* 164-173 and 184-185 (1928).

High Voltage Oil Circuit Breakers. (Discussion.)

R. W. Sorensen, *Trans. A. I. E. E., 48,* 159 (1928).

Effect of Humidity on the Dry Flashover Potential of Insulators. (Discussion.)

Royal W. Sorensen and William A. Lewis, *Trans. A. I. E. E., 48,* 443-444 (1928).

Hospital Lighting.

Royal W. Sorensen, *Western Hospital and Nurses Review, XI,* 19-20 (1928).

Field Currents from Points

C. F. Eyring, S. S. Mackeown, and R. A. Millikan, *Phys. Rev., 31,* 900-909 (1928).

The Accurate Determination of Boiler Efficiency

R. L. Daugherty, *National Engineer, 32,* 273 (1928).

BOOKS

Algebraic Arithmetic.

E. T. Bell, *Am. Math. Soc. Colloquium Publications,* Vol. 7 (1927).

A First Course in Physics for Colleges.

R. A. Millikan, H. G. Gale, and C. W. Edwards, 676 pages. Ginn & Company, 1928.

Description of the Undergraduate and Fifth-Year Courses

The Institute offers two four-year Courses of Undergraduate Study, known as the Course in Engineering and the Course in Science. For the satisfactory completion of these Courses the degree of Bachelor of Science is awarded. The course in Engineering is supplemented by definitely laid out fifth-year Courses in Civil Engineering, Electrical Engineering, Mechanical, and Aeronautical Engineering. The Course in Science prepares for fifth-year Courses in Chemistry, Chemical Engineering, Physics, Geology, Paleontology, Biology, and Mathematics. For the completion of any of these fifth-year Courses the degree of Master of Science is awarded.

THE COURSES IN ENGINEERING

The five-year plan of engineering instruction 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 Course 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 utilities and manufacturing 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 breaks between the undergraduate and graduate periods, will afford the more intensive

training required by the engineer who is to do creative work in his field.

The four-year Course in Engineering includes an unusually thorough training in physics and mathematics, and instruction in chemistry and geology; also extended 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, and economics; and, finally, those engineering subjects common to all branches of engineering, such as surveying, mechanism, descriptive geometry, machine drawing, applied mechanics, engineering materials, hydraulics, and preliminary courses in civil, mechanical, and electrical engineering.

The fifth-year Courses in Civil, Mechanical, Electrical, and Aeronautical Engineering consist mainly of the engineering subjects that are fundamental in these separate branches of engineering. Thus the Civil Engineering Course deals largely with the analysis, design and construction of structures, railways, and water systems; the Mechanical Engineering Course, with machine design, steam and gas engineering, and power-plant design and operation; the Electrical Engineering Course with the generation and transmission of electric power; and the Aeronautical Engineering Course with the principles of aerodynamics, the design and construction of airplanes, their engines and instruments. Of all these Courses, engineering research or design forms an important part.

THE COURSES IN SCIENCE

The Courses in Science prepare for those scientific and engineering professions in which an intensive training in the basic sciences and in research is of more importance than a knowledge of the principles and practice of engineering. Accordingly, the four-year Course in Science, while including the same historical, literary and economic subjects as the Course in Engineering,

requires much more extended study of the three sciences of chemistry, physics, and mathematics; also two years' study of scientific German and French. In its junior and senior years there are offered a series of Options which, when supplemented by the corresponding fifth-year Courses, afford definite preparation for various scientific professions, as outlined in the following statement.

The Option in Chemistry and the Option in Physics and the fifth-year Courses in Chemistry and Physics prepare students, on the chemical and physical sides respectively, for research and teaching in universities, colleges, and high schools, and for research positions in government laboratories and especially in the research and development departments of the larger chemical, metallurgical, and electrical companies.

The Option and the fifth-year Courses in Chemical Engineering differ from those in Chemistry in that they include, in place of some of the science work, general subjects in mechanical and electrical engineering, and (in the fifth year) an extended treatment of chemical engineering itself. This Course is designed to fit men for the installation, operation, and the research development of industrial chemical processes.

The Geology Option and the Graduate Course in Geology and Paleontology prepare for teaching and research positions in colleges and universities, for government posts in connection with geological and mining surveys, for places as directors and field explorers of museums and, above all, for expert work in geology in the oil and mining industries.

The Biology Option and the Graduate Course in Biology will prepare for teaching and research in colleges and universities, for government service in agriculture and public health, and for field studies and laboratory research in connection with museums.

The Option of the Undergraduate Course will afford a preliminary training, with emphasis on the fundamental sciences, for those who desire to pursue graduate studies in medicine, sanitation, and the public health. The Biology Option will be in effect for sophomore students in 1929-30 and those of higher classes in the succeeding years. The special subjects included in that option will be announced later.

Schedules of the Undergraduate Courses

The school year is divided into three terms. The number of units assigned in any term to any subject is the total number of hours per week devoted to that subject, including class work, laboratory work, and the estimated time for outside preparation. Laboratory assignments include drawing exercises and field work.

The subject numbers correspond to those given in the Description of Subjects on pages 155-232. For the explanation of the subject numbers in italics, see page 79. The abbreviations denote the various branches of instruction as follows:

Aeronautical Engineering	AE
Assembly	As
Applied Mechanics	AM
Biology	Bi
Chemistry	Ch
Civil Engineering	CE
Drawing	D
Economics	Ec
Electrical Engineering	EE
English	En
Geology	Ge
History and Government	H
Hydraulics	Hy
Languages	L
Mathematics	Ma
Mechanical Engineering	ME
Military	Mi
Philosophy	Pl
Physical Education	PE
Physics	Ph
Shop	Sh
Thesis	Th

BOTH COURSES

FIRST YEAR, ALL THREE TERMS

SUBJECTS	SUBJECT NUMBER	HOURS PER WEEK			UNITS
		Class	Lab.	Prep.	
English	En 1 a b c	3	0	3	6
Physics	Ph 1 a b c	2	3	4	9
Chemistry	Ch 1 a b c	3	6	3	12
Mathematics	Ma 1 a b c	4	0	8	12
History	H 1 a b c	2	0	2	4
Assembly†	*As 1 a b c*	1	0	0	1
Drawing or Shop*	D 1 or 10 **Sh 1*	0	3 or 4	0	3 or 4
Physical Education	*PE 1 a b c*	0	3	0	3
Military Science	*Mi 1 a b c*	1	2	1	4
					54 or 55
Summer					
Drawing or Shop*		...	..	..	3 or 4

*Each student takes altogether 6 units of Drawing and 8 units of Shop, distributed through the three terms and a required summer period of two weeks at the beginning of the summer vacation. Students with a recommended high school credit of ½ unit or more in mechanical drawing, and all science students, take D 1; others take D 10. All freshmen required to take D 40 after D 1 or D 10.

†Freshmen attend in the second and third terms, in addition to the general assemblies, six orientation assemblies.

COURSE IN ENGINEERING

FOR STUDENTS PREPARING FOR CIVIL, MECHANICAL, ELECTRICAL, AND AERONAUTICAL ENGINEERING

SECOND YEAR

SUBJECTS	SUBJECT NUMBER	HOURS PER WEEK			UNITS	
		Class	Lab.	Prep.	First Two Terms	Third Term
Mathematics*†	Ma 2 a b c	4	0	8	12	8*
Physics*†	Ph 2 a b c	3	3	6	12	8*
Mathematics Review†	Ma 2 d	4	0	8	..	4*
Physics Review†	Ph 2 d	3	3	6	..	4*
History	H 2 a b c	2	0	4	6	6
Descriptive Geometry	D 41 a b c	0	3	0	3	3
Machine or Structural Drawing‡	D 20 a b c or D 30 abc	0	3	0	3	3
Mechanism§	ME 1	3	3	4	10	10
Surveying§	CE 1	3	4	3		
Engineering Chemistry§	Ch 6	4	0	6		
Assembly	†*As 2 a b c*	1	0	0	1	1
Military Science	*Mi 2 a b c*	1	2	1	4	4
Physical Education	*PE 2 a b c*	0	3	0	3	3
					54	54

*Students in the first honor section complete the regular work in Mathematics and in Physics during the first two terms, and take in the third term Vector Analysis (Ma 14) and Modern Physics (Ph 3). Such students do not take Physics Review (Ph 2d) and Mathematics Review (Ma 2d).

†Students not in the first honor section take in the first 7 weeks of the third term Physics Ph 2c (8 units) and Mathematics Ma 2c (8 units), and in the last three weeks Physics Review Ph 2d (4 units) and Mathematics Review Ma 2d (4 units). A condition in either of these review subjects, unless made up in September, excludes the student from all third-year subjects for which these are prerequisite. To assist students in making up such conditions, and to aid students transferring from other colleges who may not have had such intensive courses as those of the Institute, each of these subjects will be offered as a summer course (with a fee of $20) during the three weeks preceding the opening of the fall term, provided not less than six students apply for it.

‡Drawing D 51 may be substituted for Drawing D 30bc by students preparing for Civil Engineering.

§Each student takes one of these subjects in each of the three terms.

COURSE IN ENGINEERING

THIRD YEAR

SUBJECTS	SUBJECT NUMBER	HOURS PER WEEK			UNITS		
		Class	Lab.	Prep.	First Term	Second Term	Third Term
English	En 7 a b c	3	0	5	8	8	8
Assembly	*As 3 a b c*	1	0	0	1	1	1
Economics	Ec 2 3 4	3	0	3	6	6	..
Business Law	Ec 25	3	0	3	..	..	6
Biology	Bi 1	2	6	1	..	..	9
or Accounting‡	Ec 17	3	0	6	..	..	
Geology	Ge 1 a	3	3	3	9	..	..
Paleontology	Ge 1 b	4	1	4	..	9	..
Applied Mechanics	AM 1 a b c	4	3	7	14	14	14
Direct Currents*	EE 2 3	3	3	6	12	12	12
Alternating Currents*	EE 4 5	3	3	6			
Heat Engineering*	ME 15	3	3	6			
Physical Education†	*PE 3 a b c*	0	3	0	3	3	3
					53	53	53

*Each student takes one of these subjects in each of the three terms.

†Students may substitute Military Mi 7 (6 units) for Physical Education (3 units).

‡In 1928-1929, students in the Engineering Course take Accounting, unless admitted to Biology, upon petition, by special Faculty action.

COURSE IN ENGINEERING

FOURTH YEAR

SUBJECTS	SUBJECT NUMBER	HOURS PER WEEK			UNITS		
		Class	Lab.	Prep.	1st Term	2nd Term	3rd Term
Humanities Electives*	.....	3	0	6	9	..	9
Philosophy	Pl. 1	3	0	6	..	9	..
Current Topics	H. 5 a b	1	0	1	2	2	..
U. S. Constitution	H 10	1	0	1	..	..	2
Assembly	*As 4 a b c*	1	0	0	1	1	1
Engineering Conferences	.....	..	..	..	2	2	2
Hydraulics or Option‡	Hy 1	4	0	8	12	12	12
Testing Materials	AM 3	0	3	3			
Hydraulics Lab.	Hy 2 †	0	3	3	6	6	6
Heat Eng. Lab.	ME 25	0	3	3			
Physical Education§	*PE 4 a b c*	0	3	0	3	3	3
Options, see next page.					18	18	18
					53	53	53

*For the Humanities Electives see below.

‡Hydraulics is given in the first term for Mechanical and Aeronautical Engineering students, second term for Civil Engineering students, and third term for Electrical Engineering students.

†Each student takes one of these three subjects in each term.

§Students may substitute Military Mi 10 (6 units) for Physical Education (3 units).

HUMANITIES ELECTIVES (9 units)

First Term

American Literature (MacMinn)
Eighteenth Century Ideas (Fäy)
Modern Drama (MacMinn, Stanton)

Third Term

American Literature (MacMinn)
Contemporary Literature (Judy)
German Literature (Macarthur)
Literature of the Bible (MacMinn)
Modern Drama (Stanton)
Sociology (Untereiner)

COURSE IN ENGINEERING

FOURTH YEAR (Continued)

SUBJECTS	SUBJECT NUMBER	HOURS PER WEEK			UNITS		
		Class	Lab.	Prep.	1st Term	2nd Term	3rd Term
Mechanical Engineering Option:							
Structures	CE 9	3	3	6	..	..	12
Machine Design	ME 2, 4	2	3	4	9	..	9
Machine Design	ME 3	2	6	4	..	12	..
Metallurgy	ME 10	3	0	6	9	..	..
Heat Engineering	ME 16	4	0	8	..	12	..
Heat Engineering	ME 17	3	3	3	..	..	9
Heat Eng. Lab. or Elective(see below)	ME 26	0	3	3	..	6	..
Electrical Engineering Option:							
Structures	CE 9	3	3	6	..	12	..
Diff. Equations	Ma 11	4	0	8	..	..	12
Heat Engineering	ME 16	4	0	8	12	..	..
Electrical Eng. Lab.	EE 7	0	3	3	..	..	6
Elect. and Magnetism	Ph 6 a b	3	3	6	12	12	..
Electrical Machinery	EE 6	2	0	4	6	..	..
Electrical Machinery	EE 40	2	0	4	..	6	..
Civil Engineering Option:							
Advanced Surveying	CE 2	3	6	3	12	..	..
Railway Engineering	CE 8 a b c	..	..	..	6	6	6
Theory of Structures	CE 10a b c	3	3	6	12	12	12
Highway Engineering	CE 4	3	0	3	..	..	6
Reinforced Concrete	CE 12	2	0	4	..	..	6
Aeronautics Option:							
Advanced Calculus	Ma 8 a b c	4	0	8	12	12	12
Aeronautics	AE 1	3	0	6	..	..	9
Metallurgy	ME 10	3	0	6	9	..	..
Machine Design	ME 8	4	0	8	..	12	..
Structures	CE 11 a b	..	..	..	..	6	12
General Electives:							
Advanced Calculus	Ma 8 a b c	4	0	8	12	12	12
Accounting	Ec 17	3	0	6	..	..	9
Business Study	.....	..	..	..	6	6	6

COURSE IN SCIENCE

FOR STUDENTS PREPARING FOR CHEMISTRY, CHEMICAL ENGINEERING, PHYSICS, INDUSTRIAL PHYSICS, MATHEMATICS, GEOLOGY, PALEONTOLOGY, BIOLOGY, AND MEDICINE

SECOND YEAR

SUBJECTS	SUBJECT NUMBER	HOURS PER WEEK			UNITS	
		Class	Lab.	Prep.	First Two Terms	Third Term
Mathematics*†	Ma 2 a b c	4	0	8	12	8*
Physics*†	Ph 2 a b c	3	3	6	12	8*
Mathematics Review†	Ma 2 d	4	0	8	..	4*
Physics Review†	Ph 2 d	3	3	6	..	4*
History	H 2 a b c	2	0	4	6	6
Chemistry	Ch 12 a b	2	6	2	10	..
German§	L 31 a b c	3	0	3	6	6
Option as below‡	.....	..	..	..	..	10
Assembly	*As 2 a b c*	1	0	0	1	1
Military Science	*Mi 2 a b c*	1	2	1	4	4
Physical Education	*PE 2 a b c*	0	3	0	3	3
					54	54
Options‡						
Analytical Chemistry	Ch 12	2	6	2	..	10
Organic Chemistry	Ch 43	2	6	2	..	10
Surveying	CE 1	3	4	3	..	10

*Students in the first honor section complete the regular work in Mathematics and in Physics during the first two terms, and take in the third term Vector Analysis (Ma 14) and Modern Physics (Ph 3). Students in the first honor section do not take Mathematics Review (Ma 2d) and Physics Review (Ph 2d).

†Students not in the first honor section take in the first 7 weeks of the third term Physics Ph 2c (8 units) and Mathematics Ma 2c (8 units), and in the last 3 weeks Physics Review Ph 2d (4 units) and Mathematics Review Ma 2d (4 units). A condition in either of these review subjects, unless made up in September, excludes the student from all third-year subjects for which these are prerequisite. To assist students in making up conditions, and to aid students transferring from other colleges who may not have had such intensive courses as those of the Institute, each of these subjects will be offered as a summer course (with a fee of $20) during the three weeks preceding the opening of the fall term, provided not less than six students apply for it.

‡Students take Analytical Chemistry (Ch 12c) if they are preparing for the Option in Chemistry or Chemical Engineering; Organic Chemistry (Ch. 43) if preparing for the Option in Physics or Biology; Surveying (CE 1), Descriptive Geometry (D. 42), and Physiographic Sketching (D. 51) in place of Mathematics (Ma 2c, d) if preparing for the Option in Geology, Theory of Equations (Ma 3) if preparing for the Option in Mathematics. Non-honor students are admitted to the Mathematics Option only by special vote of the Committee on Science Courses.

§Honor students take German (L. 37, 10 units) in place of German (L. 31, 6 units), and may, if they desire, omit Military Science (Mi. 2).

THIRD YEAR

SUBJECTS	SUBJECT NUMBER	HOURS PER WEEK			UNITS		
		Class	Lab.	Prep.	1st Term	2nd Term	3rd Term
English	En 7 a b c	3	0	5	8	8	8
Assembly	*As 3 a b c*	1	0	0	1	1	1
Geology, Paleontology	Ge 1 a b	..	..	..	9	9	..
Biology	Bi 1	2	6	1	..	..	9
German or French*		4	0	6	10	10	10
Chemical Principles	Ch 21 a b c	4 2	0 3	6 5	10	10	10
Physical Education†	*PE 3 a b c*	0	3	0	3	3	3
Options, as below	.....	..	..	..	12	12	12
					53	53	53
Theoretical Physics Option:							
Advanced Calculus	Ma 8 a b c	4	0	8	12	12	12
Experimental Physics Option:							
Advanced Calculus	Ma 8 a b	4	0	8	12	12	..
Differ. Equations	Ma 11	4	0	8	..	..	12
Chemistry Option:							
Chemistry of the Rare Elements	Ch 13 a b	1	9	2	12	12	..
or							
Advanced Calculus	Ma 8 a b	4	0	8	12	12	..
Atomic Structure	Ch 23	3	0	5	..	..	8
Physico-Chem. Lab.	Ch 26 b	..	3	1	..	..	4
Chemical Engineering Option:							
Applied Mechanics	AM 2 a b	4	0	8	12	12	..
Atomic Structure§	Ch 23	3	0	5	..	..	8
Physico-Chem. Lab.§	Ch 26 b	..	3	1	..	..	4
Other Options: See next page.							

*Students who have taken German L. 37 a-c, or those who have shown more than average proficiency in German L. 31 a-c, take French in the second and third terms; other students continue German through the year.

†Students may substitute Military Mi 7 (6 units) for Physical Education (3 units).

§Honor students substitute in the third term Chemical Research (Ch 71) for Physico-Chemical Laboratory and Atomic Structure (provided they have already taken Modern Physics).

COURSE IN SCIENCE

THIRD YEAR (Continued)

SUBJECT	SUBJECT NUMBER	HOURS PER WEEK			UNITS		
		Class	Lab.	Prep.	First Term	Second Term	Third Term
Geology Option:							
Crystallography.....	Ge 3 a	1	6	2	9	..	..
Mineralogy.....	Ge 3 b	1	6	2	..	9	..
Mineralogy.....	Ge 3 c	1	3	2	..	..	6
Drawing.....	D 42, 50	0	6	0	6	6	..
Drawing.....	D 51	0	6	0	..	..	6
Surveying*.....	CE 1	3	4	3	..	..	10
Mathematics Option:†							
Advanced Calculus...	Ma 8 a b c	4	0	8	12	12	12
Analytic Geometry..	Ma 4 a b	4	0	8	..	12	12

*Students in the Geology Option substitute in the third term Plane-table Surveying (CE 3) for Chemical Principles (Ch 21c).

†Students taking the mathematics option may omit in the second and third terms Chemical Principles.

COURSE IN SCIENCE

FOURTH YEAR

SUBJECT	SUBJECT NUMBER	HOURS PER WEEK			UNITS		
		Class	Lab.	Prep.	First Term	Second Term	Third Term
Humanities Electives*	.....	3	0	6	9	..	9
Philosophy	Pl 1	3	0	6	..	9	..
Current Topics	H 5 a b	1	0	1	2	2	..
U. S. Constitution	H 10	1	0	1	..	..	2
Assembly	*As 4 a b c*	1	0	0	1	1	1
Economics	Ec 2 3 4	3	0	3	6	6	..
Foreign Scientific Journals	.....	2	0	4	..	..	6
Physical Education‡	*PE 4 a b c*	0	3	0	3	3	3
Options as below	.....	..	..	..	33	33	33
					54	54	54
Physics Option:§							
Analytic Mechanics	Ph 12 a b c	4	0	8	12	12	12
Electricity	Ph 8 a b c	3	0	6	9	9	9
Electrical Measure	Ph 9 a b c	0	3	0	3	3	3
Electrical Eng.†	EE 2,3,4,5	3	3	6	12	12	..
Heat Engineering†	ME 15	3	3	6	..	..	12
Mathematics Option:							
Differ. Equations	Ma 10 a b c	3	0	6	9	9	9
Electives:							
Complex Variable	Ma 114	4	0	8	12	..	..
Modern Theory of Diff. Equations	Ma 116 a b	4	0	8	..	12	12
Relativity	Ma 122	4	0	11	15	..	..
Modern Algebra	Ma 123 abc	4	0	8	12	12	12
Differ. Geometry	Ma 108 abc	4	0	8	12	12	12
Other Options:							
See next page.							

*See page 142.

†Or research for Honor Students.

‡Students may substitute Military Mi 10 (6 units) for Physical Education (3 units).

§In 1929-30, and thereafter, separate Options will be offered in Theoretical Physics and Experimental Physics.

COURSE IN SCIENCE

FOURTH YEAR (Continued)

SUBJECTS	SUBJECT NUMBER	HOURS PER WEEK			UNITS		
		Class	Lab.	Prep.	First Term	Second Term	Third Term
Chemistry Option:							
Organic Chemistry...	Ch 41 a b	3	0	5	8	8	..
Organic Chemistry...	Ch 41 c	2	0	4	..	..	6
Organic Chemistry Laboratory.....	Ch 46 a b	0	9	0	9	9	..
Chemical Thermodynamics.....	Ch 22 a b	3	0	6	9	9	..
Instrumental Analysis	Ch 16	0	6	4	10	..	..
Industrial Chemistry.	Ch 61	2	0	4	..	6	6
Research.....	Ch 70-73	..	..	..	..	..	20
Chemical Engineering Option:							
Organic Chemistry...	Ch 41 a b	3	0	5	8	8	..
Organic Chemistry...	Ch 41 c	2	0	4	..	..	6
Organic Chem. Lab.	Ch 46 a b	0	9	0	9	9	..
Chemical Thermodynamics.....	Ch 22 a b	3	0	6	9	..*	..
Electrical Engineering	EE 2,3,4,5	3	3	6	..	12	12
Heat Engineering....	ME 15	3	3	6	..	..	12
Instrumental Analysis	Ch 16	0	6	4	10	..	..
Industrial Chemistry	Ch 61	2	0	4	..	6*	6
Geology Option:							
Historical Geology..	Ge 1 c	2	3	4	9	..	..
Petrology.....	Ge 5 a b	1	6	2	9	9	..
Field Geology.....	Ge 7 a b	..	..	..	8	..	10
Structural Geology...	Ge 9	3	0	5	..	..	8
Vertebrate Paleon...	Ge 12	2	6	2	..	10	8
Invertebrate Paleon.	Ge 11 a b	..	..	..	10	8	..
Research.....	Ge 21, 22	..	..	..	..	8	8

*Honor students, especially those intending to take the fifth-year Course in Chemical Engineering, should take Thermodynamic Chemistry in the second term, and should take Industrial Chemistry (3 units) as an extra subject.

Schedules of the Fifth-Year Courses

SUBJECTS COMMON TO ALL COURSES, ALL TERMS	NUMBER OF UNITS
Seminar in American History and Government *or* English Literature *or* Philosophy	12
Engineering or Research Conferences	2
Professional Subjects	39
	53

CIVIL ENGINEERING

PROFESSIONAL SUBJECTS	SUBJECT NUMBER	NUMBER OF UNITS		
		1st Term	2nd Term	3rd Term
Statically Indeterminate Structures	CE 23	15	..	..
Masonry Structures	CE 16	..	9	..
Machine Design	ME 9	9	..	..
Irrigation and Water Supply	CE 15	..	12	..
Structural and Civil Engineering Design	CE 21 a b c	9	9	12
Sewerage	CE 17	..	..	9
Research or Other Thesis		6	9	9
Accounting	Ec 17	..	..	9
		39	39	39
Supplementary Professional Subjects				
Water Power Plant Design	CE 101 a b	10	10	..
Arched Dams	CE 103 a b	5	5	..
Statically Indeterminate Structures	CE 105 b c	..	15	15
Geodesy and Precise Surveying	CE 107 a b c	6	6	6
Highway Problems	CE 108			
Sewage Treatment Plant Design	CE 110 b c	..	10	10
Sanitation Research	CE 112			
Analysis of Earthquake Effects upon Structures	CE 114			

FIFTH-YEAR COURSES

ELECTRICAL ENGINEERING

PROFESSIONAL SUBJECTS	SUBJECT NUMBER	NUMBER OF UNITS		
		1st Term	2nd Term	3rd Term
Alternating Current Analysis	EE 20	12	..	..
Induction Machinery	EE 22	..	12	..
Transmission Lines	EE 44	..	..	12
Alternating Current Laboratory	EE 21 a b c	6	6	6
Specifications and Design	EE 48	6	..	..
Electric Transients	EE 60	..	6	..
Dielectrics	EE 52	..	..	6
Research or Thesis	....	9	9	9
Electives, as below	....	6	6	6
		39	39	39
Electives:				
Vacuum Tubes	EE 62 a b	..	6	6
Electric Traction	EE 28	6	..	..
Electrical Communication	EE 56	6	..	..
Light and Power Distribution	EE 30	..	..	6

MECHANICAL ENGINEERING

Power Plant Engineering	ME 121, 122	..	12	12
Thermodynamics	ME 120	12	..	..
Heat Engineering Laboratory	ME 130	15	..	..
Research or Thesis	ME 100	..	15	15
Elective as below	.....	12	12	12
		39	39	39.
Electives:				
Science of Metals	ME 111	..	12	..
Metallography	ME 110	12	..	..
Metals Research	ME 112	..	..	12
Machine Design	ME 101	12	..	..
Machine Design	ME 102, 103	..	12	12
Internal Combustion Engines	ME 135, 136	..	12	12

FIFTH-YEAR COURSES

AERONAUTICAL ENGINEERING

PROFESSIONAL SUBJECTS	SUBJECT NUMBER	NUMBER OF UNITS		
		1st Term	2nd Term	3rd Term
Aerodynamics of the Airplane	AE251ab	9	6	..
Elementary Airplane Design	AE252abc	11	14	20
Properties of Fluids and Elementary Hydrodynamics	AE265	..	9	..
Aeronautical Power Plants	AE256	..	3	..
Aerodynamics	AE266	..	..	15
Research or Electives				
Electives as follows:				
Subjects of Four-Year Engineering or Science Course		12	12	12
Wind Channel	AE286abc	15	15	15
Advanced Thermodynamics	ME120	..	..	9
Calculus of Observations	Ma105	..	..	6

FIFTH-YEAR COURSES

PHYSICS OR INDUSTRIAL PHYSICS

SUBJECT	SUBJECT NUMBER	NUMBER OF UNITS		
		1st Term	2nd Term	3rd Term
Electives as follows:				
Kinetic Theory	Ph 110	..	..	12
Thermodynamics	Ph 111	12	..	..
Atomic Structure	Ph 114	9	..	..
Mathematical Physics	Ph 15 a b c	12	12	12
Physical Optics	Ph 22 a b c	12	12	12
Vacuum Tubes	EE 62 a b	..	6	6
Mathematical Analysis	Ma 119 a b c	15	15	15
Relativity	Ph 136 a b	6	6	..
Research	..	15	15	15

CHEMISTRY OR CHEMICAL ENGINEERING*

Electives from Four-Year Course in Science or Fifth-Year Course in Physics				
Other Electives as follows:				
Photochemistry	Ch 158	6	..	..
Quantum Theory Practicum	..	..	6	6
Chemical Reaction Rates	Ch 175	..	..	6
Crystal Structure	Ch 177 a b c	2	2	2
Organic Chemistry (special topics)	Ch 161 a b	..	6	6
Organic Chemical Analysis	Ch 162	6	..	..
Chemical Engineering*	Ch 166 a b c	12	12	12
Research	..	12–18	12–18	12–18

*Candidates for the degree in Chemical Engineering are required to take the subject Chemical Engineering. They must also have taken or take in this year the engineering subjects included in the Chemical Engineering Option of the Four-Year Course in Science.

FIFTH-YEAR COURSES

GEOLOGY AND PALEONTOLOGY

PROFESSIONAL SUBJECTS	SUBJECT NUMBER	NUMBER OF UNITS		
		1st Term	2nd Term	3rd Term
Electives as follows:				
Economic Geology	Ge 195-196	..	10	10
Paleontology	Ge188s or t	10	10	10
Petrography	Ge 181 a b c	10	10	10
Geomorphology	Ge 186	10	..	..
Seismology	Ge 183	6	..	..
Seminar		5-10	5-10	5-10
Physics, Chemistry or Engineering	..	20	20	20
Research	Ge 187	12-18	12-18	12-18

MATHEMATICS

SUBJECT	SUBJECT NUMBER	NUMBER OF UNITS		
		1st Term	2nd Term	3rd Term
Electives as follows:				
Modern Algebra	Ma123 a b c	12	12	12
Differential Geometry	Ma108 a b c	12	12	12
Modern Geometry	Ma109 a b c	12	12	12
Relativity	Ma122	15	..	..
Analytic Mechanics	Ph 12 a b c	12	12	12
Electricity	Ph 8, 9	12	12	12
Research		6	6	6
Subjects in fifth-year Physics Course				

Division of Physics, Mathematics, and Electrical Engineering

PHYSICS

PROFESSORS: ROBERT A. MILLIKAN, HARRY BATEMAN, PAUL S. EPSTEIN, RICHARD C. TOLMAN

RESEARCH ASSOCIATE: ARNOLD SOMMERFELD

ASSOCIATE PROFESSORS: IRA S. BOWEN, EARNEST C. WATSON

ASSISTANT PROFESSORS: WILLIAM V. HOUSTON, SAMUEL S. MACKEOWN, WILLIAM R. SMYTHE, WALTER T. WHITNEY, FRITZ ZWICKY

RESEARCH FELLOW: ALEXANDER GOETZ

TEACHING FELLOWS AND GRADUATE ASSISTANTS: ANDREW P. ALFORD, CARL D. ANDERSON, WARREN N. ARNQUIST, WILLARD C. BRUCE, JOHN S. CAMPBELL, CHARLES R. DAILY, ALFRED B. FOCKE, ARCHER HOYT, KENNETH K. ILLINGWORTH, CHARLES C. LASH, WALTER C. MICHELS, HENRY V. NEHER, JOHN M. PEARSON, RICHARD M. SUTTON, EDWARD M. THORNDIKE, JOHANNES A. VAN DEN AKKER, RALPH B. WINGER

UNDERGRADUATE SUBJECTS

Ph. 1 a, b, c. MECHANICS, MOLECULAR PHYSICS, AND HEAT. 9 units (2-3-4); first, second and third terms.

Prerequisites: A high school course, or its equivalent, and trigonometry.

The first year of a general college course in physics extending through two years. It is a thorough analytical course, in which the laboratory carries the thread of the work, and the problem method is largely used. A bi-weekly demonstration lecture, participated in by all members of the department, adds the inspirational and informational element, and serves for the development of breadth of view.

Text: Mechanics, Molecular Physics, and Heat, Millikan.

Instructors: Watson, Houston, Campbell, Daily, Illingworth, Neher, Pearson, Winger.

Ph. 2 a, b, c. ELECTRICITY, SOUND, AND LIGHT. 12 units (3-3-6), first and second terms; 8 units, third term.

Prerequisites: A high school course, or its equivalent, and trigonometry.

Continuation of Ph. 1 a, b, c, to form a well-rounded two-year course in general physics.

Text: Electricity, Sound, and Light, Millikan and Mills.

Instructors: Bowen, Whitney, Anderson, Arnquist, Bruce, Thorndyke, Van den Akker.

Ph. 2 d. PHYSICS REVIEW. 4 units; last three weeks of sophomore year.

The last three weeks of the sophomore year are devoted to a comprehensive review and examination covering the whole of the two years' work (Ph. 1 a, b, c, and 2 a, b, c).

Ph. 3. MODERN PHYSICS. 12 units (2-6-4); third term.

Prerequisites: Ph. 1 a, b, c, 2 a, b; Ma. 2 a, b.

A brief survey of recent developments in electron theory, quantum theory, radioactivity, and atomic structure. Experiments to determine e, $\frac{e}{m}$ h, and other fundamental constants will be performed. Open only to students on honor standing, sophomore year.

Instructor: Bowen.

Ph. 7 a, b. ELECTRICITY AND MAGNETISM. 9 units (3-0-6); first and second terms.

Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; Ma. 2 a, b, c, d.

A course in theoretical electricity and magnetism, primarily for electrical engineering students. Ph. 9 a, b (Electrical Measurements) must accompany this course.

Text: Electrodynamics for Engineers, Bennett and Crothers.

Instructor: Mackeown.

Ph. 8 a, b, c. ELECTRICITY AND MAGNETISM. 9 units (3-0-6); first, second and third terms.

Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; Ma. 2 a, b, c, d.

A problem course in the mathematical theory of electricity and magnetism, intended primarily as a preparation for graduate work in science. Ph. 9 a, b, c (Electrical Measurements) should accompany or precede this course.

Text: Electricity and Magnetism, Jeans.

Instructor: Smythe.

Ph. 9 a, b, c. ELECTRICAL MEASUREMENTS. 3 units (0-3-0).

Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; Ma. 2 a, b, c, d.

A laboratory course in advanced electrical measurements.

Text: Advanced Laboratory Practice in Electricity and Magnetism, Terry.

Instructors: Smythe, Michels, Lash.

Ph. 12 a, b, c. ANALYTICAL MECHANICS. 12 units (4-0-8); first, second and third terms.

Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; Ma. 2 a, b, c, d.

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 coordinates, Hamilton's principle and the principle of least action.

Texts: Statics, Lamb; Dynamics, Lamb; Higher Mechanics, Lamb.

Instructor: Zwicky.

Ph. 25. FOREIGN SCIENCE JOURNALS. 6 units (2-0-4); third term.

This subject consists in readings and reports by the students on researches published in recent German and French physical journals. It has the double object of giving practice in the reading of scientific German and French and of affording an acquaintance with important lines of research in progress.

FIFTH-YEAR SUBJECTS

Ph. 15 a, b, c. INTRODUCTION TO MATHEMATICAL PHYSICS. 12 units (4-0-8); first, second and third terms.

Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; Ma. 2 a, b, c, d.

An introduction to the application of mathematics to physics and chemistry, and practice in the solution of problems.

Text: Introduction to Theoretical Physics, Haas.

Instructor: Houston.

Ph. 22 a, b, c. PHYSICAL OPTICS. 12 units (3-3-6); first, second and third terms.

Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; Ma. 2 a, b, c, d.

Lecture and class work dealing with the fundamental theoretical equations of diffraction, interference, etc., and their experimental verification, accompanied by advanced laboratory work in light, consisting of accurate measurements in diffraction, dispersion, interference, polarization and spectrophotometry.

Text: Manual of Advanced Optics, Taylor.

Instructor: Whitney.

Ph. 110. KINETIC THEORY. 12 units; third term.

Prerequisites: Ph. 2 a, b, c, d; Ma. 2 a, b, c, d.

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 specific heats.

Instructor: Goetz.

Ph. 111. THERMODYNAMICS. 12 units; first term.

Prerequisites: Ph. 2 a, b, c, d; Ma. 2 a, b, c, d.

The two fundamental laws of thermodynamics. Entropy and the thermodynamical potentials. Equations of reciprocity. Application to gases, perfect and imperfect, and to dilute solutions. Phase rule and chemical equilibrium. Nernst's theorem.

Instructor: Zwicky.

Ph. 114. ATOMIC STRUCTURE. 9 units; first term.

Prerequisites: Ph. 2 a, b, c, d; Ma. 2 a, b, c, d.

A general presentation of the developments of the past fifteen years in the field of atomic structure, including photo-electric, isotopic, spectroscopic, field current, and cosmic-ray effects and their interpretation.

Instructor: Millikan.

Ph. 142. RESEARCH IN PHYSICS. Units in accordance with the work accomplished.

ADVANCED SUBJECTS

Ph. 121. POTENTIAL THEORY. 15 units; third term.

Prerequisites: Ma. 8 a, b, 10, 101.

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.

(Not given in 1928-1929.)

Instructor: Bateman.

Ph. 122. THEORY OF ELECTRICITY AND MAGNETISM. 12 units; first term.

Prerequisites: Ph. 8 a, b, c; Ma. 8 a, b, 10.

Electrostatics, magnetostatics, ferromagnetism, electromagnetic field of stationary currents, electromagnetic induction, phenomena in moving bodies, Maxwell's equations, ponderomotive forces of an electromagnetic field, introduction to the theory of electrons.

Instructor: Epstein.

Ph. 123. THEORY OF ELECTROMAGNETIC WAVES. 12 units; second term.

Prerequisites: Ph. 8 a, b, c; Ma. 8 a, b, 10.

Mathematical study of Maxwell's equations, propagation of waves, absorption and reflection, approximate and rigorous treatment of diffraction, theory of dispersion, electro- and magneto-optics.

Instructor: Epstein.

Ph. 124. THEORY OF ELECTRONS IN METALS. 6 units; second term.

Prerequisites: Ph. 8 a, b, c, 12 a, b, c, 15 a, b, c; Ma. 8 a, b, 10.

The application of the Fermi statistics and the wave properties of the electron to the electrical properties of metals.

Instructor: Sommerfeld.

Ph. 125. HIGHER DYNAMICS. 12 units; third term.

Prerequisites: Ph. 12 a, b, c, 15 a, b, c; Ma. 8 a, b, 10.

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.

(Not given in 1928-1929.)

Instructor: Epstein.

Ph. 126. HEAT RADIATION AND QUANTUM THEORY. 12 units; second term.

Prerequisites: Ph. 8 a, b, c, 12 a, b, c, 111; Ma. 8 a, b, 10.

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.

(Not given in 1928-1929.)

Instructor: Epstein.

Ph. 127. PHYSICAL OPTICS AND QUANTUM THEORY OF SPECTRAL LINES. 12 units; third term.

Prerequisites: Ph. 12 a, b, c, 22 a, b, c; Ma. 8 a, b, 10.

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.

(Not given in 1928-1929.)

Instructor: Epstein.

Ph. 128. Modern Aspects of the Quantum Theory. 12 units; third term.

Prerequisites: Ph. 12 a, b, c, 15 a, b, c; Ma. 8 a, b, 10, 126, 127.

Principle of correspondence, Heisenberg's form of it, Born and Jordan's matrix calculus, Schroedinger's wave equations, Weyl's theory, applications to spectroscopic problems.

Instructor: Epstein.

Ph. 129. Selected Questions in Wave Mechanics. 9 units; second term.

Prerequisites: Same as for Ph. 128.

The application of Schroedinger's wave mechanics to problems of atomic structure.

Instructor: Sommerfeld.

Ph. 130. Hydrodynamics. 30 units; first term.

Prerequisites: Ma. 114 a, b, c.

Mathematical theories of sustenance and resistance. Waves and tides. Vortex motion and turbulence. Motion of a viscous fluid. Rotating masses of fluid.

(Not given in 1928-1929.)

Text: Lamb, Hydrodynamics.

Instructor: Bateman.

Ph. 131. Theory of Elasticity. 30 units; first term.

Stresses in beams, bars, struts, springs, plates, tubes, and shells from the standpoint of the mathematical theory of elasticity. Theories of plasticity and failure. Strength of crystals. Waves in elastic solids. Earthquake waves.

Texts: Love, Mathematical Theory of Elasticity; Jeffery, The Earth; J. Prescott, Applied Elasticity.

(Not given in 1928-1929.)

Instructor: Bateman.

Ph. 132. AEROLOGY AND METEOROLOGY. 15 units; one term.

Variation with altitude of pressure, wind velocity, temperature, and humidity. General circulation of the atmosphere. Prevailing winds. World's air routes. Studies relating to clouds, fogs, thunderstorms, evaporation, and atmospheric eddies. Atmospheric electricity, visibility. (Not given in 1928-1929.)

Text: Shaw, Forecasting Weather; Gregg, Aeronautical Meteorology; Humphreys, Physics of the Air.

Instructors: Bateman, Bowen.

Ph. 136 a, b. INTRODUCTION TO THE THEORY OF RELATIVITY. 6 units; first and second terms.

The special theory of the relativity of motion in free space, with applications to mechanical and electromagnetic problems. Use of four dimensional language for expressing the results of relativity. Introduction to tensor analysis. The general theory of relativity and the theory of gravitation.

Recommended Texts: First term, Tolman, The Theory of the Relativity of Motion. Second term, Eddington, The Mathematical Theory of Relativity.

Instructor: Tolman.

Ph. 138. SEMINAR IN THEORETICAL PHYSICS. 4 units; first, second and third terms.

Recent development of the theory of quanta for specialists in mathematical physics.

Instructors: Epstein, Bateman, Houston, Zwicky.

Ph. 141. RESEARCH CONFERENCES IN PHYSICS. 4 units; first, second and third terms.

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.

Instructors: Millikan, Bateman, Epstein, Tolman, Watson.

Ph. 142. RESEARCH IN PHYSICS. Units in accordance with the work accomplished.

ASTRONOMY AND PHYSICS CLUB.

The club, consisting of physicists of the Institute and of the Mount Wilson Observatory, a group of from fifty to one hundred, meets every week either at the Institute or the Observatory Laboratory for the discussion of researches carried on by its members as well as those appearing in the physical journals.

MATHEMATICS

PROFESSORS: HARRY BATEMAN, ERIC T. BELL, HARRY C. VAN BUSKIRK
ASSOCIATE PROFESSOR: LUTHER E. WEAR
ASSISTANT PROFESSOR: CLYDE WOLFE
INSTRUCTOR: WILLIAM N. BIRCHBY
RESEARCH FELLOW: MORGAN WARD
TEACHING FELLOWS AND ASSISTANTS: MIGUEL A. BASOCO, JOHN D. ELDER, LAWRENCE S. KENNISON, ALBERT E. LOMBARD, MORRIS MUSKAT, ROBERT I. PIPER, LYNN H. RUMBAUGH, JOSEPH W. SCHWEINFEST

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.

UNDERGRADUATE SUBJECTS

Ma. 1 a, b, c. FRESHMAN MATHEMATICS. 12 units (4-0-8); first, second and third terms.

Including the fundamentals of analytical geometry, certain topics in college algebra, and some of the principles of the differential and integral calculus.

Text: Analytical Geometry, Ford; Differential and Integral Calculus, Cohen.

Ma. 2 a, b, c. SOPHOMORE MATHEMATICS. 12 units (4-0-8), first and second terms; 8 units third term.

Prerequisite: Ma. 1 a, b, c.

Includes additional topics in analytical geometry, and completes the usual subjects of the calculus, begun in the freshman year.

Text: Course in Mathematics, Vol. II, Woods and Bailey.

Ma. 2 d. MATHEMATICS REVIEW. 4 units (4-0-8).

A comprehensive review of freshman and sophomore mathematics during the last three weeks of the sophomore year.

Courses Ma. 1 a, b, c, and 2 a, b, c, d, form a continuous two-year course in analytical geometry, college algebra, and the differential and integral calculus.

Ma. 3. THEORY OF EQUATIONS. 12 units (4-0-8); third term.

Includes the elementary theorems in the roots of an equation, solution of numerical equations, determinants, symmetric functions, resultants and discriminants.

Instructor: Wear.

Ma. 4 a, b. ANALYTIC GEOMETRY. 12 units (4-0-8); second and third terms.

Will include selected topics in analytic geometry, both of the plane as well as of space.

Instructor: Wear.

Ma. 8 a, b, c. ADVANCED CALCULUS. 12 units (4-0-8); first, second and third terms.

Prerequisites: Ma. 1 a, b, c, 2 a, b, c, d.

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.

Text: Advanced Calculus, Woods.

Instructors: Birchby, Basoco.

Ma. 10 a, b, c. DIFFERENTIAL EQUATIONS. 9 units (3-0-6); first, second and third terms.

Prerequisite: Ma. 8 a, b, c.

An introductory course in differential equations, designed to be helpful both to the student of mathematics and the student of science or engineering.

Texts: Differential Equations, Cohen, Woods.

Ma. 11. DIFFERENTIAL EQUATIONS. 12 units (4-0-8); third term.

Prerequisite: ~~Ma. 8 a, b~~ Ma. 8 a, b, c.

An abridged course in Differential Equations for students in Electrical Engineering.

Texts: Differential Equations, Cohen, Woods.

Instructor: Birchby.

Ma. 12. PROBABILITY AND LEAST SQUARES. 5 units (2-0-3); third term.

Prerequisites: Ma. 1 a, b, c, 2 a, b, c, d.

A study of the fundamental principles of probability and their appli-

cation to statistical data, adjustment of observations, and precision of measurements.

Text: Theory of Errors and Least Squares, Bartlett.
Instructor: Wolfe.

Ma. 14. VECTOR ANALYSIS. 12 units (4-0-8); third term.

Prerequisites: Ma. 8 a, b, 10.

Elementary vector operations (addition, multiplication) and their application to problems of geometry and physics are treated.

Text: Coffin's Vector Analysis.

UNDERGRADUATE OR GRADUATE SUBJECTS

Ma. 108 a, b, c. DIFFERENTIAL GEOMETRY. 12 units; first, second and third terms.

Prerequisites: Ma. 8 a, b, c, 10 a, b, c.

In this course geometrical ideas gained in previous courses will be extended, and the methods of the calculus applied to twisted curves and surfaces.

Instructor: Wear.

Ma. 109 a, b, c. MODERN GEOMETRY. 12 units; first, second, and third terms.

Prerequisites: Ma. 1 a, b, c, 2 a, b, c, d, 4 a, b.

A course in the modern methods of analytic geometry.

(Not given in 1928-1929.)

Instructor: Wear.

Ma. 114. COMPLEX VARIABLE. 12 units; first term.

Prerequisites: Ma. 8 a, b, c, 10 a, b, c.

Real and complex numbers, limits, convergence and continuity, Riemannian integration. Properties of analytic functions, Cauchy's theory of residues. Conformal representation, elementary Riemann surfaces, multiform functions.

Texts: Whittaker and Watson, Modern Analysis; Ince, Ordinary Differential Equations.

Instructor: Ward.

Ma. 116 a, b. MODERN THEORY OF DIFFERENTIAL EQUATIONS. 12 units; second and third terms.

Prerequisites: Ma. 114, or equivalent.

Expansion of functions in series, asymptotic expansions. Linear differential equations in complex domain. Elementary methods of integration. General theory of linear differential equations and their solution by definite integrals and contour integrals. Classification of linear differential equations of the second order.

Texts: Whittaker and Watson, Modern Analysis; Ince, Ordinary Differential Equations.

Instructor: Ward.

Ma. 123 a, b, c. Modern Algebra. 12 units; first, second and third terms.

Prerequisite: Ma. 8.

Introductions to algebraic invariants, matrices and bilinear forms, substitution groups and their simpler applications.

Instructor: Bell.

ADVANCED SUBJECTS

Ma. 101. Vector Analysis. 15 units; second term.

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 geometrical applications are indicated.

Instructor: Bateman.

Ma. 104. Alignment Charts and Mathematical Instruments. 6 units; one term.

Prerequisites: Ma. 1 a, b, c, 2 a, b, c, d.

Methods of constructing alignment charts and other types of charts for facilitating computation. Use of the Planimeter and integraph. Calculating machines and machines for drawing curves.

(Not given in 1928-1929.)

Texts: Brodetsky, Nomography; Horsburgh, Modern Instruments of Calculation.

Instructor: Wolfe.

Ma. 105. Calculus of Observations. 6 units; one term.

Prerequisites: Ma. 8 a, b, c, 10 a, b, c, 12.

Methods of determining the roots of algebraic and transcendental equations. Method of least squares. Law of error and theory of gradu-

ation of data. Statistics. Periodogram analysis. Numerical solution of differential equations.

(Not given in 1928-1929.)

Text: Whittaker, Calculus of Observations.

Instructors: Bateman, Wolfe.

Ma. 112. Integral Equations. 9 units; third term.

Prerequisites: Ma. 8 a, b, 10, 101.

In this course the linear integral equations of the first and second kinds are discussed and the solutions of Abel, Fourier and Fredholm are applied to various physical problems.

Instructor: Bateman.

Ma. 113. Geometrical Transformations and Invariants. 15 units; third term.

Prerequisites: Ma. 1 a, b, c, 2 a, b, c, d.

Linear and bilinear transformations of one variable. Simple algebraic invariants. General theory of linear transformations and their invariants. Conformal transformations. Birational transformations. Contact transformations.

Instructor: Bateman.

Ma. 118 a, b, c. Infinite Series. 15 units; first, second and third terms.

Prerequisites: Ma. 8 a, b, c, 10 a, b, c.

Uniform convergence, integration of series, methods of summation and expansion, use and applications of complex variable, elliptic functions.

(Not given in 1928-1929.)

Instructor: Bell.

Ma. 119 a, b, c. Mathematical Analysis. 15 units; first, second and third terms.

Prerequisites: Ma. 8 a, b, c, 10 a, b, c.

Fourier series and integrals, functions of Legendre, Bessel; the fundamental equations of mathematical physics; functions of a complex variable. Numerous applications to physical problems; tensor analysis.

Texts: Byerly's Fourier Series and Spherical Harmonics; Curtis, Complex Variable; MacRobert, Functions of a Complex Variable; Ed-

dington, Mathematical Theory of Relativity; assigned readings.
Instructor: Bell.

Ma. 122. RELATIVITY. 15 units; first term.

Prerequisites: Ma. 8, 10; Ph. 1, 2.

Tensor analysis; the general theory of relativity and gravitation.

Instructor: Bell.

Ma. 140 a. SEMINAR (I) IN ALGEBRA AND THE THEORY OF NUMBERS. 9 units; third term.

Prerequisites: Graduate standing.

The Dedekind theory of algebraic numbers, Kronecker's theory of modular systems with applications to algebraic functions; comparison of recent theories of algebraic numbers.

Instructor: Bell.

Ma. 140 b. SEMINAR (II) IN ALGEBRA AND THE THEORY OF NUMBERS. 9 units, third term.

Prerequisite: Graduate standing. (A course in elliptic functions desirable.)

Applications of algebra and special functions to the theory of numbers.

Instructor: Bell.

Ma. 141 a, b, c. SEMINAR IN ELLIPTIC FUNCTIONS AND ANALYSIS. 6 units; first, second and third terms.

Prerequisite: Graduate standing in Mathematics, including a course in Complex Variable.

The theories of Jacobi, Hermite, and Weierstrass will be developed and applied, particularly to algebra and the theory of numbers.

(Not given in 1928-1929.)

Instructor: Bell.

ELECTRICAL ENGINEERING

PROFESSOR: ROYAL W. SORENSEN
ASSISTANT PROFESSOR: SAMUEL S. MACKEOWN
INSTRUCTOR: FRANCIS W. MAXSTADT
ASSISTANTS: GEORGE T. HARNESS, JR., CLAUDE D. HAYWARD, VAINO A. HOOVER, WILLIAM A. LEWIS, JOHN W. THATCHER, KARL M. WOLFE

UNDERGRADUATE SUBJECTS

EE. 2. DIRECT CURRENTS. 7 units (3-0-4); first or second terms.

Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d.

Theory and practice of direct current motors and generators. Fundamental to courses in operation and design of electrical apparatus. Numerous problems are solved.

Text: Principles of Direct Current Machines, Langsdorf; or Elements of Electrical Engineering, Cook.

Instructors: Maxstadt, Hayward, Hoover.

EE. 3. DIRECT CURRENT LABORATORY. 5 units (0-3-2); first or second terms.

Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d; and registration for EE. 2.

Uses of measuring instruments, operation of direct current motors and generators and determination of their characteristics.

Text: Laboratory notes.

Instructors: Maxstadt, Hayward, Harness, Thacher, Wolfe.

EE. 4. ALTERNATING CURRENTS. 7 units (3-0-4); second or third terms.

Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d; EE. 2.

Elementary study of alternating currents by analytical and graphical methods and alternating current machinery. The effect of inductance, capacitance, and resistance loads. Numerous problems are worked dealing with reactive circuits; resonance; coils in series and multiple; single and polyphase alternators; single and polyphase systems; synchronous motors; transformers; induction and single phase motors.

Text: Alternating Currents, Magnusson; or Elements of Electrical Engineering, Cook.

Instructors: Maxstadt, Hoover.

EE. 5. Alternating Current Laboratory. 5 units (0-3-2); second or third terms.

Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d; EE. 2, 3, and registration for EE. 4.

Uses of alternating current indicating and recording instruments; operation of alternators, induction and synchronous motors and transformers; determination of characteristics of these machines.

Text: Laboratory Notes.

Instructors: Maxstadt, Harness, Hayward, Thatcher, Wolfe.

EE. 6. Electrical Machinery. 6 units (2-0-4); first term.

Prerequisites: EE. 2, 3, 4, and 5.

Further study of direct current and alternating current machinery and circuits; communication. Numerous problems are worked.

Texts: Principles of Direct Current Machines, Langsdorf; Alternating Currents, Magnusson.

Instructor: Lewis.

EE. 7. Electrical Laboratory. 6 units (0-3-3); third term.

Prerequisites: EE. 2, 3, 4, 5, 6, 40; Ph. 7.

A continuation of EE. 3 and 5. Efficiency tests of direct and alternating current machinery, operation of generators in parallel, investigation of magnetic distribution in direct current machines. Graphic analysis of alternator performance. Complete tests of transformers.

Text: Laboratory Notes.

Instructors: Maxstadt, Harness, Hayward, Thatcher, Wolfe.

EE. 30. Electric Lighting and Power Distribution. 6 units (2-0-4); third term.

Prerequisites: EE. 2, 4, 6.

Electric distribution and wiring; calculation of simple alternating current circuits; installation and operation costs and selling price of electric power; illumination studies with photometer.

Text: Elements of Electrical Engineering, Vol. II, Franklin.

Instructor: Lewis.

EE. 40. Advanced Alternating Current Machinery. 6 units (2-0-4); second term.

Prerequisites: EE. 2, 4, 6; Ph. 7.

An advanced study of the principles involved in alternating current machinery, other than the transformer, with particular emphasis upon synchronous alternators.

Text: Alternating Current Machinery, Lawrence.

Instructor: Maxstadt.

EE. 56. Electrical Communication. 6 units (2-0-4); first term.

Prerequisites: EE. 2, 4, 6, 20, 40.

A study of the elements of telephone, telegraph and signalling devices.

Instructor: Mackeown.

EE. 70 a, b, c. Engineering Seminar. 2 units (1-0-1); first, second and third terms.

Prerequisites: EE. 2, 3, 4, 5.

Presentation and discussion of new developments in the industry. Review of current literature.

Instructors: Sorensen, Mackeown, Maxstadt.

FIFTH-YEAR SUBJECTS

EE. 20. Alternating Current Analysis. 12 units (5-0-7); first term.

Prerequisites: EE. 7 and preceding courses.

Advanced study of magnetic and electric circuits. Solution of problems involving the symbolic method and complex notation; analysis of electromotive force, and current, nonsinusoidal wave forms; use of the oscillograph.

Instructor: Sorensen.

EE. 21 a, b, c. Alternating Current Laboratory. 6 units (0-3-3); first, second and third terms.

Prerequisites: EE. 2, 3, 4, 5, 6, 7.

Complete tests of the induction motor; the operation of transformers in parallel; study of polyphase connections; rotary converter tests; photometric measurements; use of the oscillograph; testing of magnetic materials; calibration of watt-hour meters and other instruments.

Text: Advanced Laboratory Notes.

Instructors: Maxstadt, Lewis.

EE. 22. Induction Machinery. 12 units (5-0-7); second term.

Prerequisites: EE. 2, 4, 6.

An advanced study of the stationary transformer and the induction motor, with special emphasis upon problems of multiple operation which involve problems of polyphase polarity, together with single and polyphase multiple circuits.

Instructor: Sorensen.

EE. 28. Electric Traction. 6 units (2-0-4); first term.

Prerequisites: EE. 2, 4, 6.

The electric railway, selection of equipment in rolling stock, location and equipment of sub-stations, comparison of systems and power requirements for operation of electric cars and trams.

Text: Electric Traction and Transmission Engineering, Sheldon and Hausman.

Instructor: Maxstadt.

EE. 44. Transmission Lines. 12 units (4-0-8); third term.

Prerequisites: EE. 2, 4, 6, 20, 40.

Determination of economic voltage for transmission lines; line protection; elementary transient phenomena; corona; use of hyperbolic functions in line calculations.

Instructor: Sorensen.

EE. 48. Specifications and Design of Electrical Machinery. 6 units (4-0-2); first term.

Prerequisites: EE. 2, 4, 6, 40.

Preparation of specifications and design calculations for alternating and direct current machinery.

Text: Electrical Machine Design, Gray.

Instructor: Sorensen.

EE. 52. Dielectrics. 6 units (2-0-4); third term.

Prerequisites: EE. 2, 4, 6, 20, 40.

The relations of phenomena of dielectrics in high voltage engineering.

Text: Electric Phenomena in High Voltage Engineering, Peek.

Instructor: Sorensen.

EE. 60. Electric Transients. 6 units (2-0-4); second term.

Prerequisites: EE. 2, 4, 6, 20, 40.

A detailed study of circuits, including advanced work in wave propagation and transient phenomena in electric conductors.

Text: Electric Transients, Magnusson.

Instructor: Hayward.

EE. 62 a, b. VACUUM TUBES. 6 units (2-0-4); second and third terms.

Prerequisites: EE. 2, 4, 6.

Fundamental theory, and uses as detectors, amplifiers, and oscillators. Special uses of vacuum tubes in both radio and line communication.

Instructor: Mackeown.

ADVANCED SUBJECTS

STUDY AND RESEARCH IN ELECTRICAL ENGINEERING

The science of electrical engineering has, due to advances in physics and its applications, reached a status such as to demand electrical engineers qualified to conduct researches involving a knowledge of mathematics, physics, and electrical engineering far in excess of that obtainable in an undergraduate engineering course. To meet this need the Institute has provided courses of graduate study and research in electrical engineering which may be taken by students who have completed the five-year engineering course at the Institute, or by students from other colleges who have substantially the same preparation.

Students desiring to become research men, college teachers or professional experts in electrical engineering will naturally continue their work at least two years more for the degree of Doctor of Philosophy.

This graduate school of electrical engineering greatly strengthens the undergraduate courses by bringing students, who feel the five and four-year courses are best adapted to their needs, in close touch with research men and problems, and by providing special work for undergraduate students wishing to do a limited amount of research work.

EE. 200. ADVANCED WORK IN ELECTRICAL ENGINEERING.

Special problems relating to electrical engineering will be arranged to meet the needs of students wishing to do advanced work in the field of electricity. The Institute is equipped to an unusual degree for the following lines of work: Theory of Electrical Machine Design, Electric Transients, and High Voltage Engineering Problems, under the direction of Professor R. W. Sorensen; Electrical Engineering Problems using vacuum tubes under the direction of Professor S. S. Mackeown; Electrical Engineering Problems relating to the distribution and uses of electric power for lighting and industrial uses under the direction of Mr. F. W. Maxstadt.

EE. 220. SEMINAR ON TECHNICAL HIGH VOLTAGE PROBLEMS. Units to be based on work done; first, second and third terms.

A study of the literature of high voltage phenomena, and insulation problems.

Instructor: Sorensen.

EE. 221 a, b. TRANSMISSION LINE PROBLEMS. 15 units.

A study of transmission line transient problems, inductive interference, power limit analysis, etc.

Instructor: Sorensen.

EE. 223 a, b. ELECTRIC STRENGTH OF DIELECTRICS. 15 units.

A study of the effect of high potentials applied to dielectrics.

Instructor: Sorensen.

EE. 224 a, b, c. VACUUM TUBE AND RADIO FREQUENCY CIRCUITS. Units to be based on work done; first, second and third terms.

A study of the literature on vacuum tube circuits. Experimental work with oscillators, transmitters, and receivers.

Instructor: Mackeown.

EE. 225. PRINCIPLES OF ELECTRICAL DESIGN. 15 units.

A discussion and calculation course in the analysis of the principles and methods used in the design of electrical machinery.

Instructors: Sorensen, Maxstadt.

Division of Chemistry and Chemical Engineering

CHEMISTRY

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

ASSOCIATE PROFESSORS: ROSCOE G. DICKINSON, WILLIAM N. LACEY, HOWARD J. LUCAS

ASSISTANT PROFESSORS: LINUS C. PAULING, ERNEST H. SWIFT

INSTRUCTORS: ARNOLD O. BECKMAN, DON M. YOST

TEACHING FELLOWS AND GRADUATE ASSISTANTS: LEE R. BRANTLEY, FRANK C. CROXTON, ROBERT T. DILLON, FRED J. EWING, CECIL E. P. JEFFREYS, SOL F. RAVITZ, JAMES H. STURDIVANT, HOMER B. WELLMAN, RALPH R. WENNER, WILLIAM G. YOUNG.

UNDERGRADUATE SUBJECTS

Ch. 1 a, b, c. CHEMISTRY I. 12 units (3-6-3); first, second, third terms.

Lectures, recitations and laboratory practice. The class and laboratory work in the first term deals with volumetric analysis, solubility effects, the ionic theory, and equilibria in solutions; in the second term with qualitative analysis; and in the third term with equilibria in gaseous systems and with the chemistry of solids and gases.

Texts: A. A. Noyes, Introduction to the Chemistry of Solutions; Kendall, Smith's College Chemistry.

Instructors: Bell, Beckman, and Teaching Fellows.

Ch. 5. HISTORY OF CHEMISTRY. 3 units (0-0-3); first term.

Readings from a selected list of books dealing with the history of chemistry, and presentation by the student of one or more lectures on some phase of the subject.

Instructor: Bates.

Ch. 6. ENGINEERING CHEMISTRY. 10 units (4-0-6); first, second or third term.

Prerequisite: Ch. 1 a, b, c.

Conferences, lectures, and problems, dealing with the application of chemical principles to engineering problems and the relations of engineering to the chemical industries.

Text: Leighou, Chemistry of Engineering Materials.

Instructor: Lacey.

Ch. 12 a, b. QUANTITATIVE ANALYSIS. 10 units (2-6-2); first and second terms.

Prerequisite: Ch. 1 c.

Laboratory practice in the methods of gravimetric and volumetric analysis, supplemented by lectures and problems in which the principles involved in the laboratory work are emphasized.

Text: Treadwell-Hall, Quantitative Analysis.

Instructor: Swift.

Ch. 12 c. QUALITATIVE ANALYSIS. 10 units (2-6-2); third term.

Prerequisite: Ch. 1 c.

Laboratory, accompanied by lectures and conferences, supplementing the freshman work in the same subject. It includes a study of the methods for the separation and detection of the acidic constituents and practice in the complete analysis of solid substances, such as alloys, minerals, and industrial products.

Text: A. A. Noyes, Qualitative Analysis.

Instructor: Swift.

Ch. 13 a, b. CHEMISTRY OF THE RARE ELEMENTS. 12 units (1-9-2); first and second terms.

This subject serves to give a knowledge of the chemistry of the rare elements. It consists largely in working through in the laboratory, with known solutions and unknown materials, the more important groups of the recently published system of analysis for the rare elements. This work is supplemented by collateral reading and by conferences with the instructors.

Text: Noyes and Bray, Qualitative Analysis for the Rare Elements.

Instructors: Swift, Yost.

Ch. 16. INSTRUMENTAL ANALYSIS. 10 units (0-6-4); first term.

Prerequisite: Ch. 12 b.

Laboratory practice designed to familiarize the student with special analytical apparatus and methods, used both for process control and for research.

Text: Lacey, Instrumental Methods of Chemical Analysis.
Instructor: Lacey.

Ch. 21 a, b, c. CHEMICAL PRINCIPLES. 10 units (4-0-6); first, second and third terms.

Prerequisites: Ch. 12 b; Ph. 1 a, b, c, 2 a, b, c, d; Ma. 2 a, b, c, d.

Conferences and recitations dealing with the general principles of chemistry from an exact, quantitative standpoint, and including studies on the pressure-volume relations of gases; on vapor-pressure, boiling point, freezing point, and osmotic pressure of solutions; on the molecular and ionic theories; on electrical transference and conduction; on chemical and phase equilibria; on thermochemistry, and the elements of thermodynamic chemistry and of electrochemistry. A large number of problems are assigned to be solved by the student.

For certain groups of students this course may be given as 2-0-4-6 in the second term, in order that they may take the laboratory course Ch. 26 a.

Text: Noyes and Sherrill, Chemical Principles.
Instructors: Bates, Dickinson.

Ch. 22 a, b. THERMODYNAMIC CHEMISTRY. 9 units (3-0-6); first and second terms.

A continuation of subject Ch. 21, given in much the same way. The topics considered include reaction rate and a further study of electrochemistry and thermodynamic chemistry. Practice is given in the computation of free energies, activities and entropies of typical substances.

Text: Noyes and Sherrill, Chemical Principles, and mimeographed notes.

Instructor: Bates.

Ch. 23. ATOMIC STRUCTURE. 8 units; third term.

This subject consists in an elementary discussion of the principles and phenomena which have led to the modern theories of the structure of atoms. It involves the solution of numerous problems. The work is preparatory to the intensive study of the subject in treatises like that of Sommerfeld.

Text: Mimeographed notes.
Instructor: Pauling.

Ch. 26 a, b. PHYSICAL CHEMISTRY LABORATORY. 4 units (0-3-1); second and third terms.

Laboratory exercises to accompany Ch. 21.

Text: Sherrill, Laboratory Experiments on Physico-Chemical Principles.

Instructor: Bates.

Ch. 29. COLLOID AND SURFACE CHEMISTRY. 9 units (3-0-6); third term.

Prerequisite: Ch. 22.

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.

(Not given in 1928-1929.)

Text: Freundlich, Elements of Colloid Chemistry.

Instructor: Badger.

Ch. 41 a, b, c. ORGANIC CHEMISTRY. 8 units (3-0-5), first and second terms; 6 units (2-0-4), third term.

Prerequisite: Ch. 12.

Lectures and recitations treating of the classification of carbon compounds, the development of the fundamental theories, and the characteristic properties of the principal classes including hydrocarbons, alkyl halides, alcohols, acids, ethers, esters, amines, carbohydrates, aromatics.

Text: Williams, Introduction to Organic Chemistry.

Instructor: Lucas.

Ch. 43. ORGANIC CHEMISTRY. 10 units (2-6-2); third term.

Prerequisites: Ch. 1 a, b, c.

Lectures and recitations, accompanied by laboratory exercises, dealing with the more important compounds of carbon and with the structural theory from the electron point of view.

Text: Conant, Organic Chemistry.

Instructor: Lucas.

Ch. 46 a, b. ORGANIC CHEMISTRY LABORATORY. 9 units (0-9-0); first and second terms.

Prerequisite: Ch. 12.

Laboratory exercises to accompany Ch. 41 a, b, c. The preparation and purification of carbon compounds and the study of their characteristic properties. Qualified students may pursue work of research nature.

Text: Adkins and McElvain, Practice of Organic Chemistry.

Instructor: Lucas.

Ch. 61. INDUSTRIAL CHEMISTRY. 6 units (2-0-4); second and third terms.

Prerequisites: Ch. 21 a, b, c, 41 a, b, c.

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.

Text: Thorp, Outlines of Industrial Chemistry.

Instructor: Lacey.

Ch. 69. FOREIGN SCIENCE JOURNALS. 6 units (2-0-4); third term.

This subject consists in readings and reports by the students on researches published in recent German and French chemical journals. It has the double object of giving practice in the reading of scientific German and French and of affording an acquaintance with important lines of research in progress.

Ch. 70-73. 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), and in applied chemistry (Ch. 73). 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 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.

FIFTH-YEAR AND ADVANCED SUBJECTS

Ch. 152. SURFACE AND COLLOID CHEMISTRY. 8 units; third term.

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.

Text: Freundlich, Elements of Colloid Chemistry.

Instructor: Badger.

Ch. 153 a, b. THERMODYNAMIC CHEMISTRY. 9 units; first and second terms.

This course is the same as Ch. 22 a, b. See page 176.

Text: Chemical Principles, Noyes and Sherrill, and mimeographed notes.

Instructor: Bates.

Ch. 154 a, b. STATISTICAL MECHANICS (Seminar). 6 units; first and second terms.

A discussion of statistical mechanics and its applications to physics and chemistry. The topics treated will include a sufficient exposition of classical and quantum theory mechanics to serve as a foundation for statistical mechanics; applications to specific heats, chemical equilibria, absorption and emission of radiation, collisions of the first and second kinds, and the rates of physical chemical processes; and a discussion of Boltzmann's H-theorem and the relations between statistical mechanics and thermodynamics.

Text: Statistical Mechanics with Applications to Physics and Chemistry, Tolman.

(Not given in 1928-1929.)

Instructors: Tolman, Dickinson, Yost.

Ch. 155 a, b. ATOMIC STRUCTURE (Seminar). 6 units; first and second terms.

This seminar will be devoted to an elementary discussion of the principles and phenomena which have led to the modern theories of the structure of atoms. It will involve the solution of numerous problems. The work is preparatory to the intensive study of the subject in treatises like that of Sommerfeld. In the second term the work will include a more complete discussion of X-ray spectra and of radioactivity.

Text: Mimeographed notes.

Instructors: Dickinson, Noyes.

Ch. 156 a, b. INTRODUCTION TO WAVE MECHANICS, WITH CHEMICAL APPLICATIONS. 6 units; first and second terms.

Prerequisite: Ch. 155 a, b, or its equivalent.

After a discussion of the development and significance of the new quantum mechanics, the wave equation of Schrödinger is used in the treatment of the oscillator, rotator, and hydrogen atom. The perturbation theory and the theory of the Heisenberg-Dirac resonance phenomenon are then developed and applied to various problems, including the Stark effect, helium atom, hydrogen molecule ion, hydrogen molecule,

forces in the hydrogen halides, Van der Waals' forces in helium, and the scattering of X-rays by bound electrons.

(Not given in 1928-1929.)

Instructor: Pauling.

Ch. 157. The Structure of Crystals. 6 units; third term.

The subject treats the methods of determining the structures of crystals with X-rays; the various structures occurring in nature, and their relation to the phenomena of isomorphism, solid solution formation, cleavage, etc.; ionic and atomic sizes and their bearing on the chemical properties of substances; interatomic forces in crystals; the crystal energy and its use in chemical thermodynamics, and related topics.

(Not given in 1928-1929.)

Instructor: Pauling.

Ch. 158. Photochemistry. 6 units; first term.

Lectures and discussions on photochemical processes, especially in their relations to quantum phenomena. The following topics will be included: the photochemical absorption law; the processes—excitation, dissociation, ionization—accompanying the absorption of radiation; subsequent processes including fluorescence and collisions of the second kind; photosensitization; quantum yield and its relation to photochemical mechanism; catalysis and inhibition; temperature coefficients of photochemical reactions.

Instructor: Dickinson.

Ch. 158. Practicum in Wave Mechanics. 6 units, second term.

This subject, which is designed to accompany and supplement Ph. 129, will consist largely in the solution and discussion of assigned problems relating to Schrödinger's wave equation for the oscillator, the rotator, and the hydrogen atom. The relation between the quantum mechanics and the old quantum theory will also be brought out by the discussion of the treatment of these systems with the methods of the old quantum theory. A general historical survey of the development of the old quantum theory and the quantum mechanics will be presented, especial emphasis being laid on topics of chemical interest.

Instructor: Pauling.

Ch. 159. The Chemical Properties of Substances as Determined by the Magnetic and Electric Properties of Molecules. 9 units, third term.

The following topics will be discussed: Langevin's theory of paramagnetism and diamagnetism; the magnetic moments of atoms and ions and their relation to line spectra and the vector model; the Stern and Gerlach experiment; diamagnetic susceptibility and electron distribution of atoms and ions; the relation between magnetic and chemical properties; Debye's theory of dielectrics; the electric moments of molecules, and their relation to the physical and chemical properties of substances.

Instructor: Pauling.

Ch. 160. INORGANIC CHEMISTRY (Seminar). 6 units; second term.

Selected groups of inorganic compounds (e.g., the various compounds of nitrogen with hydrogen and with oxygen) will be considered from modern physico-chemical view-points; thus with reference to their physical properties, their thermodynamic constants (their heat-contents, free-energies, and entropies); their rates of conversion into one another (including effects of catalysis and energy radiations), the ionization of those that are weak acids or bases, and their electron structure and valence relations.

Instructors: Noyes, Yost, Swift.

Ch. 161 a, b. ORGANIC CHEMISTRY (Special Topics). 6 units; second and third terms.

A series of lectures and discussions on selected topics of organic chemistry that have special interest from theoretical, industrial, or biological view-points.

Instructor: Lucas.

Ch. 162. ORGANIC CHEMICAL ANALYSIS. 6 units; first term.

A laboratory study of the class reactions of carbon compounds and practice in the methods of identifying unknown substances, followed by the quantitative determination of the elements through combustion analysis.

Instructor: Lucas.

Ch. 166 a, b, c. CHEMICAL ENGINEERING. 12 units (4-0-8); first, second and third terms.

Prerequisites: Ch. 61; ME. 15.

Problems and discussions designed to bring the student in touch with the problems involved in efficiently carrying out chemical reactions on a commercial scale. The basic operations of chemical industry (such as combustion, heating, mixing, filtration, distillation) are studied both as to principle and practice.

Text: Walker, Lewis and McAdams, Principles of Chemical Engineering.

Instructor: Lacey.

Ch. 170-173. 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), and applied chemistry (173).

The main lines of research now in progress in physical chemistry are:

Ionized substances in relation to the ion attraction theory.

Free-energies, equilibria, and electrode-potentials of chemical reactions.

Rates of chemical reactions in relation to the quantum theory.

Crystal structure determined by X-ray methods.

The determination of the distribution of electrons in crystals.

Catalytic mechanism of homogeneous reactions.

Chemical reactions produced by atoms excited by radiations.

Activation of atoms and molecules by electron impact.

For a fuller survey of the researches in progress, see Publications of the Gates Chemical Laboratory, pages 130-133.

Ch. 174. Research Conference in Organic Chemistry. 2 units.

Weekly reports on recent researches in organic chemistry, including those in progress in the Gates Chemical Laboratory.

Instructors: Lucas, Alles, Koepfli.

Ch. 175. Chemical Reaction Rates (Seminar). 6 units; third term.

A theoretical consideration of the rates of gaseous reactions and their temperature coefficients.

Instructors: Tolman, Rice, Kassel, Ramsperger.

Ch. 177. Crystal Structure and Molecular Structure (Seminar). 2 units; first, second and third terms.

Reports on recent researches dealing with the structure of crystals and molecules are presented by those taking part in the seminar.

Instructor: Pauling.

Ch. 178. Research Conferences in Physical and Inorganic Chemistry. 2 units; first, second and third terms.

This subject consists of reports on the researches in progress in the laboratory and on others which have appeared recently in the literature. These conferences are participated in by all men engaged in research in the laboratory.

Instructors: Noyes, Tolman, Dickinson

Division of Civil and Mechanical Engineering*

CIVIL ENGINEERING

PROFESSOR: FRANKLIN THOMAS

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

INSTRUCTOR: FRED J. CONVERSE

TEACHING FELLOWS: DONALD BARNES, RICHARD W. CUTLER

ASSISTANTS: GUNNER GRAMATKY, KENNETH ROBINSON, JOHN E. SKAFTE

UNDERGRADUATE SUBJECTS

CE. 1. SURVEYING. 10 units (3-4-3); first, second or third term.

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.

Text: Surveying, Davis, Foote, and Rayner.

Instructor: Michael.

CE. 2. ADVANCED SURVEYING. 12 units (3-6-3); first term.

Prerequisite: CE. 1.

A continuation of CE. 1, 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.

Text: Surveying, Davis, Foote, and Rayner.

Instructor: Michael.

CE. 3. PLANE TABLE SURVEYING. 8 units (1-6-1); third term.

A course offered primarily for students in geology but may be elected by arrangement with the department. Theory and use of the plane table as applied to geological surveys. The class devotes one entire day a week to field surveys over typical terrain completing a topographic map of the region covered.

*See Division of Physics, Mathematics and Electrical Engineering, pages 155-173, for subjects in Electrical Engineering.

Text: Surveying, Davis, Foote, and Rayner.
Instructor: Michael.

CE. 4. HIGHWAY ENGINEERING. 6 units (3-0-3); third term.
Prerequisite: CE. 1.
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.
Text: Construction of Roads and Pavements, Agg.
Instructor: Michael.

CE. 8 a. RAILWAY ENGINEERING. 6 units (3-0-3); first term.
Prerequisites: CE. 1, 2.
A study of economic railway location and operation; railway plant and equipment; signaling; the solution of grade problems.
Text: Elements of Railroad Engineering, Raymond.
Instructors: Thomas, Michael.

CE. 8 b. RAILWAY SURVEYING. 6 units (2-0-4); second term.
Prerequisites: CE. 1, 2.
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.
Text: Railway Curves and Earthwork, Allen.
Instructor: Michael.

CE. 8 c. RAILWAY SURVEYING. 6 units (0-6-0); third term.
Prerequisite: CE. 8 b.
The class devotes one entire day a week to field surveys of a railroad location, applying the principles as outlined under course CE. 8 b.
Text: Railway Curves and Earthwork, Allen.
Instructor: Michael.

CE. 9. ELEMENTS OF STRUCTURES. 12 units (3-3-6); second term for Electrical Engineering students; third term for students in Mechanical Engineering.
Prerequisite: AM. 1 c.
An abridged course in design of simple structures of timber, steel, masonry, and reinforced concrete. Emphasis is placed upon methods and computations in numerous typical examples.

Text: Structural Design, Thomas.

Instructors: Thomas, Martel, Converse.

CE. 10 a. THEORY OF STRUCTURES. 12 units (3-3-6); first term.

Prerequisites: AM. 1 c.

Methods used in the calculation of stresses in and proportioning of beams, girders, and columns of timber, steel and concrete; study of the effects of moving load systems; graphic statics applied to roofs and bridges.

Text: Theory of Structures, Spofford.

Instructors: Thomas, Martel.

CE. 10 b, c. THEORY OF STRUCTURES. 12 units (3-3-6), second and third terms.

Prerequisite: CE. 10 a.

A continuation of CE. 10 a, covering the computation of stresses in truss members, the design of structural parts, connections, portals, and bracing; a study of arch, cantilever, and continuous bridges; and deflection of trusses.

Text: Theory of Structures, Spofford.

Instructors: Thomas, Martel.

CE. 11 a, b. STRUCTURES. ~~6~~ units ~~(1-3-2)~~, second term; ~~12~~ units ~~(3-3-6)~~, third term.

Prerequisite: AM. 1 c.

A brief course adapted for aeronautical engineering students in the analysis of forces by analytical and graphical methods and the calculation of stresses in beams, girders, columns and simple trusses of timber, steel, and light alloys. The third term is devoted to a study of continuous beams and trusses, trusses with redundant members, effect of flexure and direct stress, deflections in beams and trusses.

Instructors: Thomas, Martel.

CE. 12. REINFORCED CONCRETE. 6 units (2-0-4); third term.

Prerequisites: AM. 1 c; CE. 10 a.

The theory of reinforced concrete design, with a study of the applications of this type of construction to various engineering structures.

Text: Reinforced Concrete Construction, Vol. I, Hool.

Instructor: Martel.

CE. 14 a, b, c. ENGINEERING CONFERENCES. 2 units (1-0-1); first, second and third terms.

Conferences participated in by faculty and seniors of the Civil Engineering department. The discussions cover current developments and advancements within the field of civil engineering and related sciences.

FIFTH-YEAR SUBJECTS

CE. 15. IRRIGATION AND WATER SUPPLY. 12 units (5-0-7); second term.

Prerequisite: Hy. 1.

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.

Text: Principles of Engineering Irrigation, Newell and Murphy.

Instructor: Thomas.

CE. 16. MASONRY STRUCTURES. 9 units (2-3-4); second term.

Prerequisite: CE. 12.

Theory of design and methods of construction of masonry structures; foundations, dams, retaining walls, and arches.

Text: Reinforced Concrete Design, Southerland and Clifford.

Instructor: Martel.

CE. 17. SEWERAGE. 9 units (3-0-6); third term.

Prerequisite: Hy. 1.

Systems for the collection and disposal of sewage; the design of sewers and storm drains; inspection of local sewage disposal plants; the drainage of land; cost assessments.

Text: Sewerage and Sewage Disposal, Metcalf E. Eddy.

Instructor: Martel.

CE. 21 a. STRUCTURAL DESIGN. 9 units (0-9-0); first term.

Prerequisites: CE. 10 a, b, c.

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.

Instructors: Thomas, Martel.

CE. 21 b. STRUCTURAL DESIGN. 9 units (0-9-0); second term.

Prerequisites: CE. 10 a, 12.

The design of a reinforced concrete building in accordance with a selected building ordinance, with computations and drawings.

Instructors: Thomas, Martel.

CE. 21 c. CIVIL ENGINEERING DESIGN. 12 units (0-12-0); third term.

Prerequisites: CE. 15, 21.

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.

Instructors: Thomas, Martel.

CE. 23. STATICALLY INDETERMINATE STRUCTURES. 15 units, ~~first term~~.

A study of such structures as continuous spans, rigid frames and arches by the methods of least work or slope-deflections; analysis of secondary stresses.

Text: Statically Indeterminate Stresses, Parcell and Maney.

Instructor: Martel.

CE. 30. ENGINEERING SEMINAR. 2 units (1-0-1); first, second and third terms.

Conferences participated in by faculty and graduate students of the Civil Engineering department. The discussions cover current developments and advancements within the field of civil engineering and related sciences, with special consideration given to the progress of research being conducted at the Institute.

ADVANCED SUBJECTS

Special problems in the various fields of civil engineering will be arranged to meet the needs of students wishing to do advanced work in this department. The following lines of work are possible. Stream Regulation and Utilization for Power, Irrigation, and Water Supply under the direction of Prof. Franklin Thomas; Advanced Structures under the direction of Prof. Martel; Sanitation and Sewerage under the direction of Profs. Thomas and Martel; Highways and Geodesy under the direction of Prof. Michael; Analysis of Earthquake Effects upon Structures under the direction of Profs. Thomas and Martel.

CE. 101 a, b. WATER POWER PLANT DESIGN. 10 units; first and second terms.

A design of a power plant in conformity with the conditions of head, flow, and load fluctuations at a particular site. Includes selection of number and type of units, design of water passages, and general structural features.

Instructor: Thomas.

CE. 103 a, b. ARCHED DAMS. 5 units; first and second terms.

A study of the distribution of stresses in arched dams. Design and investigation of the stresses in an arched dam for a given site.

Instructor: Martel.

CE. 105 b, c. STATICALLY INDETERMINATE STRUCTURES. 15 units; second and third terms.

A continuation of the study of indeterminate structures as begun in CE. 23, with the use of analytical and instrumental methods of solution.

Text: Statically Indeterminate Stresses, Parcell and Maney.

Instructor: Martel.

CE. 107 a, b, c. GEODESY AND PRECISE SURVEYING. 6 units; first, second and third terms.

Methods of triangulation and surveying over extended areas. The adjustment of triangulation systems, the adjustment of observations by the method of least squares. Map projections, precise leveling determination of a true meridian.

Instructor: Michael.

CE. 108. HIGHWAY PROBLEMS. Units to be based on work done.

Cooperating with the Highway Research Board of the National Research Council, opportunities are offered for advanced studies in highway engineering. Arrangements may be made for special studies on subgrade materials, wearing surfaces, economics of vehicle operation, and allied subjects.

Instructor: Michael.

CE. 110 b, c. SEWAGE TREATMENT PLANT DESIGN. 10 units; second and third terms.

A design of treatment works for a selected community and site involving special conditions of location, volume, and character of disposal.

Includes selection of process, arrangement of tanks and equipment, and general design of structures.

Instructors: Thomas, Martel.

CE. 112. SANITATION RESEARCH. Units to be based upon work done; any term.

Exceptional opportunities in this field are available at the sewage treatment plant of the city of Pasadena, where the activated sludge process is in operation, supplemented by a rotary kiln drier for the reduction of sludge to commercial fertilizer.

Instructors: Thomas, Martel.

CE. 114. ANALYSIS OF EARTHQUAKE EFFECTS UPON STRUCTURES. Units to be based on work done; any term.

An experimental study of effects of vibrations in framed models used with a shaking table.

Instructors: Thomas, Martel.

MECHANICAL ENGINEERING

PROFESSORS: ROBERT L. DAUGHERTY, W. HOWARD CLAPP
INSTRUCTORS: ROBERT T. KNAPP, WALTER W. OGIER, JR.
ASSISTANTS: THOMAS E. BUTTERFIELD, RICHARD G. FOLSOM

UNDERGRADUATE SUBJECTS

ME. 1. MECHANISM. 10 units (3-3-4); first, second or third term.

Prerequisites: Ma. 1 a, b, c; Ph. 1 a, b, c; D. 1 a, b.

An analytical study of constrained motion in machines and of the relations of machine elements. Desirable types of motion; displacements of machine parts using simple valve motions, cam actuating parts, and other reciprocating and oscillating machine members as examples. Velocity studies; average and instantaneous values; velocity analysis by vectors using centros; relative velocities; application of vectors to cyclic trains and other differential motions. Acceleration analysis; inertia forces. The various linkages and combinations of machine elements are introduced and used as a means of mastering the geometry of machine motion.

Text: Mechanism, Clapp and Ogier.

Instructors: Clapp, Ogier.

ME. 2. MACHINE DESIGN. 9 units (2-3-4); first term.

Prerequisites: ME. 1; AM. 1 a, b.

Applications of mechanics of machinery and mechanics of materials to practical design and construction. Riveting and welding; boilers and plate vessels; bolts and screws; force and shrink fits; hydraulic cylinders; cylinders and cylinder heads for steam and gas engines; stuffing boxes and packing; pistons and piston rings; leaf springs, coil springs; piston pins; connecting rods and cross heads; cranks and crank-shafts; flywheels; spur gears; helical gears; bevel gears; worm gears; spiral gears.

Text: Principles of Machine Design, Norman.

Instructor: Clapp.

ME. 3. MACHINE DESIGN. 12 units (2-6-4); second term.

Prerequisite: ME. 2.

A continuation of the work in design with especial reference to belting; pulleys; rope driving; chains; friction drives; wire rope and

hoisting; plain bearings; ball bearings; roller bearings; shafts and couplings; clutches; brakes; high speed disks; piping. Class exercises and drawing board studies.

Text: Principles of Machine Design, Norman.

Instructor: Clapp.

ME. 4. MACHINE DESIGN. 9 units (2-3-4); third term.

Prerequisite: ME. 3.

A study of manufacturing processes with especial reference to the economics of design. Lectures and inspection trips.

Instructor: Clapp.

ME. 8. MACHINE DESIGN. 12 units (3-3-6); ~~second term~~.

Prerequisites: ME. 1; AM. 1 a, b.

An abbreviated course in machine design for aeronautical engineers. The energy and force problem; relations of stress and strain to failure and the determination of proper safety factors; straining actions in machines; stresses with complex loading; screws and screw fastenings; axles, shafting, and couplings; friction and lubrication; journals and bearings.

Text: Machine Design, Kimball and Barr. Lectures and problems.

ME. 9. MACHINE DESIGN. 9 units (3-0-6); first term.

Prerequisites: ME. 1; AM. 1 a, b.

An abbreviated course in machine design for fifth-year students in civil engineering, somewhat similar in scope to course ME. 8.

ME. 10. METALLURGY. 9 units (3-0-6); first term.

Prerequisite: Ch. 6.

A study of the principles underlying the manufacture and heat treatment of the ferrous metals and some of the non-ferrous alloys.

Instructor: Clapp.

ME. 15. HEAT ENGINEERING. 12 units (3-3-6); first or third term.

Prerequisites: Ma. 2 a, b, c, d; ME. 1.

Principles of thermodynamics, and their application to steam engines, steam turbines, and internal combustion engines; types of steam, gas, and oil engines, boilers, and auxiliaries. Inspection of local power

plants, elementary tests in the laboratory, and computing or drawing room exercises.

Instructors: Daugherty, Knapp, Butterfield, Folsom.

ME. 16. HEAT ENGINEERING. 12 units (4-0-8); first or second term.

Prerequisite: ME. 15.

Additional work in thermodynamics; properties of gases, saturated and superheated vapors; various cycles of steam and internal combustion engines; flow of gases and vapors through orifices, nozzles, and pipes; air compression.

Instructor: Daugherty.

ME. 17. HEAT ENGINEERING. 9 units (3-3-3); third term.

Prerequisite: ME. 16.

A study of the application of thermodynamics to modern practice in power plants and also to refrigeration; heating and ventilating; and other thermal processes. Class-room work and computing-room problems.

Instructor: Daugherty.

ME. 25. HEAT ENGINEERING LABORATORY. 6 units (0-3-3); first, second or third term.

Prerequisite: ME. 15.

Tests of steam engine, steam turbine, blower and gas engine, etc., for efficiency and economy.

Text: Power Plant Testing, Moyer.

Instructor: Knapp.

ME. 26. HEAT ENGINEERING LABORATORY. 6 units (0-3-3); second term.

Prerequisite: ME. 15.

Additional work in the laboratory on air compressors, fuel and oil testing, and special work on steam and internal combustion engines.

Text: Power Plant Testing, Moyer.

Instructor: Knapp.

ME. 50 a, b, c. ENGINEERING CONFERENCES. 2 units (1-0-1); first, second and third terms.

Presentation and discussion of new developments in the industry. Review of current literature.

Instructors: Daugherty, Clapp, Knapp, Ogier.

FIFTH-YEAR AND ADVANCED SUBJECTS

ME. 100. Advanced Work in Engineering.

In addition to the regular fifth-year and other advanced courses which are here outlined, the staff of the mechanical engineering department will arrange special courses or problems to meet the needs of advanced students.

ME. 101. Advanced Machine Design. 12 units (4-0-8); first term.

Prerequisites: AM. 1 a, b; ME. 4, 10.

The student electing this course will be expected to have a comprehensive knowledge of the constitution and properties of the principal materials of construction, and to be acquainted with machine shop processes. The various relations developed in mechanics of materials are examined as to their authority and limitations and as to their application. Examples of evolved design for parts subjected to complex stresses are critically studied. Investigation of the failure of materials under repeated stresses.

Text: Applied Elasticity, Timoshenko and Lessells.

Instructor: Clapp.

ME. 102 and 103. Machine Design Options. 12 units (0-12-0); second and third terms.

The work in these terms may follow various lines as the student may elect. He may desire to work out the design of some especial machine, or he may wish to take up internal combustion engine design, or other suitable project. This time may be combined with that for thesis, in case the latter is of a design character.

Instructor: Clapp.

ME. 110. Metallography. 12 units (2-6-4); first term.

Prerequisite: ME. 10.

A continuation of the course ME. 10 with especial reference to the structure of metallic alloys, their causes, and the relation between structure and physical properties.

Text: Science of Metals, Jeffries and Archer.

Instructor: Clapp.

ME. 111. SCIENCE OF METALS. 12 units (2-6-4); second term.

Prerequisite: ME. 110.

The structure of the ferrous alloys; causes and effects of the thermal critical points; theories of hardening and hot and cold working; constitution, properties, heat treatment, and uses of the principal alloy steels; the phase rule; preparation of specimens for microscopic analysis; optics of metallography. Lectures and laboratory exercises.

Text: The Metallography of Iron and Steel, Sauveur.

Instructor: Clapp.

ME. 112. METALS RESEARCH. 12 units (1-9-2); third term.

Special problems investigated with the aid of the electric furnace, microscope, and testing materials equipment.

ME. 120. THERMODYNAMICS. 12 units (4-0-8); first term.

Prerequisite: ME. 17.

Advanced work in engineering thermodynamics, with applications tc combustion, heat transfer, and similar practical problems.

Instructor: Daugherty.

ME. 121 and 122. POWER PLANT ENGINEERING. 12 units (1-9-2); second and third terms.

Prerequisite: ME. 120.

A study of modern power plant engineering, computation of typical problems, and design and layout for a complete plant. Class room and computing room.

Instructor: Daugherty.

ME. 125. REFRIGERATION PLANTS. Units to be based on work done; any term.

Design of various types of refrigeration plants best adapted to different conditions of service.

Instructors: Daugherty, Knapp.

ME. 130. HEAT ENGINEERING LABORATORY. 15 units (1-9-5); first term.

Prerequisites: ME. 17, 26.

Advanced work on steam turbines, internal combustion engines, lubrication, and similar subjects. Each problem will be studied in enough

detail to secure a thorough analysis. Conference hour for progress discussion.

Instructor: Knapp.

ME. 135 and 136. Internal Combustion Engines. 12 units (3-3-6); second and third terms.

Prerequisites: ME. 120, 130.

Theoretical, experimental, and design problems. The subject will be approached from the performance point of view rather than from that of the mechanical design. Fuels, carburetion, superchargers, explosion, combustion, detonation, heat transfer. Work with test engine equipped with optical indicator.

Instructor: Knapp.

ME. 132. Engine Laboratory. 15 units; first, second and third terms.

Use of the dynamometer. Experimental work in engine performance, carburation, ignition, fuel consumption, etc.

Instructors: Knapp, Klein.

AERONAUTICS

PROFESSOR: HARRY BATEMAN
ASSOCIATE: THEODOR VON KARMAN
INSTRUCTOR: ALBERT A. MERRILL
RESEARCH FELLOWS: ARTHUR L. KLEIN, CLARK B. MILLIKAN
TEACHING FELLOW: ALFRED E. LOMBARD, JR.

UNDERGRADUATE SUBJECTS

AE. 1. GENERAL AERONAUTICS. 9 units (3-0-6); ~~third~~ term.

Prerequisites: Ph. 2 a, b, c, d.

Historical development. Elementary theory of airplane, balloon, and helicopter. Theory of model testing. Control and stability of aircraft. Survey of contemporary design.

Texts: Bedell, The Airplane; Monteith, Simple Aerodynamics and the Airplane.

Instructors: Merrill and other members of the department.

AE. 4 a, b, c. AERODYNAMICAL LABORATORY. 6 units; first, second and third terms.

Prerequisites: Ph. 2 a, b, c, d.

Determination of the resistance coefficients for various bodies. Determination of pressure and velocity distribution in the wind tunnel. Experimental study of air forces on model wings, propeller sections, and airplanes.

Instructor: Merrill.

FIFTH-YEAR AND ADVANCED SUBJECTS

AE. 251 a, b. ELEMENTARY AERODYNAMICS OF THE AIRPLANE. 9 units, first term; 6 units, second term.

Prerequisites: AM. 1 a, b, c, AM. 3, CE. 11.

Airfoils, wings, and tail groups, stability and control, drag, and performance.

Texts: Warner, Airplane Design; Diehl, Engineering Aerodynamics.

Instructor: C. B. Millikan.

AE. 252 a, b, c. ELEMENTARY AIRPLANE DESIGN. 11 units, first term; 14 units, second term; 20 units, third term.

Prerequisites: AM. 1 a, b, c, AM. 3, CE. 11.

Properties of aircraft materials, beams, trusses, columns, and inde-

terminate structures, design of airplanes, shop and drafting room practice. *252* must be taken concurrently or subsequently to *251*.

Texts: Niles, Airplane Design; Case, Strength of Materials; Pippard and Pritchard, Airplane Structure.

Instructors: Klein, Raymond.

AE. *253* a, b. ADVANCED AIRPLANE DESIGN. 9 units; first and second terms.

Prerequisite: AE. *251*.

Each student carries through the complete design of an airplane to meet specifications. The course is given in conjunction with lectures by members of the Douglas Company engineering staff.

AE. *256*. AERONAUTICAL POWER PLANTS. 3 units, second term.

Prerequisites: AM. 1 a, b, c, AM. 3.

Survey course in airplane engines, performance, propellers, cooling systems, fuel and oil systems, installations.

Text: Aircraft Power Plants, Jones, Insley, Caldwell, and Kohr.

Instructor: Klein.

AE. *258*. PROPELLER DESIGN. 6 units; one term.

Prerequisite: AE. *251*.

Design of propellers for aircraft, windmills, wind channels, and air turbines.

Instructor: Klein.

AE. *260* a, b. ADVANCED THERMODYNAMICS AND AIRPLANE ENGINES. 9 units; second and third terms.

Prerequisites: ME. 101, *120*.

Thermodynamics of the internal combustion engine. Ideal and real efficiencies. Mechanics of high speed engines. Engine balance. Carburation. Conduction, radiation and cooling. Ignition systems. High speed gearing. Lubrication.

Texts: Judge, Automobile and Aircraft Engines; Niles, Airplane Design.

Instructors: Knapp, Klein.

AE. *264*. DESIGN OF AERO FOILS AND STREAMLINE BODIES. 6 units; third term.

Instructor: Bateman.

AE. 265. Properties of Fluids and Elementary Hydrodynamics. 9 units; second term.

Prerequisites: Ph. 1 a, b, c, or Hy. 1, 2.

Density, compressibility, viscosity. Equations of motion and theory of steady flow. Flow through pipes and around obstacles. Pitot and Venturi tubes. Principles of similitude. Turbulence and Reynolds' criterion. Theory of lubrication.

Text: The Mechanical Properties of Fluids, a collective work.

Instructor: Bateman.

AE. 266. Aerodynamics. 15 units; third term.

Prerequisites: AE 265; Ma. 114.

Elementary hydrodynamical theory as applied to aeronautics. Wing and propeller theory. Theories of resistance. Mechanics of the airplane. Static and dynamic stability.

Texts: Glauert, The Elements of Aerofoil and Airscrew Theory; Prandtl, Applications of Modern Hydrodynamics to Aeronautics.

Instructor: C. B. Millikan.

AE. 268. Advanced Aerodynamics. 15 units; second term.

Mathematical discussion of various theories of lift and drag. Soaring flight. Katzmayr effect. Autorotation. Special types of flight. Theory and discussion of new types of aircraft.

Instructor: Bateman.

AE. 269. Theory of Stability and Control. 15 units; third term.

Discussion of stability based on the mathematical theory of small oscillations. Effect of prescribed movements of the control surfaces. Effect of slipstream and downwash.

Texts: Bairstow, Aerodynamics; Wilson, Aeronautics.

Instructors: Bateman, C. B. Millikan.

AE. 270. Propeller Theories. 15 units; one term.

Various extensions and developments of the blade element theory. Froude theory. Vortex theory. Effect of constricting walls; effect of fuselage and wings.

Text: Glauert, The Elements of Aerofoil and Airscrew Theory.

Instructor: Bateman.

AE. 286 a, b, c. Wind Channel. 15 units; first, second and third terms.

Experimental work of all kinds in the aerodynamical laboratory: wind channel, water channel, structure laboratory, etc.

Instructors: Merrill, C. B Millikan, Klein.

AE. 290 a, b, c. AERONAUTICAL SEMINAR. 2 units; first, second and third terms.

Study and critical discussion of current contributions to aerodynamics and aeronautical engineering.

Additional and supplementary courses will be offered as the need arises. Lectures will be given from time to time by visiting scientists and engineers from this country and Europe. Flying is not given officially at the Institute, but there are ample opportunities for a student to learn to fly at one of the neighboring flying fields.

APPLIED MECHANICS

PROFESSOR: FREDERIC W. HINRICHS, JR.

INSTRUCTOR: FRED J. CONVERSE

TEACHING FELLOWS: C. HAWLEY CARTWRIGHT, RALPH W. CUTLER

UNDERGRADUATE SUBJECTS

AM. 1 a, b. APPLIED MECHANICS. 14 units (4-3-7); first and second terms.

Prerequisites: Ma. 1 a, b, c, 2 a, b, c, d; Ph. 1 a, b, c, 2 a, b, c, d.

Action of forces on rigid bodies; composition and resolution of forces; equilibrium, couples, framed structures; cords and chains; centroids; displacement; velocity and acceleration; translation, rotation, and plane motion; moments of inertia; inertia forces; kinetic and potential energy; work and energy; impulse and momentum; impact; power; efficiency.

Text: Seely and Ensign's Analytical Mechanics for Engineers.

Instructors: Hinrichs, Converse, Cartwright, Cutler.

AM. 1 c. STRENGTH OF MATERIALS. 14 units (4-3-7); third term.

Prerequisite: AM. 1 a, b.

Elasticity and strength of materials of construction; theory of stresses and strains; elastic limit; yield point; ultimate strength; safe loads; repeated stresses; beams; cylinders; shafts; columns; riveted joints; structural shapes.

Texts: Poorman's Strength of Materials, and Steel Construction, A. I. S. C.

Instructors: Hinrichs, Converse, Cartright, Cutler.

AM. 2 a, b. APPLIED MECHANICS AND STRENGTH OF MATERIALS. 12 units (4-0-8); first and second terms.

Prerequisites: Ma. 1 a, b, c, 2 a, b, c, d; Ph. 1 a, b, c, 2 a, b, c, d.

An abridged course for students electing the Chemical Engineering Option in the Science Course, condensing in the work of two terms as much as possible of the general field outlined above in AM. 1 a, b, c.

Texts: Wood's Text-book of Mechanics, Boyd's Strength of Materials, and Carnegie Pocket Companion.

Instructor: Hinrichs.

AM. 3. TESTING MATERIALS LABORATORY. 6 units (0-3-3); first, second or third term.

Prerequisite: AM. 1 c.

Tests of the ordinary materials of construction in tension, compression, torsion, and flexure; determination of elastic limits; yield point, ultimate strength, and modulus of elasticity; experimental verification of formulas derived in the theory of strength of materials.

Texts: Upton's Materials of Construction, and Hinrichs' and Martel's Laboratory Manual for Testing Materials.

Instructor: Converse.

FIFTH-YEAR AND ADVANCED SUBJECTS

AM. 202 a, b, c. THEORY OF ELASTICITY. Units to be based on work done; first, second and third terms.

A study of the behavior of an elastic solid under stress.

Instructor: Hinrichs.

ENGINEERING DRAWING

ASSISTANT PROFESSOR: GEORGE B. BRIGHAM, JR.

ASSISTANTS: DONALD P. BARNES, GUY CHILBERG, DOUGLAS KINGMAN, EARNEST E. SECHLER

D. 1. FREEHAND DRAWING. 3 units (0-3-0); first or third term.

The study and representation of geometrical solids and other simple models to develop careful observation and accurate draftsmanship. Correct proportions and neatness of linework will be emphasized.

Instructor: Brigham.

D. 2. FREEHAND DRAWING. 3 units (0-3-0); elective.

Prerequisite: D. 1.

Similar to D. 1 but with advanced subject matter.

Instructor: Brigham.

D. 10. ELEMENTARY MECHANICAL DRAWING. 3 units (0-3-0); first or third term.

The study of applied geometry by means of two dimensional geometrical constructions. The care and use of drawing instruments. Accuracy and precision are required.

Text: French, Engineering Drawing.

Machine Drawing, D. 20 a, b, and c, and D. 21 and 22 are planned to prepare all engineering students for the drawing required in the professional work of the engineering departments. Accuracy, neatness and good lettering are required.

D. 20 a. MACHINE DRAWING AND LETTERING. 3 units (0-3-0); first term.

Prerequisite: D. 10.

The study of the general principles of working drawings of machinery covering conventional representations and dimensioning. The work includes the executing of simple working drawings in pencil and tracings in ink. It also includes lettering plates in pencil and ink.

Text: James and Mackenzie, Working Drawings of Machinery.

D. 20 b. MACHINE DRAWING AND LETTERING. 3 units (0-3-0); second term.

Prerequisite: D. 20 a.

A continuation of D. 20 a, covering dimensioned freehand sketches of machine parts, and complete detail working drawings made from the sketches. The work will be done in pencil and traced. The lettering plates will continue throughout this course.

Text: James and Mackenzie, Working Drawings of Machinery.

D. 20 c. MACHINE DRAWING AND LETTERING. 3 units (0-3-0); third term.

Prerequisite: D. 20 b.

A continuation of D. 20 b, covering assembly and outline drawings of small machines or groups of machine parts. The work will be done in pencil and ink, and the lettering plates will continue in the form of bills of material.

D. 21. ADVANCED MACHINE DRAWING. 3 units (0-3-0); elective any term.

Prerequisite: D. 20 a, b, c.

The study and execution of design drawings for proposed mechanisms designed by upper class mechanical engineering students.

Text: James and Mackenzie, Working Drawings of Machinery.

Instructor: Brigham.

D. 22. ADVANCED MACHINE DRAWING. 3 units (0-3-0); elective any term.

Prerequisite: D. 21.

A continuation of D. 21 with more advanced subject matter.

Instructor: Brigham.

Structural Drawing, D. 30 a, b, and c, and D. 31 and 32 are especially planned to prepare civil engineering students for the drawing required in the professional work of the civil engineering department. Accuracy, neatness and good lettering are required.

D. 30 a. STRUCTURAL DRAWING AND LETTERING. 3 units (0-3-0); first term.

Prerequisite: D. 10.

The study of the general principles of working drawings of structural steel and reinforced concrete covering conventional representations, billing and dimensioning. The work includes the execution of simple working drawings in pencil and tracings in ink. It also includes lettering plates in pencil and ink similar to those required for D. 20 a.

Text: Bishop, Structural Drafting and the Design of Details.

D. 30 b. STRUCTURAL DRAWING AND LETTERING. 3 units (0-3-0); second term.

Prerequisite: D. 30 a.

A continuation of D. 30 a, covering complete detail working drawings of structural steel members. The work will be done in pencil and traced. The lettering plates will continue throughout this course.

Text: Bishop, Structural Drafting and the Design of Details.

D. 30 c. STRUCTURAL DRAWING AND LETTERING. 3 units (0-3-0); third term.

Prerequisite: D. 30 b.

A continuation of D. 30 b, covering working drawings of trusses, erection plans, and checking. The work will be done in pencil and ink, and the lettering plates will continue in the form of material, shop and shipping bills.

Text: Bishop, Structural Drafting and the Design of Details.

D. 31. ADVANCED STRUCTURAL DRAWING. 3 units (0-3-0); elective any term.

Prerequisite: D. 30 a, b, c.

The study and execution of drawings of structural steel or reinforced concrete for structures designed by upper class civil engineering students.

Text: Bishop, Structural Drafting and the Design of Details.

Instructor: Brigham.

D. 32. ADVANCED STRUCTURAL DRAWING. 3 units (0-3-0); elective any term.

Prerequisite: D. 31.

A continuation of D. 31 with more advanced subject matter.

Text: Bishop, Structural Drafting and the Design of Details.

Instructor: Brigham.

Descriptive Geometry, D. 40, 41 a, b, c, 42 and 43, are planned to cover a thorough study of shape description and representation. Especial emphasis will be placed upon the visualization of problems in order to develop three dimensional observation. The work will include practical as well as purely geometrical problems.

D. 40. ELEMENTARY DESCRIPTIVE GEOMETRY. 3 units (0-3-0); second term or summer school.

The study of the graphical representation of three dimensional geometrical constructions by means of orthographic projection. The work includes principle, auxiliary and oblique views.

Text: Hood, Geometry of Engineering Drawing.

D. 41 a. DESCRIPTIVE GEOMETRY. 3 units (0-3-0); first term.

Prerequisite: D. 40.

A continuation of D. 40 covering the "Analysis of Structures" and straight and curved line constructions.

Text: Hood, Geometry of Engineering Drawing.

D. 41 b. DESCRIPTIVE GEOMETRY. 3 units (0-3-0); second term.

Prerequisite: D. 41 a.

A continuation of D. 41 a, covering problems involving the relationship of lines and planes and the intersection and development of surfaces.

Text: Hood, Geometry of Engineering Drawing.

D. 41 c. DESCRIPTIVE GEOMETRY. 3 units (0-3-0); third term.

Prerequisite: D. 41 b.

A continuation of D. 41 b, covering more complicated problems involving single curved surfaces, warped and double curved surfaces.

Text: Hood, Geometry of Engineering Drawing.

D. 42. DESCRIPTIVE GEOMETRY. 6 units (0-6-0); first term.

Prerequisite: D. 40.

This course covers in one term the same ground as D. 41 a and b. It is planned primarily for geology students, and includes practical problems in mining and earth structures.

Text: Hood, Geometry of Engineering Drawing.

Instructor: Brigham.

D. 43. Advanced Descriptive Geometry. 3 units (0-3-0); elective any term.

Prerequisite: D. 41 a, b, c.

The study of lineal perspective and the execution of mechanical perspective drawings of machines, bridges, and other structures.

Instructor: Brigham.

D. 44. Perspective Sketching. 3 units (0-3-0); elective any term.

Prerequisite: D. 43.

The study of freehand perspective drawing. Models will be selected by the student and executed in various mediums. The work is planned to illustrate the relation between mechanical and natural perspective and to develop freedom in pictorial representation.

Instructor: Brigham.

D. 50. Block Diagrams and Land Forms. 6 units (0-6-0); second term.

The graphical representation of land forms and geological structure by means of pictorial drawings. The work, which will be mainly freehand, includes the drawing of block diagrams of various land forms in perspective, and of "isometric diagrams and problems in structural geology."

Text: Lobeck, Block Diagrams.

Instructor: Brigham.

D. 51. Physiographic Sketching. 6 units (0-6-0); third term.

Freehand sketching from landscape forms and details of geological structure. Sketches will be made in both the drawing room and the field, and by means of various mediums. Required of geology students; elective for civil engineering students.

Text: Lobeck, Block Diagrams.

Instructor: Brigham.

HYDRAULICS

PROFESSOR: ROBERT L. DAUGHERTY
INSTRUCTOR: ROBERT T. KNAPP

UNDERGRADUATE SUBJECTS

Hy. 1. HYDRAULICS. 12 units (4-0-8); first, second or third term.
Prerequisite: AM. 1 a, b.

Physical properties of water; hydrostatics; flow of water in pipes, nozzles, and channels; theory, construction, and installation of hydraulic turbines, and a study of their characteristics with a view to intelligent selection of the proper type for any given conditions; centrifugal pumps and other hydraulic equipment.

Text: Hydraulics and Hydraulic Turbines, Daugherty.
Instructor: Daugherty.

Hy. 2. HYDRAULIC LABORATORY. 6 units (0-3-3); first, second or third term.
Prerequisite: AM. 1 a, b.

Experiments on the flow of water through orifices and nozzles, through pipes and Venturi meters, over weirs; use of Pitot tube; tests of impulse and reaction turbines, centrifugal pumps, and other hydraulic apparatus.
Instructor, Knapp.

ADVANCED SUBJECTS

Hy. 200. ADVANCED WORK IN HYDRAULIC ENGINEERING.
Special problems in hydraulics will be arranged to meet the needs of students wishing to do advanced work in this field.

Hy. 101. HYDRAULIC MACHINERY. Units to be based on work done; any term.

A study of such machines as the hydraulic turbine and the centrifugal pump and their design to meet specified conditions.
Instructor: Daugherty.

MILITARY TRAINING

PROFESSOR: LIEUT. COLONEL LEWIS M. ADAMS
ASSISTANT PROFESSOR: LIEUTENANT LOUIS J. CLATERBOS
MASTER SERGEANT: JOSEPH LARACY
MASTER SERGEANT: LOUIS H. BAILEY

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 national defense plan 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 defense of the country in the event 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 who are American citizens and physically eligible 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.

UNDERGRADUATE SUBJECTS

Mi. 1 a, b, c. MILITARY SCIENCE AND TACTICS (Basic Course). 4 units (1-2-1); first, second and third terms.

Freshman 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 freshman year.

Mi. 2 a, b, c. MILITARY SCIENCE AND TACTICS (Basic Course). 4 units (1-2-1); first, second and third terms.

Prerequisite: *Mi. 1 a, b, c.*

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, tripods and field derricks, topographic sketching, nature and use of explosives, and bridge construction. Selected sophomores are assigned as corporals in the R. O. T. C. battalion.

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 and may apply for admission to the advanced course. Such selected students receive a money allowance from the United States Government for commutation of rations of approximately nine dollars ($9) per month, and an allowance for purchase of tailored uniform. They are required to attend one summer advanced R. O. T. C. Camp for 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 to and from camp, and pays each student seventy cents (70c) per day for attendance at this summer camp. The advanced course covers the instruction necessary for the training of the student 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.

Mi. 7 a, b, c. MILITARY SCIENCE AND TACTICS (Advanced Course). 6 units (2-3-1); first, second and third terms.

Prerequisites: *Mi 1 a, b, c, 2 a, b, c.*

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.

Mi. 10 a, b, c. MILITARY SCIENCE AND TACTICS (Advanced Course). 6 units (2-3-1); first, second and third terms.

Prerequisites: *Mi. 1 a, b, c, 2 a, b, c, 7* a, b, c.

Senior work consists of recitations and conferences in the following subjects: Military bridges, military history and 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.

In June, 1925, in 1926, and again in 1927, the California Institute of Technology was designated by the War Department as a "Distinguished College." This much sought-for honor was obtained by its R. O. T. C. battalion demonstrating a superior state of efficiency at the annual inspection of the special War Department board of officers in April.

The system of annual inspections and designation of "Distinguished Colleges" was abandoned by the War Department during the last college year, a visit by the Corps Area R. O. T. C. Officer taking its place. As a result of this visit in March, 1928, the Institute was again given "honor" rating, which entitled it to designate one of its Seniors in Military as the "Honor Student" for the year. This distinction was won by Mr. Carmun C. Shaffer, '28, and was published in Orders by the Commanding General Ninth Corps Area.

SHOP INSTRUCTION

INSTRUCTORS: ARTHUR F. HALL, MURRAY W. HAWS, OSCAR L. HEALD, 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.

UNDERGRADUATE SUBJECTS

Sh. 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.

Instructor: Martin.

Sh. 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.

Instructor: Heald.

Sh. 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.
Instructor: Henck.

Sh. 4. MACHINE SHOP. 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.
Instructor: Hall.

Sh. 1-4. (Above subjects.) Distributed through the three terms and the summer period of the freshman year. (8 units for the year.)

Division of Geology and Paleontology

Professors: John P. Buwalda, F. L. Ransome, Chester Stock, Wendell P. Woodring

Instructor: Rene Engel

Curator in Vertebrate Paleontology: Eustace L. Furlong

Artist: John L. Ridgway

Research Fellows: Ralph L. Lupher, John W. Patterson

Teaching Fellows and Graduate Assistants: Alexander Clark, Thomas Clements, Rollin P. Eckis, Lozell C. Hookway, C. Lewis Gazin, John H. Maxson, Bernard N. Moore

Preparator in Invertebrate Paleontology: H. Colliander

UNDERGRADUATE SUBJECTS

Ge. 1 a. Physical Geology. 9 units (3-3-3); first term.

Prerequisites: Ch. 1 a, b, c; Ph. 1 a, b, c.

A consideration of the composition and structure of the Earth and the internal and external processes which modify the crust and the surface. Dynamical and structural geology. Lectures, recitations, laboratory and weekly field trips.

Text: Pirsson and Schuchert's Text-book of Geology, Part I.

Instructor: Buwalda.

Ge. 1 b. Elementary Paleontology. 9 units (4-1-4); second term.

Prerequisite: Ge. 1 a.

A discussion of the principles on which the history of life is based. Illustrations of evolution taken from certain groups of animals of which the fossil record is essentially complete. Occasional field trips.

Text: Lull, Organic Evolution.

Instructor: Stock.

Ge. 1 c. Historical Geology. 9 units (2-3-4); first term.

Prerequisite: Ge. 1 b.

The astronomical origin and geological history of the Earth. An account of the changing vistas of geological time and of the successive faunas and floras which have peopled the earth's surface from age to age. Lectures, recitations, laboratory, and occasional field trips.

Text: Graban, Text-book of Geology, Part II.

Instructor: Woodring.

Ge. 3 a. CRYSTALLOGRAPHY. 9 units (1-6-2); first term.

Prerequisites: Ch. 1 a-c; Ph. 1 and 2.

A study of crystal systems and forms, not only from the classical geometric view-point, but also in light of the modern atomic conceptions of crystal structure; also, the physical properties characteristic of crystals.

Text: Dana's Text-book of Mineralogy.

Instructor: Engel.

Ge. 3 b, c. MINERALOGY. 9 units (1-6-2); second term, 6 units (1-3-2); third term.

Prerequisite: Ge. 3 a.

Lectures and laboratory work devoted to the study of the physical and chemical properties of minerals, of their associations and modes of occurrence, and to their identification.

Text: Dana's Text-book of Mineralogy.

Instructor: Engel.

Ge. 5 a, b. PETROLOGY. 9 units (1-6-2); first and second terms.

Prerequisites: Ge. 3 a, b.

The origin, properties, and microscopic identification of the common rocks. Lectures and laboratory.

Text: Rocks and Rock Minerals, Pirsson-Knopf.

Instructor: Engel.

Ge. 7 a, b. FIELD GEOLOGY. 8 units first term, 10 units third term.

Prerequisites: Ge. 1 a-c; 3 a, b; 5 a, b.

Technical field methods of mapping the distribution of rocks, determining structure, and deciphering the geological history of a region. Students map a certain area and prepare a report on its structure and history. Eleven field days are scheduled per term, usually on Fridays, but with one or two trips of several days. Students may be called upon to expend small sums for traveling expenses. Field work, conferences, and laboratory.

Text: Field Geology, Lahlee.

Instructors: Buwalda, Moore.

Ge. 9. STRUCTURAL GEOLOGY. 8 units (3-0-5); third term.

Prerequisite: Ge. 7 a.

A consideration of the structural features of the Earth's crust; joints, folds, faults, foliation. Computation of thicknesses and depths. Determination of the nature and amount of displacements on faults by use of descriptive geometry. Lectures and laboratory.

Instructor: Buwalda.

Ge. 11 a, b. INVERTEBRATE PALEONTOLOGY. 10 units first term, 8 units second term.

Prerequisites: Ge. 1 a, b, c.

A study of the more important groups of fossil invertebrates, principally from the dynamic point of view. Changes in structures and their significance in evolution and in adaptation to ecologic conditions are emphasized. Principles of use of fossil invertebrates in determining age of rocks in which they are found and in deciphering their ecologic significance.

Instructor: Woodring.

Ge. 12 a, b. VERTEBRATE PALEONTOLOGY. 10 units (2-6-2) second term; 8 units third term.

Prerequisite: Ge. 1 b.

Osteology, affinities, and history of the principal groups of fossil mammals and reptiles. History of vertebrate life with special reference to the region of western North America.

Instructor: Stock.

Ge. 20. FOREIGN SCIENCE JOURNALS. 6 units (2-0-4); third term.

This subject consists in readings and reports by the students on researches published in recent German and French geological and paleontological journals. It has the double object of giving practice in the reading of scientific German and French and of affording an acquaintance with important lines of research in progress.

Ge. 21. THESIS PROBLEM IN GEOLOGY. 8 units; second and third terms.

Prerequisite: Ge. 7 a.

The student investigates a limited geologic problem, preferably of his own choosing, under direction, in the field or laboratory. Individual initiative is developed, principles of research are acquired, and practice

gained in technical methods. The student prepares a thesis setting forth the results of the research and their meaning.

Ge. 22. THESIS PROBLEM IN PALEONTOLOGY. 8 units; second and third terms.

Prerequisites: Ge. 11 a, b, or Ge. 12 a, b; may be taken concurrently.

Special investigations in either invertebrate or vertebrate paleontology. Research on a limited problem involving either field relationships of fossil assemblages or consideration in the laboratory of the structural characters and relations of fossil forms. Preparation of a thesis.

Ge. 23. SUMMER FIELD GEOLOGY. 12 units.

Intensive geologic mapping of a selected area from a centrally located field camp. Determination of the stratigraphy, fossil content, structure, and geologic history. The area chosen will probably lie in the California Coast Ranges in odd-numbered years and in the Great Basin region in the alternate years. Course begins immediately after Commencement (about June 12th). Required at the end of both the Junior and the Senior Year in the Geology and Paleontology course. Tuition, $15.00.

Instructor: Buwalda (even-numbered years); Woodring (odd-numbered years).

FIFTH-YEAR SUBJECTS

Ge. 181 a, b, c. PETROGRAPHY. 10 units; first, second and third terms.

Optical mineralogy and study of the petrographic characteristics of certain important types of rocks. Use of the microscope in the identification of minerals and rocks.

Instructor: Engel.

Ge. 183. SEISMOLOGY. 6 units; first term of even-numbered years.

Study and conferences on the principles of physical and geological seismology.

Text: Davidson's Manual of Seismology.

Instructor: Buwalda.

Ge. 184. LABORATORY STUDIES IN SEISMOLOGY. First, second or third term.

Laboratory practice in the measurement and interpretation of in-

strumental earthquake records; investigation of specific seismologic problems.

Instructors: Staff of Seismological Laboratory.

Ge. 186. GEOMORPHOLOGY. 10 units; first term of odd-numbered years.

Nature and origin of the physiographic features of the earth. Geologic processes involved in their development. Use of physiography in elucidating the later geologic history of regions.

Instructor: Buwalda.

Ge. 187. RESEARCH.

Original investigation, designed to give training in methods of research, to serve as theses problems for higher degrees, and to yield contributions to scientific knowledge. These may at present be most advantageously carried on in the fields of (n) general areal geology, (o) stratigraphic geology, (p) structural geology, (q) physiography or geomorphology, (r) mineralogy and petrology, (s) vertebrate paleontology, (t) invertebrate paleontology, (u) seismology, (v) economic geology. The region within easy reach of Pasadena offers an extraordinary variety of research problems.

ADVANCED SUBJECTS

Ge. 188. ADVANCED STUDY.

Subjects as listed under Ge. 187.

Ge. 189 a, c. SEMINAR IN PHYSICAL GEOLOGY. 5 units; first and third terms.

Study and critical discussion of current contributions to geologic knowledge.

Instructor: Buwalda.

Ge. 190 a, b. SEMINAR IN VERTEBRATE PALEONTOLOGY. 5 units; second and third terms.

Discussion of progress and results of research in vertebrate paleontology. Critical review of current literature.

Instructor: Stock.

Ge. 191 a, b. SEMINAR IN INVERTEBRATE PALEONTOLOGY. 5 units; first and second terms.

Conferences on investigations in invertebrate paleontology and re-

views of current literature. Intensive studies of particular aspects of invertebrate paleontology. Principles of nomenclature.

Instructor: Woodring.

Ge. 195. ORE DEPOSITS. 10 units; second term.

Prerequisites: Ge. 1, 3, 5, 7.

A study of metalliferous deposits with particular reference to their geological relations and origins. Lectures, recitations, and field trips.

Text: Not prescribed, but Emmons' Principles of Economic Geology is suggested, with Lindgren's Mineral Deposits as collateral reading.

Instructor: Ransome.

Ge. 196. NON-METALLIFEROUS DEPOSITS. 10 units; third term.

Prerequisites: Ge. 1, 3, 5, 7.

Modes of occurrence, distribution, and origin of the principal non-metallic mineral products, including mineral fuels, building materials, etc.

Text: Not prescribed, but Ries' Economic Geology or an equivalent text will be found useful.

Ge. 197 a, b. ORE DEPOSITS OF THE WESTERN UNITED STATES AND MEXICO. 8 units; second and third terms.

Prerequisites: Ge. 195, Ge. 196.

A study of the principal mining districts in the Western United States and Mexico, with particular reference to processes and principles. If practicable, field trips will be arranged to some of the most interesting districts. Instructions will be based partly on reading of U. S. Geological Survey reports, with collateral library work.

Instructor: Ransome.

Ge. 198 a, b. ECONOMIC GEOLOGY SEMINAR. 5 units; second and third terms.

Prerequisites: Ge. 195, Ge. 196, or equivalents.

Discussion of current literature and special problems. The seminar work may be varied by occasional lectures.

Instructor: Ransome.

Division of the Humanities

ENGLISH

PROFESSOR: CLINTON K. JUDY
ASSOCIATE: C. F. TUCKER BROOKE
ASSOCIATE PROFESSOR: GEORGE R. MACMINN
ASSISTANT PROFESSOR: HARVEY EAGLESON
INSTRUCTORS: L. W. JONES, ROGER STANTON
ASSISTANT: ROBLEY D. EVANS

A course in English composition is prescribed for all students in the Freshman year, and a course in the survey of English literature is prescribed for all students in the Junior year. In the Senior year the students are offered a number of options in English, American, and European literature.

The instruction in composition is intended to give a thorough training in both written and spoken English. The instruction in literature is intended to provide an appreciative acquaintance with the chief works of the most significant authors, past and present, in the development of modern civilization, and to foster the habit of self-cultivation in books.

The regular courses in English do not exhaust the attention given at the Institute to the student's use of the language; all writing, in whatever department of study, is subject to correction with regard to English composition.

UNDERGRADUATE SUBJECTS

En. 1 a, b, c. ENGLISH COMPOSITION AND READING. 6 units (3-0-3); first, second and third terms.

This course is designed to give the student a thorough review of the principles of composition, with much practice in writing and speaking, and a broad introduction to good reading. The student is offered every inducement to self-cultivation, and is allowed ample opportunity for the exercise of special talents or the pursuit of special intellectual interests.

The work of the honor section is directed toward the stimulation of intellectual initiative. Each member of the section may study some

carefully chosen topic in accordance with the elementary principles of research. He is held to high standards of excellence in writing and speaking, and is expected to undertake a considerable amount of cultural reading.

Texts: English Composition for College Students, Thomas, Manchester, and Scott; The New World, second series, Bruce and Montgomery; Webster's Collegiate Dictionary.

Instructors: Eagleson, Jones, Stanton.

En. 7 a, b, c. Survey of English Literature. 8 units (3-0-5); first, second and third terms.

Prerequisite: En. 1 a, b, c.

A selective study of English literature from the beginnings to the end of the 19th century, focused on the most distinguished works of the greater writers in poetry, drama, the novel, and the essay. Special attention is given to the social background of the works assigned for reading, and to the chief cultural movements of the modern world. In the first term the emphasis is placed on Shakespeare and the English Renaissance; in the second term on the life and literature of the 18th century; in the third on the Victorian Era.

Texts: The Oxford Shakespeare; A Book of English Literature, Snyder and Martin.

Instructors: Eagleson, Jones, Judy, MacMinn, Stanton.

En. 8. Contemporary English and European Literature. 9 units (3-0-6); first and third terms.

Prerequisite: En. 7 a, b, c.

A continuation of the survey of English literature to cover the period, 1890-1928; with some extension into Continental literature. Wide reading is required.

Text: English Literature During the Last Half-Century, Cunliffe.

Instructors: Eagleson, Judy.

En. 9. Contemporary American Literature. 9 units (3-0-6); first and third terms.

Prerequisite: En. 7 a, b, c.

A survey of the literature of the United States during the past half-century, with emphasis upon the chief writers of the present time. Special attention is given to the reflection of national characteristics in the novel, the short story, drama, and poetry.

Text: Recent American Literature, Foerster.

Instructor: MacMinn.

En. 10. Modern Drama. 9 units (3-0-6); first and third terms.

Prerequisite: En. 7 a, b, c.

A study of the leading European and British dramatists, from Ibsen to the writers of the present time. Special attention may be given to new movements in the theatre, to stage decoration and production. Wide reading of plays is required.

Text: Chief Contemporary Dramatists, first series, Dickinson.

Instructor: Stanton.

En. 11. Literature of the Bible. 9 units (3-0-6); third term.

Prerequisite: En. 7 a, b, c.

A study of the Old and New Testaments, exclusively from the point of view of literary interest. Special attention is given to the history of the English Bible. Opportunity is offered for reading modern literature based on Biblical subjects.

Text: The Modern Reader's Bible, Moulton.

Instructor: MacMinn.

En. 12 a, b, c. Debating. 4 units (2-0-2).

Elective, with the approval of the Registration Committee, for upper classmen in the first and second terms. Study of the principles of argumentation; systematic practice in debating; preparation for intercollegiate debates.

Elective, with the approval of the Freshman Registration Committee, for Freshmen, 2 units (1-0-1) in the second term, and 4 units (2-0-2) in the third term. Lectures on the principles of formal logic and the theory of argumentation and debate.

Instructor: Untereiner.

En. 13 a, b, c. Reading in English. Units to be determined for the individual by the Department.

Elective, with the approval of the Registration Committee, in any term.

Collateral reading in literature and related subjects, done in connection with regular courses in English, or independently of any course, but under the direction of members of the department.

En. 14. Special Composition. 2 units (1-0-1); any term.

This course may be prescribed for any student whose work in composition, general or technical, is unsatisfactory.

En. 15 a, b, c. Journalism. 3 units (1-0-2).

Elective, with the approval of the Registration Committee.

A study of the principles and practice of newspaper writing, editing, and publishing, especially as applied to student publications at the Institute.

Text: Newspaper Writing and Editing, Bleyer.

Instructor: MacMinn.

En. 16. Spelling. No credit.

This course may be prescribed for any student whose spelling is unsatisfactory.

En. 20. Summer Reading. Maximum, 16 credits.

Credits are allowed to the maximum number of 16 for vacation reading from a selected list of books in various subjects, and written report thereon.

FIFTH-YEAR AND ADVANCED SUBJECTS

En. 100. Literature. 12 units; first, second and third terms.

A study of some selected period, or type, or author, or group of authors in American, English or European literature, with an introduction to the methods of research and criticism applicable thereto.

Instructors: Brooke, Eagleson, Judy, MacMinn.

LANGUAGES

PROFESSOR: JOHN R. MACARTHUR

ASSISTANTS: JOSEPH W. SCHWEINFEST, FRANK A. NICKELL, HAMPTON A. SMITH

The courses in this department are primarily arranged to meet the needs of scientific students who find it necessary to read books, treatises, and articles in French, German, and Italian. In these languages correct pronunciation and the elements of grammar are taught, but the emphasis is laid upon the ability to translate from them into English. An elective course in Greek is offered to students interested in that language.

UNDERGRADUATE SUBJECTS

L. 1 a, b. ELEMENTARY FRENCH. 10 units (4-0-6); second and third terms.

A course in grammar, pronunciation, and reading that will provide the student with a vocabulary of extent and with a knowledge of grammatical structure sufficient to enable him to read at sight French scientific prose of average difficulty. Accuracy and facility will be insisted upon in the final tests of proficiency in this subject.

Texts: An Introduction to the Study of French, Bond; Technical and Scientific French, Williams.

Instructor: Macarthur.

L. 11. ELEMENTARY ITALIAN. 9 units (3-0-6); one term, as required.

A course designed to give the student who has already some acquaintance with Latin or with another Romance language sufficient knowledge of the forms and vocabulary of Italian to enable him to read scientific Italian, especially in the field of Mathematics.

Text: Elementary Italian, Marinoni and Passarelli.

Instructor: Macarthur.

L. 31 a, b, c. ELEMENTARY GERMAN. 6 units (3-0-3); first, second and third terms.

This subject is presented in the same manner as the Elementary French.

Texts: First German Course for Science Students, Fiedler and Sandbach; German Science Reader, Wright.

Instructors: Macarthur and Assistants.

L. 34 a, b, c. SCIENTIFIC GERMAN. 10 units (4-0-6); first, second and third terms.

Prerequisite: L. 31 a, b, c, or one year of college German.

This is a continuation of L. 31 a, b, c, with special emphasis on the reading of scientific literature.

Text: Aus der Werkstatt grosser Forscher, Danneman.

Instructors: Macarthur and Assistants.

L. 37 a, b, c. ELEMENTARY AND SCIENTIFIC GERMAN. 10 units (4-0-6); first, second and third terms.

This course is a combination of L. 31 and 34 presented in a single year and open to students of exceptional ability.

Texts: First German Course for Science Students, Fiedler and Sandbach; Die Radioaktivitat, Fajans; German Science Reader, Wright.

Instructors: Macarthur and Assistants.

L. 38. SCIENTIFIC GERMAN. 10 units (4-0-6); first term.

This course is a continuation of L. 37.

Instructors: Macarthur and Assistants.

L. 39 a, b, c. READING IN FRENCH, ITALIAN, OR GERMAN. Units to be determined for the individual by the department. Elective, with the approval of the Registration Committee, in any term.

Reading in scientific or literary French, Italian, or German, done under direction of the department.

L. 40. GERMAN LITERATURE. 9 units (3-0-6); first term.

Prerequisites: L. 37 a, b, c; L. 38 a, b, c.

The reading of selected German classics, poetry and drama, accompanied by lectures on the development of German literature.

Instructor: Macarthur.

L. 51 a, b, c. GREEK. 6 units (3-0-3).

This is a course in the elements of the classical Greek language. Special reference is made to scientific nomenclature. Outside reading upon topics drawn from Greek literature, art, philosophy, and science is reported on in term papers. The course is elective.

Texts: Alpha, Frost; Xenophon's Anabasis; The Study of Greek Words in English, Including Scientific Terms, Hoffman.

Instructor: Macarthur.

HISTORY AND GOVERNMENT

ASSOCIATES: MAX FARRAND, WILLIAM B. MUNRO, FREDERICK J. TURNER

LECTURER: BERNARD FAY

INSTRUCTOR: RAY E. UNTEREINER

ASSISTANTS: JOHN H. MAXSON, KENNETH SOLOMON

UNDERGRADUATE SUBJECTS

H. 1 a, b, c. ANCIENT AND MEDIEVAL HISTORY. 4 units (2-0-2); first, second and third terms.

Lectures and discussions upon the early civilizations out of which modern Europe developed, and upon the institutions of the Middle Ages. The students are referred to original sources in the library.

Texts: Ancient Times, Breasted; History of Western Europe, Vol. I, Robinson.

Instructor: Macarthur.

H. 2 a, b, c. MODERN EUROPEAN HISTORY. 6 units (2-0-4); first, second and third terms.

Prerequisite: En. 1 a, b, c.

The general political and social history of Europe from 1500 to 1926, presented as the background and development of movements underlying present conditions.

Instructors: Judy, Munro, Untereiner.

H. 5 a, b. CURRENT TOPICS. 2 units (1-0-1); first and second terms.

This course is given collaterally with En. 10, and is articulated with a selected weekly journal of general information and opinion.

H. 10. THE CONSTITUTION OF THE UNITED STATES. 2 units (1-0-1); third term.

A study of the principles and provisions of the national constitution in the light of present-day interpretation by the courts. Required of all seniors.

Instructor: Munro.

H. 12. Eighteenth Century Ideas. 9 units (3-0-6); first term.

The development of European political, philosophical, and scientific thought in the eighteenth century.

Instructor: Fay.

FIFTH-YEAR AND ADVANCED SUBJECTS

H. 100. Seminar in American History and Government. 12 units (1-0-11); first, second and third terms.

Open only to fifth-year students and seniors who have attained honor grades.

First term: The Framing of the Federal Constitution (1786-1788), and the Subsequent Development of Certain Constitutional Provisions, Farrand.

Second term: The Jackson Era, 1829-1837, Turner.

Third term: The Development of American Political Institutions During the Period, 1897-1913, with Special Reference to Municipal Government, Munro.

ECONOMICS

PROFESSOR: GRAHAM A. LAING
ASSISTANT PROFESSOR: CLYDE WOLFE
INSTRUCTORS: ALBERT A. MERRILL, RAY E. UNTEREINER

The subjects in this group have the twofold 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.

UNDERGRADUATE SUBJECTS

Ec. 2. GENERAL ECONOMICS. 6 units (3-0-3); first term.

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.

Text: Economics, Vol. I, Fairchild.

Instructors: Laing, Untereiner.

Ec. 3. ECONOMIC HISTORY. 2 units (1-0-1); second term.

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.

Text: Introduction to Economic History, Gras.

Instructor: Laing.

Ec. 4. SELECTED ECONOMIC PROBLEMS. 4 units (2-0-2); second term.

Prerequisite: Ec. 2.

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.

Text: Economics, Vol. II, Fairchild.

Instructors: Laing, Untereiner.

Ec. 10. MATHEMATICS OF FINANCE. 4 units (1-0-3); first term.

The mathematical theory underlying compound interest, annuities, and mathematical expectation, with application to such subjects as the accumulation of reserves, the amortization of debts, evaluation of bonds, partial payments, capitalized costs, and insurance.

Text: Mathematics of Investment, Hart.

Instructor: Wolfe.

Ec. 11. STATISTICS. 3 units (1-0-2); second term.

Statistical methods and the graphic portrayal of results, with their application to concrete business problems.

Text: Elements of Statistical Method, King.

Instructor: Wolfe.

Ec. 12. ECONOMIC HISTORY. 6 units (2-0-4); third term.

A more detailed treatment of the subjects discussed in Economics 3.

Text: Introduction to Economic History, Gras; and other reading to be assigned.

Instructor: Laing.

Ec. 14. TAXATION. 4 units (2-0-2); second term.

A study of the general principles of public expenditure and public revenues with special reference to American taxation methods.

Text: Introduction to Public Finance, Plehn.

Instructor: Untereiner.

Ec. 17. ACCOUNTING. 9 units (3-0-6); third term.

An abridged course in accounting.

Text: Bookkeeping and Accounting, McKinsey.

Instructor: Merrill.

Ec. 20. FINANCIAL ORGANIZATION. 8 units (3-0-5); third term.

Prerequisites: Ec. 2, 4.

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 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.

Instructor: Laing.

Ec. 25. Business Law. 6 units (3-0-3); third term.

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.

Text: American Business Law, Frey.

Instructor: Untereiner.

Ec. 26 a, b. Business Law. 8 units (3-0-5); third and first terms.

Similar in scope to Ec. 25, but giving a more extensive treatment of the different subjects considered.

Texts: American Business Law, Frey; Cases on Commercial Law, Bays.

Instructor: Untereiner.

Ec. 30 a, b. Business Administration. 8 units (3-0-5); first and second terms.

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.

Instructor: Laing.

Ec. 34. Corporation Finance. 6 units (2-0-4); first term.

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.

Text: Corporation Finance, Dewing.

Instructor: Laing.

Ec. 40. Industrial Plants. 6 units (2-0-4); third term.

A study of the methods that are employed in machine shops and

manufacturing plants. The course is especially adapted to the needs of the practicing engineer.

Text: Industrial Organization, Kimball.

Instructor: Clapp.

Ec. 45 a, b. SEMINAR IN SOCIAL AND ECONOMIC ORGANIZATION. 4 units (2-0-2); second and third terms.

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 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. The number of students is limited and the seminar is open to juniors and seniors.

Instructor: Laing.

PHILOSOPHY, ETHICS AND SOCIOLOGY

ASSOCIATE: THEODORE G. SOARES
INSTRUCTOR: RAY E. UNTEREINER

UNDERGRADUATE SUBJECTS

Pl. 1. INTRODUCTION TO PHILOSOPHY. 9 units (3-0-6); second term.

A study of the development of Western thought and its issue in modern philosophy.

Text: John Herman Randall, The Making of the Modern Mind.

Instructor: Soares.

Pl. 4. ETHICS. 9 units (3-0-6); second term.

A study of the social experience exhibited in the Bible as a basis for a consideration of the evolution of morality. Modern problems of conduct in the light of this historical survey.

Texts: Soares, Social Institutions and Ideals of the Bible; Dewey and Tufts, Ethics.

Instructor: Soares.

Pl. 5. SOCIOLOGY. 9 units (3-0-6); third term.

The development of races, with a study of biological selection, physical adaptation, and the influence of climatic and geographical conditions. The genesis and evolution of the social organism, and the influence of the economic, religious, intellectual and political interests. A course in principles, with theses assigned for the application of these principles to specific social problems.

Instructor: Untereiner.

FIFTH-YEAR AND ADVANCED SUBJECTS

Pl. 100. A STUDY OF SOME ASPECTS OF PHILOSOPHICAL, ETHICAL OR SOCIAL DEVELOPMENT. 12 units; first, second and third terms.

Instructors: Soares, Untereiner.

Division of Physical Education

PHYSICAL DIRECTOR: WILLIAM L. STANTON

INSTRUCTOR: HAROLD Z. MUSSELMAN

ASSISTANTS: LOUIS J. CLATERBOS (football and basketball), VAINO A. HOOVER, BURT RICHARDSON (intramural sports), LAYTON STANTON (coach of freshmen), ARTHUR GRIFFITH (wrestling and boxing), I. BERMAN (wrestling), A. LARRECQ (boxing)

PHYSICIAN TO ATHLETES: DR. FLOYD L. HANES

ADVISER IN ATHLETICS: DAVID BLANKENHORN

All freshmen and other new students must pass a medical examination before they will be admitted to the Institute; all other students must satisfy the Department of Physical Education 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.

The program of physical education is designed to give general physical development to all. 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) corrective exercises for those physically deficient; (2) group games; (3) fundamentals of highly organized athletics. 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.

PE. 1, 2, 3, 4. PHYSICAL EDUCATION. 3 units; first, second and third terms.

The physical education program of the Institute is based on intramural and intercollegiate sports in which all students are required to participate during all four undergraduate years. The intramural sports comprise 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., and is required of all students not taking part in intercollegiate sports. The intercollege sports comprise competition with other members of the Southern California Intercollegiate Conference, of which the Institute is a member. Representative freshmen and varsity teams, trained by experienced coaches, in the major sports are developed. 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. During the freshman and sophomore years, all students are given physical examinations and strength tests in the first and third terms. These tests are used as a basis of comparison with other men of the same weight and height. Corrective or special exercises are prescribed throughout the four years for those who can not compete in intramural or intercollegiate sports.

Degrees Conferred, June 8, 1928

Doctor of Philosophy

Warren Phelps Baxter, B.S., M.S., California Institute of Technology
Arnold Orville Beckman, B.S. and M.S., University of Illinois
Jacob Lloyd Bohn, B.S., Pennsylvania Stage College; M.A. Harvard University
P'ei-Yuan Chou, B.S. and M.S., University of Chicago
Robert Hennah Dalton, B.S., M.S., California Institute of Technology
James Hugh Hamilton, B.S., M.S., California Institute of Technology
Hervey Crandall Hicks, Ph.B. and M.S., University of Chicago
Albert Clarence Hodges, B.A. and M.A., University of Texas
Sydney Bettinson Ingram, B.A., University of British Columbia
Frederick Charles Lindvall, B.S., University of Illinois
Clark Blanchard Millikan, A.B., Yale University
Martin Emery Nordberg, B.S. and M.S., Iowa State College
Boris Podolsky, B.S. and M.A., University of Southern California
Charles Francis Richter, A.B., Stanford University
Harold Heiges Steinour, B.S., University of Southern California; M.S., California Institute of Technology
Lars Thomassen, B.S., Norway Institute of Technology
William Ure, B.A. and M.S., University of British Columbia
Morgan Ward, A.B., University of California

Master of Science

Arthur Perry Banta, A.B., Stanford University
Benedict Cassen, A.R.C.S., Imperial College of Science and Technology
Charles Lewis Gazin, B.S., California Institute of Technology
Vaino Alexander Hoover, B.S., California Institute of Technology
Francis Crawford Martin, M.E., Melbourne University; B.S., London University
John Haviland Maxson, B.S., California Institute of Technology
Louis Henry Mesenkop, B.S., California Institute of Technology
Carol Gray Montgomery, B.S., California Institute of Technology
Stanley Chapin Morgan, B.S., Queen's University; M.S., University of Alberta
Frank Andrew Nickell, B.S., California Institute of Technology
Carl Fred Renz, B.S., Iowa State College
Nathan Frost Scudder, B.S., California Institute of Technology
Lloyd Edward Swedlund, B.S., University of Colorado
Francis Earl Turner, B.S., California Institute of Technology
Ralph Mayhew Watson, B.S., California Institute of Technology

Bachelor of Science

(Stars indicate graduation with honor)

Science

*Richard Carl Aussieker
Frank Wagner Bell
Jack Berman
*Alexander Clark
*Robert Isham Coulter
*Robley Dunglison Evans
Joseph Burwell Ficklen, III
*William McHenry Goodall
Thomas Clifford Graham
*George Thomas Harness, Jr.
Lozell Charlie Hookway
Jean Edward Joujon-Roche
*Charles Coyle Lash
*Albert Eaton Lombard, Jr.
*Edwin Mattison McMillan
*Henry Edward Nash
Alfred Clifford Nestle
Bennett Preble
*Joseph William Schweinfest
Nicolai Kiprianoff Senatoroff
Bertie Halsey Shepley, Jr.
*Hampton Smith
Kenneth Alfred Solomon
*Edward Eugene Tuttle
*Paul Berthold Wagner
Baker Wingfield

Engineering

*Stratford Bradish Biddle, Jr.
*Thomas Herbert Brighton
Robert Dugan Buchanan
*Maxwell Follansbee Burke
Guy Lewis Chilberg
*George Richard Crane
*Ralph Waldo Cutler
Philip Thaddeus Durfee
*Richard Henri Duval
*Luther Judd Eastman
Kenneth Macdonald Fenwick
*Richard Gilman Folsom
Moe William Gewertz
F. Gunner Gramatky
Charles Albert Hisserich
Hugh Alger Hossack
*William Morton Jacobs
*Ray Kenneth Jacobson
George Shinichiro Kaneko
*Douglas George Kingman
Jackson G. Kuhn
Charles Finley Lewis
*Russell James Love
*Don Everett McFaddin
Elbert Edward Miller
Cyrus Gordon Minkler
Donald Sprague Nichols
Francis Noel
William Lewis Olsen
Evan Ellis Pugh
Walter Hammond Righter
Kenneth Hall Robinson
Ellwood Hart Ross
Ernest Edwin Sechler
*Carmun Cuthbert Shaffer
*John Egon Skafte
Arthur Tomizo Suzuki
Donald Tolman Tarr
Huston Warfield Taylor
*Edwin Wilson Templin
Ralph Scott Thacker
*John William Thatcher
Ralph Clarence Weber

Honors, 1928

JUNIOR TRAVEL PRIZES: ALBERT E. MYERS, BOLIVAR ROBERTS

SENIOR SCHOLARS: THOMAS H. EVANS, RUSSELL W. RAITT, ALBERT C. REED

BLACKER JUNIOR SCHOLARS: HOWARD CARY, JOE FOLADARE, LOWELL F. GREEN, ROLAND C. HAWES, PHILLIP O. JANSSEN, FRANK N. MOYERS, THEODORE F. STIPP, OSCAR F. VAN BEVEREN

BLACKER SOPHOMORE SCHOLARS: ROBERT P. COLEMAN, WILLIAM F. EBERZ, CARTER H. GREGORY, ROBERT B. JACOBS, LAURENCE E. KINSLER, RAYMOND A. PETERSON

FRESHMAN SCHOLARS:

*ROBERT V. CAREY, South Pasadena High School
CHARLES JONES, Long Beach High School
DELMAR LARSEN, Hollywood High School, Los Angeles
JAMES LIPP, Manual Arts High School, Los Angeles
JOSEPH SHEFFET, Venice High School, Los Angeles
CARL THIELE, Hollywood High School, Los Angeles
HALLEY WOLFE, Porterville High School

CONGER PEACE PRIZE:

THOMAS H. EVANS, LESLIE O. SCOTT, SIDNEY ZIPSER

*Alumni Scholarship.

Graduate Students

Name	Major Subject	Home Address
Alexander, Samuel Thompson A.B., University of California, 1926	Phys.	Hollywood
Anderson, Alfred B. C. A.B., University of California at Los Angeles, 1928	Phys.	Los Angeles
Anderson, Carl David B.S., California Institute, 1927	Phys.	Pasadena
Arnquist, Warren Nelson B.S., Whitman College, 1927	Phys.	Yakima, Washington
Barnes, Donald Porter B.S., Oregon State College, 1928	C.E.	Pasadena
Basoco, Miguel Antonio B.A., University of California, 1924; M.S., University of Chicago, 1926	Math.	Los Angeles
Beeler, Raymond Arthur B.A., Pomona College, 1927	Phys.	Pasadena
Biddle, Russell Lee B.S., University of Pittsburgh, 1925; M.A., Columbia University, 1928	Biol.	Crafton, Pennsylvania
Bilicke, Albert Constant B.A., Williams College, 1924; M.S., California Institute, 1927	Chem.	Los Angeles
Blackburn, John Francis B.S., University of Chicago, 1926	Phys.	Hollywood
Bleakney, William McChesney B.S., Whitman College, 1926	Phys.	Echo, Oregon
Brantley, Lee Reed A.B., University of California at Los Angeles, 1927	Chem.	Los Angeles
Broadwell, Samuel Jonathan B.S., Throop College of Technology, 1918; M.S., University of Chicago, 1920	Phys.	Los Angeles
Brooks, Ernest Arthur B.A., Pomona College, 1927	A.E.	Claremont
Bruce, Willard Charles B.A., University of Minnesota, 1926	Phys.	Pasadena
Campbell, J. Stuart B.S., California Institute, 1926	Phys.	Pasadena

NAME	MAJOR SUBJECT	HOME ADDRESS
CARTWRIGHT, CHARLES HAWLEY B.S., California Institute, 1926	Phys.	San Gabriel
CASSEN, BENEDICT A.R.C.S., Imperial College of Science and Technology, London, England, 1927; M.S., California Institute, 1928	Phys.	Pasadena
CHAO, CHUNG-YAO B.S., National Southeastern University, Nanking, China, 1927	Phys.	Chu-Ki, Chekiang, China
CHILBERG, GUY LEWIS B.S., California Institute, 1928	M.E.	Azusa
CLARK, ALEXANDER B.S., California Institute, 1928	Geol.	Whittier
CLEMENTS, THOMAS E.M., University of Texas, 1922	Geol.	Hollywood
CRANE, GEORGE RICHARD B.S., California Institute, 1928	E.E.	Pasadena
CROXTON, FRANK CUTSHAW B.A., Ohio State University, 1927; M.A., 1928	Chem.	Columbus, Ohio
CUTLER, RALPH WALDO B.S., California Institute, 1928	C.E.	Huntington Park
DAILY, CHARLES ROBERT A.B., Colorado College, 1925	Phys.	Colorado Springs, Colorado
DAY, RALPH KOHLRAUSCH Ph.B., Yale University, 1925	Phys.	Washington, D. C.
DELSASSO, LEO PETER A.B., University of California at Los Angeles, 1925	Phys.	Los Angeles
DILLON, ROBERT TROUTMAN B.S., California Institute, 1925; M.S., 1927	Chem.	Oroville
DITTWE, GEORGE ROBERT B.S., Purdue University, 1921	A.E.	Oakland
ECKIS, ROLLIN POLLARD B.A., Pomona College, 1927	Geol.	San Diego
ELDER, JOHN DYER B.S., University of Chicago, 1925	Math.	Los Angeles
ENGEL, RENE L. H. B.S., University of Paris, 1909; M.S., 1912	Geol.	Pasadena

Name	Major Subject	Home Address
Evans, Robley Dunglison B.S., California Institute, 1928	Phys.	Pasadena
Evjen, Haakon Muus E.E., Cornell University, 1926; M.S., California Institute, 1927.	Phys.	Oslo, Norway
Ewing, Frederick Junior B.S., California Institute, 1927	Chem.	Pasadena
Focke, Alfred Bosworth B.S., Case School of Applied Science, 1928	Phys.	Cleveland, Ohio
Folsom, Richard Gilman B.S., California Institute, 1928	M.E.	Los Angeles
Gazin, Charles Lewis B.S., California Institute, 1927; M.S., 1928	Geol.	Pasadena
Gramatky, Ferdinand Gunner B.S., California Institute, 1928	C.E.	Wilmar
Haeff, Andrew Vasily Electrical and Mechanical Engineer, Polytechnic Institute of the Special Region of the Eastern Province, 1928	E.E.	Harbin, China
Harness, George Thomas B.S., California Institute, 1928	E.E.	Glendale
Hayward, Claude DeWayne B.S., California Institute, 1926; M.S., 1927	E.E.	Santa Ana
Hergenrother, Rudolf Clemens B.S., Cornell University, 1925; M.S., Pennsylvania State College, 1928	Phys.	Schenectady, New York
Hetherington, William Alford A.B., Columbia College, 1926; M.A., Columbia University, 1927	Biol.	Walnut Creek
Hill, Mason Lowell B.A., Pomona College, 1926	Geol.	Pomona
Hincke, William Berrard B.S., University of Illinois, 1923	Chem.	Pasadena
Holroyd, Howard Byington B.S., Iowa State College, 1924	Phys.	Plymouth, Iowa
Hookway, Lozell Charles B.S., California Institute, 1928	Geol.	Pasadena
Hoover, Vaino Alexander B.S., California Institute, 1927; M.S., 1928	E.E.	Pasadena

NAME	MAJOR SUBJECT	HOME ADDRESS
HOWELL, LYNN GORMAN B.A., University of Texas, 1925; M.A., 1926	Phys.	Winnsboro, Texas
HOYT, ARCHER B.A., Whitman College, 1927	Phys.	San Anselmo
HUFF, LORENZ DITMAR A.B., University of Oklahoma, 1927; M.S., 1928	Phys.	Norman, Oklahoma
ILLINGWORTH, KENNETH KNIGHT A.B., Colorado College, 1924; M.A., Dartmouth College, 1926	Phys.	Colorado Springs, Colorado
JEFFREYS, CECIL E. P. B.A., University of Texas, 1925; M.A., 1927	Chem.	San Angels, Texas
JOHNSTON, NORRIS B.S., Massachusetts Institute of Technology, 1924; M.S., 1926	Phys.	Minneapolis, Minnesota
KENNISON, LAWRENCE SANFORD A.B., Dartmouth College, 1926; A.M., Brown University, 1928	Math.	Ayer, Massachusetts
KINGMAN, DOUGLAS GEORGE B.S., California Institute, 1928	M.E.	Alhambra
KIRKPATRICK, HARRY ALLISTER B.S., Occidental College, 1914	Phys.	Los Angeles
KIRSCHMAN, H. DARWIN B.S., California Institute, 1918; M.S., 1919	Chem.	Los Angeles
KNAPP, ROBERT TALBOT B.S., Massachusetts Institute of Technology, 1920	M.E.	Pasadena
LASH, CHARLES COYLE B.S., California Institute, 1928	E.E.	Los Angeles
LAURITSEN, CHARLES CHRISTIAN Odense Tekniske Skole, 1911	Phys.	Pasadena
LEWIS, WILLIAM ABBETT, JR. B.S., California Institute, 1926; M.S., 1927	E.E.	Pasadena
LEWIS, WILLIAM BRADLEY B.A., Williams College, 1927	Chem.	Los Angeles
LOMBARD, ALBERT EATON, JR. B.S., California Institute, 1928	A.E.	Pasadena
LUPHER, RALPH LEONARD B.A., University of Oregon, 1926; M.A., 1927	Geol.	Eugene, Oregon
MAXSON, JOHN HAVILAND B.S., California Institute, 1927; M.S., 1928	Geol.	Pasadena

Name	Major Subject	Home Address
MAXSTADT, FRANCIS WILLIAM	E.E.	Pasadena
M.E., Cornell University, 1916; M.S., California Institute, 1925		
MCMILLAN, EDWIN MATTISON	Phys.	Pasadena
B.S., California Institute, 1928		
MCRAE, DANIEL BRENT	Chem.	San Bernardino
B.S., University of Utah, 1926		
MESENKOP, LOUIS HENRY	E.E.	Hollywood
B.S., California Institute, 1927; M.S., 1928		
MICHELS, WALTER CHRISTIAN	Phys.	Pasadena
B.S., Rensselaer Polytechnic Institute, 1927		
MILLIKAN, GLENN ALLAN	Chem.	Pasadena
B.S., Harvard College, 1927		
MOORE, BERNARD NETTLETON	Geol.	Los Angeles
B.S., California Institute, 1927		
MORGANS, WILLIAM RICHARD	Phys.	Wales
B.S., University College, Wales, 1925; M.S., 1927		
MOUZON, JAMES CARLISLE	Phys.	Abilene, Texas
A.B., Southern Methodist University, 1927		
MURPHY, FRANKLIN MAC	Geol.	Wheaton, Minnesota
B.A., University of California at Los Angeles, 1928		
MUSKAT, MORRIS	Phys.	Marietta, Ohio
B.A., Ohio State University, 1926; M.A., 1926		
NEHER, HENRY VICTOR	Phys.	Springfield, Oregon
B.A., Pomona College, 1926		
NICKELL, FRANK ANDREW	Geol.	Los Angeles
B.S., California Institute, 1927; M.S., 1928		
OBOUKHOFF, NICOLAS MIKHAILOVICH	E.E.	Harbin, China
University of Moscow, 1896; Technological Institute of Kharkov, 1907; E.E., Ecole Superieure d'Electricite de Paris, 1909		
OSWALD, W. BAILEY	A.E.	Hollywood
B.A., University of California at Los Angeles, 1927		
PATTERSON, JOHN WILFRED	Geol.	Los Angeles
E.Met., Colorado School of Mines, 1925; M.A., University of Wyoming, 1926		
PEARSON, JOHN MAGNUS	Phys.	Portland, Oregon
B.S., University of Chicago, 1925		
PIPER, ROBERT IRVING	Phys.	Missoula, Montana
B.A., University of Montana, 1928		

Name	Major Subject	Home Address
Pugh, Emerson Martindale B.S., Carnegie Institute of Technology, 1918; M.S., University of Pittsburgh, 1927	Phys.	Evanston, Wyoming
Ransom, John Horace B.S., University of Chicago, 1923	Phys.	Glendale
Ravitz, Sol Frederick B.A., University of Utah, 1927; M.A., 1927	Chem.	Salt Lake City, Utah
Richardson, Burt Ph.B., Yale University, 1919	Phys.	Glendale
Robinson, Kenneth Hall B.S., California Institute, 1928	C.E.	Pasadena
Rumbaugh, Lynn Hamilton A.B., Miami University, 1928	Phys.	Carthage, Missouri
Sandberg, Edward Charles B.S. and E.M., Michigan College of Mines, 1926	Geol.	Ajo, Arizona
Schaffer, Norwood Korter B.S., University of Washington, 1926; M.S., 1927	Chem.	Seattle, Washington
Schubauer, Galen Brandt B.S., Pennsylvania State College, 1928	Phys.	Mechanicsburg, Pennsylvania
Schweinfest, Joseph William B.S., California Institute, 1928	Phys.	Anaheim
Sechler, Ernest Edwin B.S., California Institute, 1928	A.E.	Santa Barbara
Shaffer, Allyn Moore B.S., Northwestern University, 1916; M.S., 1920	Chem.	Cranford, New Jersey
Skafte, John Egon B.S., California Institute, 1928	C.E.	Denmark
Skolnik, Samuel B.S., University of Buffalo, 1926	Phys.	Los Angeles
Slocum, Roy Friend B.A., University of Redlands, 1927	E.E.	Redlands
Smith, Hampton B.S., California Institute, 1928	Geol.	Monrovia
Sokoloff, Vadim Michailovitch B.S., California Institute, 1926	Phys.	Pasadena

Name	Major Subject	Home Address
Solomon, Kenneth Alfred B.S., California Institute, 1928	Phys.	Glendale
Stanton, W. Layton B.S., California Institute, 1927	Geol.	Sierra Madre
Stapp, Frederick Pearce A.B., Stanford University, 1927	Ch.E.	Los Angeles
Sturdivant, James Holmes B.A., University of Texas, 1926; M.A., 1927	Chem.	Greenville, Texas
Sutton, Richard Manliffe B.S., Haverford College, 1922	Phys.	Pasadena
Swartz, Charles Albert B.S., California Institute, 1927	Phys.	Pasadena
Taylor, Daniel Dwight A.B., Colorado College, 1924	Phys.	Colorado Springs, Colorado
Thatcher, John William B.S., California Institute, 1928	E.E.	Montebello
Thorndike, Edward Moulton B.S., Wesleyan University, 1926; A.M., Columbia University, 1927	Phys.	Montrose, New York
Titlebaum, Albert A.B., Columbia University, 1926; A.M., 1928	Biol.	Brooklyn, New York
Urmston, Joseph A.B., University of California at Los Angeles, 1928	Chem.	Pasadena
Van den Akker, Johannes Archibald B.S., California Institute, 1926	Phys.	Los Angeles
Wellman, Homer Bigelow B.A., Carleton College, 1926; M.S., University of Michigan, 1927	Chem.	Cape Town, South Africa
Wenner, Ralph Richter B.S., Cooper Union Institute of Technology, 1926; M.S., Northwestern University, 1927	Chem.	Pasadena
Wolfe, Karl Morgan B.S., West Virginia University, 1925	E.E.	Kingwood, West Virginia
Young, William Gould B.A., Colorado College, 1924; M.A., 1925	Chem.	Colorado Springs, Colorado

Undergraduate Students

Abbreviations: Eng., Engineering; Sci., Science; E.E., Electrical Engineering; M.E., Mechanical Engineering; C.E., Civil Engineering; Ch., Chemistry; Ch.E., Chemical Engineering; Ph., Physics; Ge., Geology; Ma., Mathematics; A.E., Aeronautical Engineering.

SENIOR CLASS

Students whose names are starred attained honor standing during the preceding year (an average of 145 credits per term for Juniors and Sophomores; 140 credits per term for Seniors).

NAME	COURSE (OPTION)	HOME ADDRESS
Allison, Donald Kreeck	Sci.(Ch.E.)	Los Angeles
Arnold, William Archibald	Sci.(Ph.)	San Fernando
Asquith, Harlan Robert	Eng.(C.E.)	Los Angeles
Atwater, Eugene	Eng.(E.E.)	Los Angeles
*Baker, Bill	Eng.(A.E.)	Piru
Baker, Howard Eugene	Eng.(C.E.)	Los Angeles
Baustian, Wilbert Wiese	Eng.(M.E.)	Pasadena
*Berman, Isadore	Sci.(Ch.E.)	Los Angeles
Birge, Knowlton Root	Eng.(E.E.)	Pasadena
Bode, Francis Dashwood	Sci.(Ge.)	South Pasadena
Booth, William Walter	Sci.(Ma.)	Zelzah
Bosserman, Charles Ashton	Eng.(A.E.)	Glendale
Campbell, Horace Allen	Eng.(A.E.)	Riverside
Clark, Donald Sherman	Eng.(M.E.)	Bakersfield
*Cline, Frederick	Eng.(C.E.)	Covina
*Cole, Dallas Ervie	Eng.(C.E.)	Pasadena
Compton, Thomas Henry	Sci.(Ge.)	Los Angeles
Coupland, Bert Russell	Eng.(E.E.)	Los Angeles
Cramer, Alphonse	Eng.(M.E.)	Los Angeles
*Cravitz, Philip	Eng.(C.E.)	Los Angeles
*Daly, John Warlaumont	Sci.(Ge.)	Buena Park
D'Arcy, Nicholas Anthony	Eng.(C.E.)	Roscoe
de Camp, Lyon Sprague	Eng.(A.E.)	Los Angeles
Dodge, Howard Grindal	Eng.(C.E.)	Pasadena
*Dunham, James Waring	Eng.(C.E.)	Pasadena
Dunn, Allen Winfield	Eng.(E.E.)	Hollywood
Edson, Thomas Farrer	Eng.(E.E.)	Pasadena
Espinosa, Julius Nelson	Eng.(E.E.)	Los Angeles
*Evans, Thomas Hayhurst	Eng.(C.E.)	Los Angeles
Everett, Monroe Miller	Eng.(C.E.)	Moorpark
*Exley, Sidney Thomas, Jr.	Eng.(C.E.)	Pasadena
Findlay, Willard Alexander	Sci.(Ge.)	Avalon

NAME	COURSE (OPTION)	HOME ADDRESS
*Fracker, Henry Edward	Eng.(E.E.)	Pasadena
Fredendall, Beverly Frank	Eng.(E.E.)	Ontario
Ganssle, Karl Albert	Sci.(Ph.)	Pasadena
Gilmore, Albert Monroe	Eng.(M.E.)	Bell
*Grimes, Walter Bert	Eng.(C.E.)	Pasadena
*Grunder, Lawrence Jacob	Eng.(E.E.)	Los Angeles
*Hasler, Maurice Fred	Sci.(Ph.)	Hollywood
Hatch, William B., Jr.	Eng.(A.E.)	Ypsilanti, Michigan
Hiyama, Thomas Tamotsu	Eng.(E.E.)	Pasadena
*Holdaway, V. Lyman	Eng.(E.E.)	Los Angeles
*Hugg, Ernest Branch	Eng.(C.E.)	Huntington Park
Johnson, Donald Hall	Sci.(Ch.E.)	Olive View
Johnson, Josef Jerome	Sci.(Ph.)	Altadena
Jones, Harlen E. R.	Eng.(M.E.)	Fresno
Keeley, James Henry	Eng.(M.E.)	El Monte
Keeling, Harry James	Eng.(M.E.)	Los Angeles
Kibort, Leon	Eng.(Gen.)	Pasadena
*Kingman, Kenneth Edward	Sci.(Ch.E.)	Alhambra
*Kircher, Reymond John	Eng.(E.E.)	El Paso, Texas
*Larrecq, Anthony James	Eng.(M.E.)	Los Angeles
Lau, Kam Hu	Sci.(Ch.E.)	Honolulu, T. H.
Lee, Edson Churchill	Eng.(E.E.)	Potoskey, Michigan
Leonard, Leonid Vladimir	Eng.(M.E.)	San Francisco
Lindhurst, Roland William	Eng.(E.E.)	Los Angeles
Lohman, Kenneth Elmo	Sci.(Ge.)	Pasadena
*Lohman, Stanley William	Sci.(Ge.)	Pasadena
Lufkin, George Schild	Eng.(A.E.)	Los Angeles
Lynn, Laurence Edwin	Eng.(C.E.)	Glendale
*McMillan, Wallace Angus	Sci.(Ch.E.)	Alhambra
McWilliams, Homer Gore	Sci.(Ph.)	Los Angeles
Milliken, Donald Booth	Eng.(C.E.)	Pasadena
Mohr, William Henry	Eng.(C.E.)	Santa Monica
Muff, Elmer Mason	Eng.(M.E.)	Glendale
*Murdoch, Philip Griffis	Sci.(Ch.E.)	Pasadena
*Myers, Albert Edward	Sci.(Ch.E.)	Cucamonga
*Nagashi, Masahiro Howard	Eng.(A.E.)	Beryl, Utah
Niles, Joe Allen	Eng.(A.E.)	Pasadena
Noland, Thomas Jefferson	Eng.(C.E.)	San Diego
O'Haver, Hubert Maurice	Eng.(M.E.)	Los Angeles

NAME	COURSE (OPTION)	HOME ADDRESS
*Olman, Samuel	Eng.(C.E.)	Los Angeles
Olson, Donald Keith	Sci.(Ch.E.)	Alhambra
Perry, Douglas Brill	Sci.(Ch.)	Hollywood
Pierce, Firth	Eng.(A.E.)	Pomona
*Pohl, Wadsworth Egmont	Sci.(Ch.E.)	Redlands
*Raitt, Russell Watson	Sci.(Ph.)	South Pasadena
*Rapp, John Clay	Eng.(E.E.)	Wasco
*Reed, Albert Clark	Eng.(A.E.)	Los Angeles
Reed, Homer Charles	Eng.(A.E.)	Glendale
Reilly, James Thomas	Eng.(C.E.)	Pasadena
Reinen, Otto Frank, Jr.	Sci.(Ch.E.)	Long Beach
Roberts, Bolivar	Eng.(E.E.)	Pasadena
Robinson, True William	Sci.(Ph.)	Altadena
Rofelty, Richard Goebel	Eng.(M.E.)	South Pasadena
*Rummelsburg, Alfred	Sci.(Ch.)	Eagle Rock
Russell, Kenneth Freels	Eng.(M.E.)	Los Angeles
Schumacher, Karl Fritz	Eng.(C.E.)	San Diego
Scott, Leslie Owen	Eng.(M.E.)	Pasadena
Scullin, James Conrad	Eng.(M.E.)	Alhambra
Shields, Clyde Emerson	Eng.(C.E.)	San Diego
Shields, Morton Kingman	Eng.(A.E.)	San Diego
Sinram, Maurice Harold	Eng.(E.E.)	Hollywood
Springsholz, Charles Adolph	Eng.(C.E.)	Santa Barbara
Steward, Willard Palmer	Sci.(Ph.)	Santa Ana
Sutherland, John Clark	Sci.(Ge.)	Pasadena
*Taylor, George Frederic	Sci.(Ge.)	Los Angeles
Terry, Paul M.	Eng.(E.E.)	Montebello
*Thompson, Frank Walden	Eng.(M.E.)	Glendale
Towne, Alfred Edward	Eng.(E.E.)	Kelseyville
Waite, Howard Winfred	Eng.(M.E.)	Burbank
Walton, Arthur Frank	Eng.(A.E.)	Long Beach
Weise, Carl Arthur	Eng.(A.E.)	Tustin
*Weismann, George Francis	Eng.(M.E.)	Alhambra
West, Lloyd Everett	Eng.(E.E.)	Riverside
Westlund, Karl Wilson	Eng.(M.E.)	Yuba City
Wheeler, Fred Aston	Eng.(M.E.)	Hollywood
White, Dudley Lawton	Eng.(A.E.)	Los Gatos
White, Robert James	Sci.(Ch.)	Hollywood
Wilson, Fred Russell	Eng.(E.E.)	Pasadena

JUNIOR CLASS

NAME	COURSE (OPTION)	HOME ADDRESS
Alderman, Frank Edward	Eng.	Santa Ana
Anderson, John Edward	Eng.	Los Angeles
*Arndt, William Frederick	Eng.	Hollywood
Ayers, Wilbur Walter	Eng.	Highgrove
Beam, Jess Alexander	Eng.	Los Angeles
Bechtold, Ira Christian	Sci.(Ge.)	Anaheim
*Bernhardi, Tom George	Sci.(Ch.E.)	Los Angeles
Blohm, Clyde Lehnhard	Sci.(Ch.E.)	Los Angeles
Booth, Eugene Charles	Eng.	Anaheim
Boyle, James Robert Lester	Eng.	Santa Ana
Brasher, Bert Vessie	Sci.(Ch.E.)	Walnut Park
*Bungay, Robert Henry	Eng.	Glendale
Bussey, George Leland	Eng.	Los Angeles
Butler, Albert	Eng.	Santa Barbara
Carberry, Deane Edwin	Eng.	Pasadena
Carlson, Chester Floyd	Sci.(Ph.)	Pasadena
Cary, Henry Howard	Eng.	Los Angeles
Clark, John Drury	Sci.(Ch.)	Fairbanks, Alaska
Clark, Willis Henry, Jr.	Eng.	Los Angeles
Crane, Horace Richard	Sci.(Ph.)	Turlock
*Crawford, Franklin Goodrich	Eng.	Pasadena
*Cromley, Raymond Avalon	Sci.(Ph.)	Long Beach
Deardorff, Herbert Hadley	Eng.	Pasadena
Doherty, Norman Frederick	Sci.(Ch.E.)	Los Angeles
Downs, Roscoe Phillips	Eng.	North Hollywood
Eastman, Harvey Selden	Sci.(Ch.E.)	Pasadena
Effmann, Karl Herman	Eng.	Los Angeles
Elliott, Orrin Mathews	Eng.	San Diego
Ellis, Eugene Vance	Eng.	Okmulgee, Oklahoma
Fink, Kenneth Charles	Sci.(Ph.)	Kingsburg
*Foladare, Joe	Sci.(Ph.)	Los Angeles
Gates, Clinton Eugene	Eng.	Pasadena
*Gaylord, John Wallace	Sci.(Ch.E.)	Pasadena
Giebler, Clyde Edgar	Eng.	Los Angeles
Grant, Edmond Glen	Eng.	Long Beach
*Green, Lowell Forrest	Sci.(Ph.)	Santa Ana
Groch, Fred Reston	Eng.	Pasadena
Hall, John Leland	Eng.	Los Angeles
Hamilton, John Douglas	Sci.(Ch.E.)	Sawtelle

NAME	COURSE (OPTION)	HOME ADDRESS
*Hawes, Roland Cyril	Sci.(Ch.)	Rapid City, South Dakota
Hesse, John Fred, Jr.	Eng.	Las Vegas, Nevada
Hillman, Ernest Christian	Eng.	Los Angeles
Hoch, Winton Christoph	Sci.(Ge.)	Pacific Palisades
*Hodder, Roland Frederick	Sci.(Ge.)	Glendale
Hoeppel, Raymond Winfield	Sci.(Ch.E.)	Arcadia
*Hopper, Rea Earl	Eng.	Riverside
Howse, Samuel Eric	Eng.	West Hollywood
Ignatieff, Alex Ivan	Eng.	Suifenho, Manchuria, China
Imus, Henry Oscar	Sci.(Ch.)	Los Angeles
Janofsky, Jack	Eng.	Los Angeles
*Janssen, Philip Otto	Sci.(Ch.)	Pomona
Kelly, William Francis	Eng.	Santa Monica
Kleinbach, Hugo Otto	Eng.	Glendale
Koehm, Edward	Eng.	Los Angeles
Kuhn, Truman Howard	Sci.(Ge.)	Glendora
Langsner, George	Eng.	Ontario
Leppert, Melvin Lawrence	Eng.	Monrovia
Levine, Ernest	Eng.	Los Angeles
Liedholm, George Edward	Sci.(Ch.E.)	Long Beach
Lockhart, Ross Monroe	Sci.(Ch.E.)	Pasadena
*Lord, Roy Stanley	Eng.	Pasadena
Macdonald, Edwin	Eng.	Pasadena
MacDonald, James Harrington	Eng.	Glendora
Maitland, William Blackstock	Sci.(Ge.)	Glendale
Mason, Harry Shattuck	Eng.	Los Angeles
Mauzy, Harris Kenneth	Eng.	South Pasadena
McLean, Ralph Stewart	Eng.	Brea
McMillan, John Robertson	Eng.	Los Angeles
*Miles, Kenneth Leonard	Eng.	Santa Barbara
Mitchell, Gordon S.	Eng.	Hollywood
Morton, William	Eng.	Portland, Oregon
Moss, Harland Ray	Sci.(Ch.E.)	Hollywood
*Moyers, Frank Neff	Eng.	Highgrove
Murray, John Stalker	Sci.(Ph.)	Pasadena
Musset, Roger Marx	Eng.	Glendale
Myers, Henry Glysson	Eng.	Pasadena
Nelson, Warren Campbell	Sci.(Ch.E.)	Los Angeles
Newcomb, Daniel Albert	Sci.(Ch.E.)	Corona

NAME	COURSE (OPTION)	HOME ADDRESS
Nomann, Arthur Behrend	Eng.	Whittier
*Nye, Lawrence Carlton	Sci.(Ph.)	Los Angeles
Oaks, Robert Martin	Eng.	Pasadena
Overhage, Carl F. J.	Eng.	Duesseldorf, Germany
*Pritchett, Jack Dean	Eng.	Cabazon
*Read, George Wilber	Eng.	Glendale
*Reynard, Willard Grant	Sci.(Ch.E.)	Los Angeles
Reynolds, George Lawrence	Eng.	Glendale
Riggs, William Christopher	Eng.	Dos Cabezos, Arizona
Ross, George Arthur	Eng.	Fillmore
Ruff, Theodore Fred	Eng.	Los Angeles
Russell, Lloyd Wallace	Eng.	Los Angeles
*Sass, Otto	Sci.(Ph.)	Los Angeles
Sawyer, Herbert Goodman	Sci.(Ph.)	Napa
*Scharf, David Walter	Sci.(Ge.)	Los Angeles
*Scott, Frederick Schell	Sci.(Ch.E.)	Pasadena
*Sheffet, David	Eng.	Venice
Shields, John Charles	Eng.	Pasadena
Silverman, Michael Morris	Eng.	Los Angeles
Slick, Wilfred Larsen	Eng.	Long Beach
Smith, Richard Hale	Sci.(Ph.)	South Pasadena
Stein, Myer Samual	Eng.	Los Angeles
*Stipp, Theodore Frank	Eng.	Glendale
Stirton, Robert Ingersoll	Sci.(Ch.)	Los Angeles
*Strong, Austin Webber	Eng.	San Diego
*Stroud, Robert Addis	Eng.	Los Angeles
Sturgess, Jack Bainbridge	Eng.	Glendale
Suzuki, Katsunoshin	Eng.	Kanagawa Ken, Japan
Swift, Frederick Thayer, Jr.	Eng.	Altadena
Thayer, Eugene Merlin	Eng.	Huntington Park
*Todorovitch, Victor Douchan	Sci.(Ph.)	Tokyo, Japan
Towler, John William	Eng.	Santa Barbara
*Trostel, Everett G.	Sci.	Santa Ana
Tucker, Merrill Douglas	Sci.(Ge.)	Alhambra
*Van Beveren, Oscar Franz	Sci.(Ge.)	Hollywood
*West, Samuel Stewart	Sci.(Ph.)	Lankershim
Westphal, Richard Dodd	Eng.	Audubon, New Jersey
*Wheeler, George Richard	Eng.	Richgrove
*Whitman, Nathan Davis	Eng.	South Pasadena

NAME	COURSE (OPTION)	HOME ADDRESS
Widess, Rubin	Eng.	Pasadena
*Wilkinson, Walter Dunbar	Sci.(Ch.)	Santa Barbara
Wilmot, Charles Alfred	Sci.(Ph.)	Santa Monica
Wilson, Robert Warren	Sci.(Ge.)	Los Angeles
Yoshioka, Carl Kaoen	Eng.	Los Angeles
Zipser, Sidney	Eng.	Los Angeles

SOPHOMORE CLASS

NAME	COURSE	HOME ADDRESS
*Alden, Lucas Avery	Sci.	Montrose
*Amann, Jack Huber	Eng.	Pasadena
*Anderson, Maynard Marion	Eng.	San Diego
Atwood, Albert William, Jr.	Sci.	Washington, D. C.
Babcock, William Chapman	Sci.	Long Beach
Barkley, David Wright	Sci.	Los Angeles
Barnett, Richard James	Eng.	Temecula
Bell, Thomas William	Eng.	Whittier
Bennett, Elliott Powell	Eng.	Los Angeles
Biggers, John Carter	Eng.	Alhambra
Bland, Reginald Barrett	Sci.	Pasadena
Bolles, Lawrence William	Sci.	Santa Ana
Boothe, Perry Mattison	Eng.	Los Angeles
Bovee, John Leroy	Eng.	Anaheim
Bowen, George Henry	Sci.	Los Angeles
Brooks, Arthur Clinton	Eng.	Balboa
*Buffum, Charles Emery	Sci.	Long Beach
Butler, Smedley Darlington, Jr.	Eng.	San Diego
Butrovich, George William	Eng.	Fairbanks, Alaska
*Cate, Paul Herman	Sci.	Los Angeles
Chamberlain, Glenn John	Eng.	San Diego
*Coleman, Robert Prewitt	Sci.	Pasadena
Connable, Harry Stanton	Eng.	Hollywood
Cordes, Nelson Myers	Eng.	Los Angeles
*Crawford, Albert Thomas	Sci.	Santa Ana
Crossman, Edward Bishop	Sci.	Brentwood Heights
*Cutts, Francis William	Sci.	Portland, Oregon
*Detweiler, John Struss	Sci.	Los Angeles
Dickey, Walter Linn	Eng.	Los Angeles

NAME	COURSE	HOME ADDRESS
*Dorman, Steven Charles	Sci.	San Bernardino
Drake, Herbert Belding	Sci.	Mill Valley
Eastman, Samuel Clare	Eng.	Pasadena
*Eberz, William Ferdinand	Sci.	Altadena
Falls, Theodore Frank	Sci.	Audubon, New Jersey
Ferguson, Lawrence LaVerne	Eng.	Pasadena
*Fitch, Elliott Bryant	Sci.	Napa
Folsom, Oliver Hazard	Eng.	Los Angeles
Folsom, Theodore Robert	Sci.	San Diego
Ford, Frank Hubert	Eng.	Pasadena
Frick, Lester LaVerne	Eng.	Long Beach
Futcher, Ralph Allan	Eng.	Vancouver, B. C., Canada
*Girard, John Emile	Eng.	Los Angeles
Graff, Donald Badger	Eng.	Pasadena
Grafman, Abraham Jack	Eng.	Hollywood
Green, Edwin Francis	Eng.	Los Angeles
*Gregory, Carter Holt	Sci.	San Marino
*Griffin, Robert Hardy	Eng.	San Diego
Gunderson, Norman Robert	Sci.	Randsburg
Hall, Marvin William	Eng.	Los Angeles
Harker, Joseph Clyde	Eng.	Los Angeles
Harmon, Cliver	Sci.	San Diego
*Hatcher, John Burton	Sci.	Los Angeles
Holzman, Ben	Sci.	Los Angeles
*Horn, Aubrey	Eng.	South Pasadena
Horton, Warren Birch	Eng.	Fargo, North Dakota
Hutchinson, Francis William	Eng.	Crockett
*Ingham, Herbert Smith	Sci.	Los Angeles
*Jacobs, Robert Byron	Sci.	Santa Monica
*Jecker, Duroc Albert	Sci.	South Pasadena
Johnson, Byron Bethune	Eng.	St. Louis, Missouri
Johnston, William Elmore	Eng.	Van Nuys
Jurling, Theodore Waldemar	Eng.	Los Angeles
Keachie, Edward Chester	Eng.	Los Angeles
Kinney, Edward Story	Sci.	San Diego
*Kinsler, Lawrence Edward	Sci.	Los Angeles
*Kircher, Charles Edmund, Jr.	Sci.	El Paso, Texas
Kuykendall, Charles Edwin	Sci.	South Pasadena
Labory, Raymond Frary	Eng.	Los Angeles

NAME	COURSE	HOME ADDRESS
Laird, Francis Neil	Sci.	Alhambra
*Leeper, Laverne	Eng.	San Bernardino
Lehman, Robert Marshall	Eng.	Salt Lake City, Utah
Levine, Alex Herbert	Sci.	Long Beach
Lewis, Charles Kimmel	Eng.	Santa Ana
Lewis, George Edward	Eng.	Pasadena
Love, James Herman	Eng.	Chatsworth
Marshall, David Stearns	Eng.	Palo Alto
Marshall, Marion Chelsey	Eng.	Long Beach
*Matison, Harry	Sci.	Pasadena
McGarry, John Felbert	Eng.	Hermosa Beach
*Mehl, John Wilbur	Sci.	Upland
Merrithew, William Sterling	Eng.	Los Angeles
Miller, Bertram Folger	Eng.	Los Angeles
Montgomery, John Cochran	Sci.	Pasadena
*Morris, Ross Elliott	Sci.	Los Angeles
Murdock, DeWolfe	Eng.	Santa Ana
Myers, Glenn	Eng.	Santa Monica
Newby, Oscar McMullin	Eng.	Corona
*Olmsted, Ennis Gunning	Eng.	Colorado Springs, Colorado
Page, Hollis Bem	Sci.	Sawtelle
Peer, Edward Stephen	Sci.	Long Beach
*Peterson, Raymond Alfred	Sci.	Denver, Colorado
Pickles, Sidney Benson	Sci.	Monterey
Pratt, Leland DeWitt	Sci.	Huntington Park
Randall, John Alden	Eng.	Los Angeles
Rice, George Skidmore	Eng.	Alhambra
*Robinson, Roger Theophilus	Sci.	Pasadena
Roney, William Hamilton	Eng.	Alhambra
Saygol, Charles Clinton	Eng.	Los Angeles
*Sherman, Robert Lansing	Eng.	Portland, Oregon
Shull, George Orval	Sci.	Los Angeles
Smith, Robert Graves	Eng.	Riverside
*Smits, Howard Gardner	Eng.	Glendale
Snyder, Robert Earl	Sci.	Pasadena
*Stipp, Charles Klop	Eng.	Glendale
Strauss, Ferdinand Edward	Eng.	Mosier, Oregon
Tarbet, Thomas Vernon	Eng.	Pasadena
Thomas, William Jacob	Sci.	Los Angeles

Name	Course	Home Address
Tutschulte, Alvin Carl	Eng.	Los Angeles
Uecke, Edward Harry	Eng.	Los Angeles
*Ugrin, Nick Thomas	Eng.	San Diego
Ung, Philip Fay	Eng.	Los Angeles
Van Reed, Mabry	Eng.	San Diego
Voak, Alfred Suter	Eng.	Atascadero
Webb, Glenn Miller	Sci.	Los Angeles
West, William Textor	Sci.	Hollywood
White, Thomas Robert	Sci.	Redlands
Wilking, Arnold Philip	Sci.	Arlington
Williams, Raymond Nelson	Sci.	Los Angeles
Wilson, Roger Montgomery	Sci.	Pasadena
Wright, Eldon Emerson	Sci.	Los Angeles
Zabaro, David	Eng.	Los Angeles

FRESHMAN CLASS

Name	Home Address
Adams, William Avanzino	Long Beach
Anderson, David William	Alhambra
Anderson, Thomas Foxen	Glendale
Arnerich, Paul Frank	Pasadena
Arnold, Emmer Joseph	Los Angeles
Ayers, John Kimball	Los Angeles
Baba, Komao Nobu	Turlock
Barton, Millard Vernon	Hollywood
Bascom, John Dwight	Pasadena
Bates, Dana Barker	Santa Monica
Bayley, Rupert Morris	Pasadena
Behlow, Lewis Bushnell	Alhambra
Belford, James William	Montebello
Bergren, William Raymond	Pasadena
Berry, William Ladew	Burbank
Blossom, Howard Clifford	St. Louis, Missouri
Bowler, Gordon Edson	Pomona
Bowles, Weston Walter	Los Angeles
Bradburn, James Rupert	Los Angeles
Brakesman, Gordon Jay	Los Angeles
Brewer, Robert Thomas	Spokane, Washington

NAME	HOME ADDRESS
Brown, Rupert Arthur	Pasadena
Bruderlin, Henry Hurst	Los Angeles
Burman, Paul Gustav	San Gabriel
Carey, Robert Van Pelt	South Pasadena
Cawley, Clifford Comer	Los Angeles
Chambers, John Voris	Redondo
Clagett, William	Kellogg, Idaho
Claussen, William Hammerich	Pasadena
Cline, Franklin Joseph, Jr.	Covina
Cogen, Sol	Los Angeles
Cox, John Luther	Alhambra
Crater, Myron Lee	Pasadena
Dean, Arthur Malcolm	Chula Vista
Elconin, Victor	Los Angeles
Evans, William Morris	Long Beach
Feely, Martin Gerald	Los Angeles
Foss, Robert Edwin	Rivera
Fox, John Murray	Johannesburg
Freeman, Robert Broman	Pasadena
Frick, William Oliver	Hollywood
Gates, Ellis H.	Long Beach
Gelber, Murray Samuel	Los Angeles
Goodman, Clark	Los Angeles
Gould, Laurence Keeney	Alhambra
Gregory, Jackson	Pasadena
Grieger, John Miller	Pasadena
Griswold, Edward Allen	Alhambra
Groat, William	Whittier
Guiberson, Samuel Allen	Beverly Hills
Hamlin, Charles Frederick	San Luis Obispo
Harsh, Charles Maxfield	Eagle Rock
Harshman, Elbert Nelson	Los Angeles
Hastings, Allen	Pasadena
Hayes, Edward Adams	El Monte
Hegardt, Karl Edward	Downey
Hibbs, Frank John, Jr.	Los Angeles
Hill, James W.	Los Angeles
Huntley, Walter Palmer	Tustin
Iwasaki, Tetsuo Frank	Los Angeles

Name	Home Address
Johnson, Harold Baum	Los Angeles
Jones, Charles Wright	Long Beach
Josenhans, John Frederick	Chicago, Illinois
Kanegae, Masami	Huntington Beach
Keeley, Kedrick Vincent	El Monte
Kent, William Lyon	Covina
Killgore, Cecil Lloyd	Hollywood
Lani, Leslie Vincent	Elko, Nevada
Larsen, Delmar Herman	Sherman
Lemon, George Thomas	Monterey Park
Lind, Karl Frank	Los Angeles
Lipp, James Everett	Los Angeles
Maass, Randel Oscar	Anaheim
Mason, Frank Merrill	Riverside
Mathews, Thomas Edwin	Glendale
McCord, Charles Joseph	Ojai
McKinley, John Daniel	Alhambra
McKinney, John Eby	Colton
McLaughlin, James Patrick	Redondo Beach
Moore, Lewis William	Redlands
Moore, Ross Robert	El Segundo
Morgan, Richard David	Meacham, Oregon
Morse, Barnard Alexander	Altadena
Nicholson, Hunter, Jr.	Los Angeles
Noble, Robert James	San Diego
Oelschlager, Ray Troy	North Hollywood
Oulton, Thomas Dixon	Pasadena
Packer, Walter Hamilton	Philadelphia, Pennsylvania
Parsons, Paul Gates	Hermosa Beach
Paulson, Walter Henderson	Pasadena
Pelzel, Robert E.	Los Angeles
Persson, Sture Henning	Halsingborg, Sweden
Polk, Wendell Robert	Los Angeles
Polley, Allison Brownell	Long Beach
Pownall, Henry Bland	Santa Monica
Prudames, Edwin Mott	Los Angeles
Pruden, Worrell Franzoni	Hollywood
Rhyner, Lewis Albert	Glendora
Roach, Harold	Los Angeles

NAME	HOME ADDRESS
Rossall, Kenneth Brown	Glendale
Rule, Bruce Herbert	Los Angeles
Saylor, William Henry	Covina
Schaafsma, Jan Gerard	Honolulu, T. H.
Schoeller, Charles Philip	Palmdale
Schuhart, Marvin Arno	Pasadena
Schultz, Behrend Carl	Los Angeles
Schultz, Henry William	Pasadena
Schultz, William Francis	Los Angeles
Schultz, William Otto	Los Angeles
Seavey, Walter Kelley	Pasadena
Secord, Grover Marion	Alhambra
Shaul, Donald Robert	Los Angeles
Sheffet, Joseph	Venice
Shockley, William Bradford	Hollywood
Shuler, William Reeves	El Monte
Simpkinson, Arthur Albert	Los Angeles
Skaredoff, Nicolai Nicolaevich	Yokohama, Japan
Skoog, Folke Karl	Alhambra
Smith, Alvin Joseph	Pasadena
Solomon, Hyman	Los Angeles
Stamps, Roy Kauffmann, Jr.	Los Angeles
Telford, Robert Cedric	Los Angeles
Thiele, Carl Leslie	Hollywood
Thomas, Richard Nutley	Riverside
Thornburg, Harold Babcock	Los Angeles
Tickner, Alvin James	Pasadena
Vander Goot, Herbert Albert	Glendora
Van Marter, Claude Harolde	Long Beach
Van Wingen, Nico	Pasadena
Warfel, John Spencer	Los Angeles
Wengren, Frank Erie	Pasadena
Wherritt, Robert Clay	Los Angeles
White, Wayne Bertram	Los Angeles
Willis, Prentice Fay	Pasadena
Wilson, Chester Eugene	North Hollywood
Wilson, William Wayne	Pasadena
Wofford, George	Los Angeles
Wolfe, Halley	Porterville

Name	Home Address
Woods, Robert Austin	Glendale
Zuckerman, Herbert Samuel	Berkeley

SPECIAL STUDENTS

Name	Course	Home Address
Gilbert, John Gustav	Eng.	Long Beach
Houda, Milton	EE.	Los Angeles
Petcoff, Dimitri	Ge.	
Schwieso, Charles M.	English	Pasadena

SUMMARY

Graduate School			
National and International Research Fellows		14	
Research Fellows of the Institute		8	
Graduate Students: Physics		50	
Chemistry and Chemical Engineering		20	
Mathematics		3	
Geology		16	
Biology		3	
Engineering		27	
		141	141
Undergraduate School			
Seniors: Science: Ph. 8; Ch. 2; Ch.E. 12; Ge. 8; Ma. 1	31		
Engineering: Ae. 14; C.E. 21; E.E. 22; M.E. 21; Gen. 1	79	110	
Juniors: Science: Ph. 15; Ch. 5; Ch.E. 15; Ge. 9	44		
Engineering 78; Gen. 1	79	123	
Sophomores: Science	54		
Engineering	67	121	
Freshmen		140	
Special		4	
		498	498
			639

Index