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CATALOGUE NUMBER *for* 1939

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VOLUME 48 NUMBER 1

A COLLEGE, GRADUATE SCHOOL, AND INSTITUTE OF RESEARCH IN SCIENCE, ENGINEERING AND THE HUMANITIES

CATALOGUE NUMBER *for* 1939

PASADENA · CALIFORNIA · JANUARY, 1939

CONTENTS

CALENDAR

1939

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	..
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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
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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	..
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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	..	..
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S	M	T	W	T	F	S
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3	4	5	6	7	8	9
10	11	12	13	14	15	16
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OCTOBER

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1	2	3	4	5	6	7
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NOVEMBER

S	M	T	W	T	F	S
..	..	..	1	2	3	4
5	6	7	8	9	10	11
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DECEMBER

S	M	T	W	T	F	S
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3	4	5	6	7	8	9
10	11	12	13	14	15	16
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24	25	26	27	28	29	30
31	..	..	..	..	..	..

1940

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
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FEBRUARY

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S	M	T	W	T	F	S
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7	8	9	10	11	12	13
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OCTOBER

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DECEMBER

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22	23	24	25	26	27	28
29	30	31	..	..	..	..
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CALENDAR

1939

JANUARY 3 ..... Registration (9 A.M. to 3 P. M.)
JANUARY 14 ..... Examinations for Removal of Conditions
MARCH 1 ..... Last Day for Application for Fellowships and Assistantships
MARCH 13-18 ..... Term Examinations
MARCH 18 ..... Notifications of Awards of Fellowships and Assistantships
MARCH 18 ..... End of Second Term (12 M.)
MARCH 19-26 ..... Recess
MARCH 24 ..... Meeting of Freshman Registration Committee
MARCH 25 ..... Meeting of Registration Committee
MARCH 25 and APRIL 1 ..... Examinations for Admission to Freshman Class and for Freshman Scholarships (see page 76)
MARCH 27 ..... Registration (9 A. M. to 3 P. M.)
APRIL 8 ..... Examinations for Removal of Conditions
APRIL 15 ..... List of Approved Candidates for Bachelor of Science Degree Posted
MAY 25 ..... Last Day for Examinations and Presenting Theses for the Degree of Doctor of Philosophy
MAY 30 ..... Memorial Day Recess
JUNE 3 ..... End of Examinations for Candidates for the Degrees of Bachelor of Science and Master of Science
JUNE 5-10 ..... Term Examinations for All Undergraduates Except Seniors
JUNE 6 ..... Meetings of Committees on Course in Engineering and Course in Science (10 A. M.)
JUNE 7 ..... Faculty Meeting (10 A. M.)
JUNE 8 ..... Class Day
JUNE 9 ..... Commencement
JUNE 9 ..... Annual Meeting of Alumni Association
JUNE 3, 9, 10 ..... Examinations for Admission to Upper Classes
JUNE 10 .. Entrance Examinations in Chemistry and English for High School Juniors
JUNE 10 ..... End of College Year (12 M.)
JUNE 19 ..... Meeting of Freshman Registration Committee
JUNE 20 ..... Meeting of Registration Committee
SEPTEMBER 15 and 16 ..... Examinations for Admission to Upper Classes
SEPTEMBER 15 ..... Examinations for Removal of Conditions
SEPTEMBER 19 ..... Registration of Freshmen (1:30 P. M.)
SEPTEMBER 21-22 ..... Registration of Students Transferring From Other Colleges (9 A. M. to 3 P. M.)
SEPTEMBER 22 ..... General Registration (9 A. M. to 3 P. M.)
SEPTEMBER 25 ..... Beginning of Instruction
NOVEMBER 18 ..... Last Day for Announcing Candidacy for Bachelor's Degree
NOVEMBER 30-DECEMBER 4 ..... Thanksgiving Recess
DECEMBER 11-16 ..... Term Examinations
DECEMBER 16 ..... Last Day for Applications for Candidacy for the Degree of Doctor of Philosophy in June, 1940
DECEMBER 16 ..... End of First Term (12 M.)
DECEMBER 22 ..... Meeting of Freshman Registration Committee
DECEMBER 28 ..... Meeting of Registration Committee
JANUARY 2, 1940 ..... Registration (9 A. M. to 3 P. M.)

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(Arranged in the order of seniority of service)

		Term Expires
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Professor of Physics
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. 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 Swedish Royal Academy of Science, 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 Italiana della Scienze, 1925; of the Gold Medal of the American Society of Mechanical Engineers, 1926; of the Messel Medal of the Society of Chemical Industry of England, 1928; of the Gold Medal of the Society of Arts and Sciences, 1929; of the Gold Medal of the Radiological Society of North America, 1930; Gold Medal of the Holland Society, 1930; and of the Gold Medal of Honor, Roosevelt Memorial Foundation, 1932; Member, Pontificia Accademia delle Scienze, 1936; Commandeur de l'Ordre National de la Légion d' Honneur, 1936. California Institute, 1916-

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Chairman of the Observatory Council
Member of the Executive Council

B.L., University of Wisconsin, 1898; Ph.D., University of Göttingen, 1903. Instructor in Mathematics, Massachusetts Institute of Technology, 1903-1904; Assistant Professor of Mathematics, Yale University, 1904-1908; Associate Professor of Mathematics, University of Wisconsin, 1908; Professor of Mathematical Physics, 1910-1925; President, University of Chicago, 1925-1928; President of the Rockefeller Foundation, 1928-1936. LL.D., University of Wisconsin, 1926; Yale University, 1926; Dartmouth College, 1927; Pomona College, 1937; Sc.D. (hon.), Columbia University, 1926. Colloquium Lecturer, American Mathematical Society, 1906; Visiting Lecturer, Mathematical Physics, Harvard University, 1911-1912; Member of Research Staff, Naval Experiment Station, New London, Connecticut, 1917-1919. Member, National Academy of Sciences. California Institute, 1936-

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Professor of Biology
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B.S., University 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., Johns Hopkins University, 1915; University of Kentucky, 1916; McGill University, 1921; University of Edinburgh, 1922; University of California, 1930; Sc.D. (hon.), University of Michigan, 1924; Docteur Honoris Causa, University of Paris, 1935; Ph.D. (Dr. of Nat. Phil.), Heidelberg University, 1931. M.D. (hon.), University of Zurich, 1933. Fellow of the American Association for the Advancement of Science (President, 1930); Member, American Philosophical Society; President, National Academy of Sciences, 1927-1931; Member, Linnean Society of London; Royal Society of Sciences of Denmark; Foreign Member, Royal Society of London; Finnish Society of Sciences; Associate Member, Société Royale des Sciences Médicales et Naturelles de Bruxelles; Society Belge de Biologie, Bruxelles; Société de Biologie de France; Corresponding Member, Zoological Society of London; Académie des Sciences de Russie; Bavarian Academy of Sciences; Honorary Member, Royal Irish Academy, Ordinary Member, Royal Society of Sciences of Upsala; Foreign Associate, Royal Accademia Nazionale dei Lincei, Rome; Correspondent, Académie des Sciences, Institut de France; Member, Academia Scientiarium Instituti, Bononiensis (Bologna); Member, Pontificia Accademia delle Scienze, 1936; Honorary Foreign Member, Académie Royale de Medicine de Belgique, 1936; Corresponding Member, Accademia di Scienze Lettere et Arti, Padova, 1937; Foreign Associate, Académie des Sciences de l'Institut de France, 1938. Recipient of the Nobel Prize in Medicine of the Swedish Royal Academy of Science, 1933. California Institute, 1928-

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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; Litt.D., University of Southern California, 1930; LL.D., Mills College, 1931; 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, 1925-1930; Chairman of the Division of History, Economics and Government, Harvard University, 1920-1928; Weil Foundation Lecturer, University of North Carolina, 1921; McBride Foundation Lecturer, Western Reserve University, 1925; Jacob H. Schiff Foundation Lecturer, Cornell University, 1926; Marfleet Lecturer, University of Toronto, 1929; Acting Director, Harvard Graduate School of Public Administration, 1936-1937; President of the American Association of University Professors, 1930-1931; President of the American Political Science Association, 1927; Vice-President and Chairman of the Section on Historical and Philological Sciences, American Association for the Advancement of Science, 1931. Fellow of the American Academy of Arts and Sciences. California Institute, 1925-

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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-

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B.A., Cambridge University, 1903; Smith Prize, 1905; Fellowship, Trinity College, Cambridge, 1905-1911; 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, 1917. Member, American Philosophical Society, National Academy of Sciences. California Institute, 1917-

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Ph.D., University of Liége, 1924; member of the Belgian Biological Expedition in Brazil, 1923; Assistant in Botany, University of Liége, 1925; National Research Fellow, Geneva, 1925, and College de France, Paris, 1926; Advanced Fellow of the C.R.B. Foundation, Philadelphia, 1927; Professor of Botany, Director of the Botanic Institute and Garden, University of Liége, 1927; Co-director of the Hautes-Fages Experiment Station in the Ardennes, 1927; Treub Laboratorium of the Botanic Garden, Buitenzorg, Java, 1931-1932. Comite Directeur de l'Institut des Parcs Nationaux du Congo Belge, 1933; Commission de l'Institut National pour l'Étude Agronomique du Congo Belge, 1935; Commission Botanique du Fonds de la Recherche Scientifique en Belgique; Advanced Fellow of the C.R.B. Foundation, Pasadena, 1938.

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B.S., University of Toronto, 1919; M.S., University of Illinois, 1921; D.Sc., Harvard University, 1923. National Research Council Fellow in Biology, Berlin and Birmingham, 1925-1926; Professor of Genetics, University of Wisconsin. California Institute, 1938.

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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-

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W. Howard Clapp, E.M.

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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. Chairman, Los Angeles Section, American Society of Mechanical Engineers, 1937-1938; Alternate, American Engineering Council, 1937-1938; member, Executive Committee, Los Angeles Engineering Council, 1938-1939. Instructor, California Institute, 1911-1913; Assistant Professor, 1913-1914; Associate Professor, 1914-1918; Professor, 1918-

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Robert L. Daugherty, M.E.

Professor of Mechanical and Hydraulic Engineering

A.B. in Mechanical Engineering, Stanford University, 1909; M.E., 1914. Assistant in Mechanics, Stanford 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, 1928-1930. Vice-Chairman and Chairman, Board of Directors, City of Pasadena, 1927-1931. California Institute, 1919-

373 South Euclid Avenue

Roscoe Gilkey Dickinson, Ph.D.

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. Instructor, California Institute, 1917-1920; National Research Fellow, 1920-1923; Research Associate, 1923-1926; Assistant Professor, 1926-1928; Associate Professor, 1928-1938; Professor, 1938-

530 Bonita Avenue

Theodosius Dobzhansky

Professor of Genetics

Diploma, University of Kiev, 1921. Assistant in Zoology, Polytechnic Institute of Kiev, 1921-1924. Lecturer in Genetics, University of Leningrad, 1924-1927. Research Fellow, Bureau of Genetics, Russian Academy of Sciences, 1925-1927. Research Fellow in Biology of the International Education Board, Columbia University, 1927-1928; California Institute, 1928-1929; Assistant Professor, 1929-1936; Professor, 1936-

360 South Wilson 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; Privatdocent, Moscow University, 1909-1913; Privatdocent, University of Zurich, 1919-1922; Exchange Professor, Aachen Inst. Tech., 1927 and 1929. Member National Academy of Sciences. California Institute, 1921-

1484 Oakdale Street

Beno Gutenberg, Ph.D.

Professor of Geophysics

Technische Hochschule, Darmstadt, 1907; Universität Göttingen, 1908; Ph.D., 1911. Assistant, Zentral Büro der Internationalen Seismologischen Vereinigung, Strassburg, 1913-1914; Reichszentrale fuer Erdbebenforschung, Strassburg, 1914-1919; Privatdozent fuer Geophysik, Universität Frankfurt A/M, 1924-1926; A. O. Professor, 1926-1930. California Institute, 1930-

399 Ninita Parkway

HERMAN ELIOT HAYWARD, PH.D.

Visiting Professor of Botany

A.B., University of Minnesota, 1916; M.S., University of Chicago, 1925; Ph.D., 1928. Instructor, State Teachers College, River Falls, Wisconsin, 1919-1926; University of Chicago, 1926-1927; Assistant Professor, 1927-1928; Associate Professor, 1928-1930; Professor, 1930-

258 South Hudson Avenue

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

Professor of Mechanics
Dean of Upper Classmen

Graduate of the United States Military Academy, 1902; A.B., Columbia University, as of 1902; B.S., United States Military Academy, as of 1902; M.A. (hon.), Occidental College, 1926. Assistant Professor, Professor of Applied Mechanics, University of Rochester, 1910-1919. Assistant Professor, California Institute, 1920-1923; Professor and Dean, 1923-

1071 North Garfield Avenue

WILLIAM VERMILLION HOUSTON, PH.D.

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. National Research Fellow, California Institute, 1925-1927; Assistant Professor, 1927-1929; Associate Professor, 1929-1931; Professor, 1931-

3207 Lombardy Road

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

THEODORE VON KÁRMÁN, PH.D., DR. ING., SC.D.

Professor of Aeronautics
Director of the Daniel Guggenheim Laboratory

M.E., Budapest, 1902; Ph.D., Göttingen, 1908. Doctor of Engineering (hon.), University of Berlin, 1929; Doctor of Science (hon.), University of Brussels, 1937. Privatdocent, Göttingen, 1910-1913; Professor of Mechanics and Aerodynamics, Director of the Aerodynamical Institute, University of Aachen, 1913-1934; Honorary Adviser of the Aeronautical Department of Tsing Hua University (China), 1933-. Member of Gesellschaft der Wissenschaften zu Göttingen, 1925; foreign member of the Royal Academy of Sciences, Torino, 1928; Honorary Fellow, Institute of Aeronautical Sciences, 1936; Member of National Academy of Sciences, 1938. Rouse-Ball Lecturer at the University of Cambridge, 1937; C.R.B. Lecturer in Belgium, 1937; Wilbur Wright Lecturer of the Royal Aeronautical Soc., 1937. California Institute, 1928-

1501 South Marengo Avenue

WILLIAM NOBLE LACEY, PH.D.

Professor of Chemical Engineering

A.B. in Chemical Engineering, 1911, and Chemical Engineer, 1912, Stanford University; M.S., 1913; Ph.D., University of California, 1915. Assistant in Chemistry, Stanford 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. Instructor, California Institute, 1916-1917; Assistant Professor, 1917-1919; Associate Professor, 1919-1931; Professor, 1931-

2136 Minoru Drive, Altadena

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-

1642 Pleasant Way

CHARLES CHRISTIAN LAURITSEN, PH.D.

Professor of Physics

Odense Tekniske Skole, 1911; Ph.D., California Institute of Technology, 1929. Assistant in Physics, California Institute, 1927-1930; Assistant Professor, 1930-1931; Associate Professor, 1931-1935; Professor, 1935-

1444 Blanche Street

JOHN ROBERTSON MACARTHUR, PH.D.

Professor of Languages

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. Associate Professor, California Institute, 1920-1923; Dean of Freshmen, 1923-1937; Professor of Languages, 1923-

866 South Pasadena Avenue

ROMEO RAOUL MARTEL, S.B.

Professor of Structural 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, and at the World Engineering Congress at Tokyo in 1929. Instructor, California Institute, 1918-1920; Assistant Professor, 1920-1921; Associate Professor, 1921-1930; Professor, 1930-

809 Fairfield Circle

ARISTOTLE D. MICHAL, PH.D.

Professor of Mathematics

A.B., Clark University, 1920; A.M., 1921; Ph.D., Rice Institute, 1924. Teaching Fellow in Mathematics, Rice Institute, 1921-1924; Instructor in Mathematics, Summer Quarter, University of Texas, 1924; Instructor in Mathematics, Rice Institute, 1924-1925; National Research Fellow in Mathematics, 1925-1927; Assistant Professor of Mathematics, Ohio State University, 1927-1929. Associate Professor of Mathematics, California Institute, 1929-1938; Professor, 1938-

2002 Oakdale Street

SEELEY G. MUDD, M.D.

Professor of X-Ray Therapy
Director of Radiological Research

B.S., Columbia University, 1917; M.D., Harvard University, 1924. Research Associate in Radiation, California Institute, 1931-1935; Professor, 1935-

1550 Oak Grove Avenue

J. Robert Oppenheimer, Ph.D.

Professor of Theoretical Physics

B.A., Harvard University, 1925; Ph.D., University of Göttingen, 1927. Associate Professor of Physics, University of California, 1930-1936; Professor, 1936-. Assistant Professor, California Institute of Technology, 1928-1934; Associate Professor, 1934-1937; Professor, 1937-. California Institute, 1928-.

Athenæum

Linus Pauling, Ph.D., Sc.D.

Professor of Chemistry
Director of the Gates and Crellin Laboratories of Chemistry

B.S., Oregon State College, 1922; Ph.D., California Institute of Technology, 1925. Sc.D. (hon.), Oregon State College, 1933. National Research Fellow in Chemistry, 1925-1926. Fellow of the John Simon Guggenheim Memorial Foundation, 1926-1927. Lecturer in Physics and Chemistry, University of California, 1928-1933; Massachusetts Institute of Technology, 1932; George Fisher Baker Lecturer, Cornell University, 1937-1938. Langmuir Prize of the American Chemical Society, 1931. Member of National Academy of Sciences and American Philosophical Society. Assistant in Chemistry, California Institute, 1922-1923; Teaching Fellow, 1923-1925; Research Fellow, 1926-1927; Assistant Professor, 1927-1929; Associate Professor, 1929-1931; Professor, 1931-

1245 Arden Road

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

Professor of Ethics

A.B., University of Minnesota, 1891; A.M., 1892; Ph.D., University of Chicago, 1894; D.B., 1897; D.D., Knox College, 1901; D.D., Meadville Theological School, 1938. Professor of Homiletics, University of Chicago, 1906-1908; Professor of Religious Education and Head of the Department of Practical Theology, 1908-1930. President, Religious Education Association, 1921-1924. California Institute, 1927-

1542 Morada Place, Altadena

Royal Wasson Sorensen, E.E., D.Sc.

Professor of Electrical Engineering

B.S., in Electrical Engineering, University of Colorado, 1905; E.E., 1928; D.Sc. (hon.), 1938. 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, 1917-1929, 1930-1932. Consulting Engineer, Circuit Breaker Research Department, General Electric Company, 1929-1930. Member, Board of Consulting Engineers, Metropolitan Water District of Southern California, 1931-. Vice-President, American Institute of Electrical Engineers, 1933-1935, and member of Board of Directors, 1936-. Associate Professor, California Institute, 1910-1911; Professor, 1911-

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. Curator of Vertebrate Paleontology, Los Angeles Museum. California Institute, 1926-

1633 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. Visiting Carnegie Professor, Birmingham, 1932; Leeds and Durham, 1933. Member of National Academy of Sciences, American Philosophical Society, American Society of Naturalists. California Institute, 1928-

1244 Arden Road

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; Member and Vice-Chairman, Board of Directors, Metropolitan Water District, 1928-; Director, American Society of Civil Engineers, 1930-1933. Associate Professor, California Institute, 1913-1914; Professor, 1914-

685 South El Molino Avenue

HARRY CLARK VAN BUSKIRK, PH.B.

Professor of Mathematics

Ph.B., Cornell University, 1897. Associate Professor, California Institute, 1904-1915; Registrar, 1915-1935; Professor, 1915-

390 South Holliston Avenue

EARNEST CHARLES WATSON, PH.B.

Professor of Physics

Ph.B., Lafayette College, 1914; Assistant in Physics, University of Chicago, 1914-1917. Assistant Professor, California Institute, 1919-1920; Associate Professor, 1920-1930; Professor, 1930-

1124 Mar Vista Avenue

FRITS WARMOLT WENT, PH.D.

Professor of Plant Physiology

A.B., Utrecht, 1922; A.M., 1925; Ph.D., 1927. Assistant in Botanical Laboratory, 1924-1927; Assistant, Lands Plantentuin, Buitenzorg, Java, 1927-1930; Director, Foreigners' Laboratory, Java, 1930-1932. Corresponding Member, Koninklijke Akademie van Wetenschappen te Amsterdam. Assistant Professor, California Institute, 1932-1935; Professor, 1935-

200 South Catalina Avenue

DINSMORE ALTER, PH.D.

Research Associate in Statistics

B.S., Westminster College (Pa.), 1909; M.S., University of Pittsburgh, 1910; Ph.D., University of California, 1916. Instructor in Physics and Astronomy, University of Alabama, 1911-1912; Assistant Professor, 1912-1913, Adjunct Professor, 1913-1914; Instructor in Astronomy, University of California, 1914-1917; Assistant Professor of Astronomy, University of Kansas, 1917-1919, Associate Professor, 1919-1924; Professor, 1924-1936. Director, Griffith Observatory, Los Angeles, 1935-. Fellow of the John Simon Guggenheim Memorial Foundation, 1929-1930. Fellow of the Royal Astronomical Society. California Institute, 1935-

Griffith Observatory, Los Angeles

JOHN AUGUST ANDERSON, PH.D.

Research Associate in Astrophysics†
Executive Officer of the Observatory Council

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-

994 Poppy Street, Altadena

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†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.

SAMUEL JACKSON BARNETT, PH.D.

Research Associate in Physics

A.B., University of Denver, 1894; Graduate in the School of Astronomy, University of Virginia, 1896; Ph.D., Cornell University, 1898. Instructor in Physics and Biology, University of Denver, 1894-1895; Assistant in Astronomical Observatory, University of Virginia, 1895-1896; University Scholar and President White Fellow, Cornell University, 1896-1898; Instructor in Physics and later Professor of Physics, Colorado College, 1898-1900; Assistant Professor of Physics, Stanford University, 1900-1905; Professor of Physics, Tulane University of Louisiana, 1905-1911; Assistant Professor of Physics, 1911-1912, and Professor of Physics, 1912-1918, Ohio State University; Physicist, Carnegie Institution of Washington, 1918-1926 (Department of Terrestrial Magnetism, 1918-1923; Research Associate, 1924-1926); Professor of Physics, University of California at Los Angeles, 1926-. Recipient of Comstock Prize, National Academy of Sciences, 1918; Fellow of the American Academy of Arts and Sciences. California Institute, 1924-

939 Thayer Avenue, Westwood Hills, Los Angeles

EDWIN R. BUCHMAN, DR. PHIL. NAT.

Research Associate in Organic Chemistry

Ch.E., Rensselaer Polytechnic Institute, 1922; S.M., Massachusetts Institute of Technology, 1925; Dr. Phil. Nat., University of Frankfurt, 1933. Columbia University, 1933-1935; Johns Hopkins University, 1936-1937; Research Fellow, California Institute, 1937-1938; Research Associate, 1938-

Athenæum

GODFREY DAVIES, M.A.

Associate in History

B.A., Honour School of Modern History, Oxford University, 1914; Secretary to C. H. Firth, then Regius Professor of Modern History, Oxford University, 1914-1916; Tutor in the School of Modern History, 1919-1924; Assistant Professor of History, University of Chicago, 1925-1930. Visiting Scholar of the Huntington Library, 1930-1931; Member of Research Staff, 1931-. California Institute, 1930-

395 South Bonnie Avenue

EDWARD MEAD EARLE, PH.D.

Associate in History

B.S., Columbia University, 1917; M.A., 1918; Ph.D., 1923. Lecturer in History, Columbia University, 1920-1923; Assistant Professor, 1923-1926; Associate Professor, 1926-; Professor, School of Economics and Politics, Institute for Advanced Study, Princeton, N. J., 1934-. Huntington Library Fellow, 1939. California Institute, 1939.

Athenæum

EDWIN FRANCIS GAY, PH.D., LL.D., LITT.D.

Associate in Economic History

A.B., University of Michigan, 1890; Ph.D., University of Berlin, 1902. Instructor, Assistant Professor, and Professor of Economics, Harvard University, 1902-1919; Dean of Graduate School of Business Administration, 1908-1919; Professor of Economic History, 1924-1936. LL.D., Harvard University, 1918; University of Michigan, 1920; Northwestern University, 1927; Tulane University, 1935. Litt.D., Manchester University, England, 1933. Member of Research Staff, Huntington Library, 1936-. California Institute, 1936-

2040 San Pasqual Street

JOSEPH BLAKE KOEPFLI, D.PHIL.

Research Associate in Chemistry

A.B., Leland Stanford Junior University, 1924; M.A., 1925; D. Phil., Oxford University, 1928. Research Fellow in Organic Chemistry, California Institute, 1928-1929. Instructor in Pharmacology, Johns Hopkins University School of Medicine, 1929-1931. California Institute, 1932-

955 Avondale Road, San Marino

CLYDE STANLEY MCDOWELL, Captain U. S. N., Retired

Supervising Engineer for the 200-inch Telescope

Graduate U. S. Naval Academy, 1904; promoted Commander, 1918; Captain, 1926. Sc.D. (hon.), University of Wisconsin, 1921. In charge of Physical and Electrical Laboratories, New York Navy Yard, 1912-1915; Staff of the Commander, U. S. Submarine Forces, 1915-1918; member and Executive Secretary, U. S. Anti-Submarine Board, 1917-1918; command Naval Experiment Station, New London, Connecticut, 1917-1918; Staff of the Commander, U. S. Naval Forces in European waters. 1918-1919; Naval Inspector of Machinery and Inspector of Ordnance, General Electric Company, Schenectady, 1919-1921; Vice-President, American Institute of Electrical Engineers, 1920-1921; New Construction Superintendent, New York Navy Yard, 1921-1922; Staff of the Commander, Base Forces, U. S. Fleet, 1922-1924; Chief Engineer, Mare Island Navy Yard, 1924-1927; Manager, Navy Yard, Pearl Harbor, T. H., 1929-1930; Inspector of Naval Material, San Francisco, 1930-1932; Inspector of Machinery, Westinghouse Electric and Manufacturing Company, 1932-1934; Inspector of Machinery, New York Shipbuilding Corporation, Camden, N. J., 1933-1934. Awarded Navy Cross for war work. California Institute, 1934-

745 South Oak Knoll Avenue

CHARLES BOWIE MILLICAN, PH.D.

Associate in English Literature

A.B., Emory University, 1922; A.M., University of North Carolina, 1923, Harvard University, 1927; Ph.D., Harvard University, 1930; Assistant in English, Emory University, spring of 1922; Fellow in English, University of North Carolina, 1922-1923; Instructor, 1923-1924; Instructor in English, Indiana University, 1924-1926, on leave, 1926-1930; Rumrill Scholar, Harvard University, 1926-1927, Shattuck Scholar, 1927-1928, Dexter Traveling Scholar, summer of 1928, Thayer Fellow, 1928-1929, Sheldon Traveling Fellow, 1929-1930; Assistant Professor of English, New York University, 1930-1933, Associate Professor, 1933-; Research Fellow, Huntington Library, 1938-1939. California Institute, 1939.

1833 North Allen Avenue, Altadena

ROBERT THOMAS MOORE, A.M.

Associate in Vertebrate Zoology

A.B., University of Pennsylvania, 1903; A.M., Harvard University, 1904; University of Munich, 1904-1905. Fellow of the Royal Geographical Society (London), American Geographical Society; Council of American Ornithological Union. California Institute, 1929-

Meadow Grove Place, Flintridge

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-

615 South Mentor Avenue

EDWARD A. WHITNEY, M.A.

Associate in English and History

A.B., Harvard College, 1917; M.A., Harvard University, 1922; Instructor, Assistant Professor and Associate Professor of History and Literature in Harvard University, 1920-; Master of Kirkland House, Harvard University, 1931-1935. Research Fellow, Huntington Library, 1938-1939. California Institute, 1939.

620 South Mentor Avenue

HARRY OSCAR WOOD, A.M.

Research Associate in Seismology

A.B., Harvard University, 1902; A.M., 1904. Instructor in Mineralogy and Geology, University of California, 1904-1912; Research Associate in Seismology, Hawaiian Volcano Observatory of the Massachusetts Institute of Technology, 1912-1917; Research Associate in Seismology, Carnegie Institution of Washington, 1921-. California Institute, 1928-

220 North San Rafael Avenue

LOUIS BOOKER WRIGHT, PH.D.

Associate in English Literature

A.B., Wofford College, 1920; M.A., University of North Carolina, 1924; Ph.D., 1926. Instructor in English, University of North Carolina, 1925-1927; Johnston Research Scholar, Johns Hopkins University, 1927-1928; Fellow of the John Simon Guggenheim Memorial Foundation, 1928-1929; Visiting Professor, Emory University, winter quarter, 1929; Assistant Professor of English, University of North Carolina, 1929-1930; Associate Professor, 1930-1932. Visiting Scholar of the Huntington Library, 1931-1932; Member of the Research Staff, 1932-. California Institute, 1931-

580 South Berkeley Avenue

ARCHIBALD B. YOUNG, A.B., B.L.

Lecturer in Business Law

A.B., Central University, 1904; B.L., University of Louisville, 1907. California Institute, 1937-

808 South San Rafael Avenue

CARL DAVID ANDERSON, PH.D., SC.D., Nobel Laureate

Associate Professor of Physics

B.S., California Institute of Technology, 1927; Ph.D., 1930. Sc.D. (hon.), Colgate University, 1937. Recipient of the gold medal of the American Institute of the City of New York, 1935; of the Nobel Prize in Physics of the Swedish Royal Academy of Science, 1936; of the Elliott Cresson Medal of the Franklin Institute, 1937. Member of National Academy of Sciences and American Philosophical Society. Assistant and Teaching Fellow in Physics, California Institute, 1927-1930; Research Fellow, 1930-1933; Assistant Professor, 1933-1937; Associate Professor, 1937-

280 South Michigan 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-

831 Sunset Boulevard, Arcadia

RICHARD MCLEAN BADGER, PH.D.

Associate Professor of Chemistry

B.S., California Institute of Technology, 1921; Ph.D., 1924. International Research Fellow in Chemistry, 1928-1929. Assistant in Chemistry, California Institute, 1921-1922; Teaching Fellow, 1922-1924; Research Fellow, 1924-1928; Assistant Professor, 1929-1938; Associate Professor, 1938-

215 Highland Place, Monrovia

HUGO BENIOFF, PH.D.

Associate Professor of Seismology

B.A., Pomona College, 1921; Ph.D., California Institute of Technology, 1935. Assistant, Mount Wilson Observatory, summers, 1917-1921; Assistant, Lick Observatory, 1923-1924; Research Assistant in Seismology, Carnegie Institution of Washington, 1924-1937. Assistant Professor, California Institute, 1937; Associate Professor, 1937-

4327 Chevy Chase Drive, La Canada

IAN CAMPBELL, PH.D.

Associate Professor of Petrology

B.A., University of Oregon, 1922; M.A., 1924; Ph.D., Harvard University, 1931. Assistant Professor of Geology, Louisiana State University, 1925-1928; Instructor in Mineralogy and Petrology, Harvard University, 1928-1931; Geologist, Wisconsin Geological Survey, 1924; Petrologist, Vacuum Oil Company, 1926-1927; Petrologist, Panama Corporation, 1927-1928; Junior Geologist, United States Geological Survey, 1929-. Assistant Professor, California Institute, 1931-1934; Associate Professor, 1934-. Research Associate, Carnegie Institution of Washington, 1935-

405 South Bonnie Avenue

JESSE WILLIAM MONROE DUMOND, PH.D.

Associate Professor of Physics

B.S., California Institute of Technology, 1916; M.S. in E.E., Union College, 1918; Ph.D., California Institute, 1929. Teaching Fellow, California Institute, 1921-1925; Research Fellow, 1925-1931; Acting Associate Professor of Physics, Stanford University, 1931. Research Associate, California Institute, 1931-1938; Associate Professor, 1938-

1585 Homewood Drive, Altadena

HARVEY EAGLESON, PH.D.

Associate Professor of English Language and Literature
Resident Associate in Blacker House

B.A., Reed College, 1920; M.A., Stanford University, 1922; Ph.D., Princeton University, 1928. Instructor in English, University of Texas, 1922-1926. Assistant Professor, California Institute, 1928-1938; Associate Professor, 1938-

Blacker House

STERLING EMERSON, PH.D.

Associate 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. Assistant Professor, California Institute, 1928-1937; Associate Professor, 1937-. California Institute, 1928-

391 South Wilson Avenue

PHILIP SHEARER FOGG, M.B.A.

Associate Professor of Business Economics
Registrar

A.B., Stanford University, 1925; M.B.A., Harvard University, 1929. Instructor, American Institute of Banking, 1932-1938; Instructor in Economics, California Graduate School of Design, 1937-; Assistant Professor of Business Economics, California Institute, 1930-1938; Associate Professor, 1938-

1273 San Pasqual Street

HORACE NATHANIEL GILBERT, M.B.A.

Associate Professor of Business Economics

A.B., University of Washington, 1923; M.B.A., Harvard University, 1926. Instructor in Business Policy, Harvard University, 1926-1928; Instructor in Business Economics, 1928-1929. Assistant Professor, California Institute, 1929-1930; Associate Professor, 1930-

385 South Bonnie Avenue

ALEXANDER GOETZ, PH.D.

Associate Professor of Physics

Ph.D., University of Göttingen, 1921; Habilitation, 1923. Assistant Professor of Physics, University of Göttingen, 1923-1927; a.o. Professor, 1929-. Fellow in Physics of the International Education Board, 1927-1928. Visiting Professor, Imperial Universities of Japan and University of Tsin-Hua, China, 1930. Research Fellow of International Education Board, California Institute, 1927-1928; Research Fellow, 1928-1929; Associate Professor, 1929-

2400 N. Holliston Avenue

ARIE JAN HAAGEN-SMIT, PH.D.

Associate Professor of Biology

A.B., Utrecht, 1922; A.M., 1926; Ph.D., 1929. Head Assistant, Department of Organic Chemistry, Utrecht, 1929-1934; Lecturer in Organic Chemistry, Utrecht, 1934-1936; Lecturer in Biological Chemistry, Harvard University, 1936-1937; Associate Professor, California Institute, 1937-

503 South Hudson Avenue

WILLIAM HUSE, M.A.

Associate Professor of English Language and Literature
Editor of Institute Publications

A.B., Stanford University, 1921; M.A., Princeton University, 1928. Instructor in English, Washington University, 1921-1923; Instructor in English, Princeton University, 1923-1924; Assistant Professor of English, University of Kansas, 1927-1929. Assistant Professor, California Institute, 1929-1938; Associate Professor, 1938-

3676 Yorkshire Road

ARTHUR LOUIS KLEIN, PH.D.

Associate Professor of Aeronautics

B.S., California Institute of Technology, 1921; M.S., 1924; Ph.D., 1925. Teaching Fellow in Physics, California Institute, 1921-1925; Research Fellow in Physics and in Aeronautics, 1927-1929; Assistant Professor, 1929-1934; Associate Professor, 1934-

2771 Glendower Avenue, Los Angeles

ROBERT TALBOT KNAPP, PH.D.

Associate Professor of Hydraulic Engineering

B.S., Massachusetts Institute of Technology, 1920; Ph.D., California Institute of Technology, 1929. Designer with C. M. Gay & Son, Refrigerating Engineers, 1920-1921; Consulting Engineer, Riverside Cement Company, 1927-1929; American Society of Mechanical Engineers Freeman Scholar in Europe, 1929-1930. Consultant, Metropolitan Water District of Southern California, 1934-1936; Collaborator, Soil Conservation Service, U. S. Department of Agriculture, 1935-1936; Cooperative Agent and Hydraulic Engineer, Soil Conservation Service, 1936-. Instructor, California Institute, 1922-1930; Assistant Professor, 1930-1936; Associate Professor, 1936-

549 East California Street

IRVING PARKHURST KRICK, PH.D.

Associate Professor of Meteorology

A.B., University of California, 1928; M.S., California Institute of Technology, 1933; Ph.D., 1934. Teaching Fellow, California Institute, 1932-1933; Instructor, 1933-1935; Assistant Professor, 1935-1938; Associate Professor, 1938-

2174 San Pasqual Street

FREDERICK CHARLES LINDVALL, PH.D.

Associate Professor of Electrical Engineering

B.S., University of Illinois, 1924; Ph.D., California Institute of Technology, 1928. Electrical Engineering Department, Los Angeles Railway Corporation, 1924-1925; Engineering General Department, General Electric Company, Schenectady, 1928-1930. Assistant in Electrical Engineering, California Institute, 1925-1927; Teaching Fellow, 1927-1928; Instructor, 1930-1931; Assistant Professor, 1931-1937; Associate Professor, 1937-

1860 Allen Drive, Altadena

HOWARD JOHNSON LUCAS, M.A.

Associate Professor of Organic Chemistry

B.A., Ohio State University, 1907; M.A., 1908; Chemist, United States Government, 1910-1913. Instructor, California Institute, 1913-1915; Associate Professor, 1915-

95 North Holliston Avenue

SAMUEL STUART MACKEOWN, PH.D.

Associate Professor of Electrical Engineering

A.B., Cornell University, 1917; Ph.D., 1923. Instructor in Physics, Cornell University, 1920-1923. National Research Fellow in Physics, California Institute, 1923-1926; Assistant Professor, 1926-1931; Associate Professor, 1931-

1240 Arden Road

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. Member of the Faculty, Summer Sessions, University of California at Los Angeles, 1920-1931. California Institute, 1918-

255 South Bonnie 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 and Consulting Engineer with County Engineer, Ulster County, N. Y., summers of 1925, 1928-1932; Chief of Surveys, 200-inch Telescope, Palomar Mt., Summer, 1935. California Institute, 1918-

388 South Oak Avenue

CLARK BLANCHARD MILLIKAN, PH.D.

Associate Professor of Aeronautics

A.B., Yale University, 1924; Ph.D., California Institute of Technology, 1928. Assistant in Physics, California Institute, 1925-1926; Teaching Fellow in Physics and in Aeronautics, 1926-1929; Assistant Professor, 1929-1934; Associate Professor, 1934-

1500 Normandy Drive

GENNADY W. POTAPENKO

Associate Professor of Physics

Dipl. in Phys., University of Moscow, 1917; Habilitation, 1920. Assistant in Physics, Moscow Institute of Petrography, 1914-1916; Research Fellow, University of Moscow, 1917-1920; Docent of Physics, 1920-1932. Professor of Physics, University of Iaroslawl, 1924-1926; Associate Professor, Mining Academy of Moscow, 1917-1927. Professor of Physics and Director of the Physical Institute, Mining Academy of Moscow, 1927-1932. Professor of Physics and Director of the Physical Institute and of the Meteorological Observatory, Agriculture Academy of Moscow, 1929-1931. Research Associate, University of Berlin, 1927; Visiting Lecturer, University of Göttingen, 1929. Recipient of Silver Medal, University of Moscow, 1914; of the Prize in Physics, Russian Scientific Council, 1928. Fellow of the Rockefeller Foundation, California Institute, 1930-1931; Research Fellow, 1931-1932; Associate Professor, 1932-

1718 Oakdale Street

WILLIAM RALPH SMYTHE, PH.D.

Associate 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; Assistant Professor, 1927-1934; Associate Professor, 1934-

674 Manzanita Avenue, Sierra Madre

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Associate Professor of Analytical Chemistry

B.S. in Chemistry, University of Virginia, 1918; M.S., California Institute of Technology, 1920; Ph.D., 1924. Teaching Fellow, California Institute, 1919-1920; Instructor, 1920-1928; Assistant Professor, 1928-1938; Associate Professor, 1938- 3140 East California Street

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Associate Professor of Economics and History
Dean of Freshman

A.B., University of Redlands, 1920; A.M., Harvard University, 1921; J.D., Mayo College of Law, 1925; Ph.D., Northwestern University, 1932. 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. Instructor, California Institute, 1925-1930; Assistant Professor, 1930-1937; Associate Professor, 1937-

1089 San Pasqual Street

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Associate Professor of Mathematics

A.B., University of California, 1924; Ph.D., California Institute of Technology, 1928. Research Worker in Mathematics, Institute for Advanced Study, 1934-1935. Assistant in Mathematics, California Institute, 1925-1926; Teaching Fellow, 1926-1928; Research Fellow, 1928-1929; Assistant Professor, 1929-1935; Associate Professor, 1935- 265 South Holliston 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-

2247 Lambert Drive

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Associate Professor of Physiology

B.A., University of Leiden, 1926; M.A., University of Utrecht, 1929; Ph.D., 1933. Assistant in Comparative Physiology, University of Utrecht, 1929, 1931; Dondersfonds Research Fellow, 1930-1931; Chief Assistant Medical Physiology, University of Utrecht, 1932-1934. California Institute, 1934-

1364 Cordova Street

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Associate Professor of Inorganic Chemistry

B.S., University of California, 1923; Ph.D., California Institute of Technology, 1926. Teaching Fellow in Chemistry, University of Utah, 1923-1924; duPont Fellow, California Institute, 1924-1925; Teaching Fellow, 1925-1926; Research Fellow, 1926-1927; Instructor, 1927-1929; Fellow of the International Education Board, 1928-1929; Assistant Professor, 1929-1935; Associate Professor, 1935-

1025 San Pasqual Street

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Associate Professor of Theoretical Physics

Graduate, Eidg. Technische Hochschule, Zurich, 1920; Ph.D., 1922. Assistant in Physics, Eidg. Technische Hochschule, 1921-1925. Fellow of International Education Board, California Institute, 1925-1927; Assistant Professor, 1927-1929; Associate Professor, 1929-

1260 Lorain Road, San Marino

DONALD PORTER BARNES, M.S.

Resident Engineer at the California Institute (U. S. Bureau of Reclamation)

B.S., Oregon State College, 1928; M.S., California Institute of Technology, 1930. Designer, Pasadena Water Department, 1930-1931; Instructor in Civil Engineering, Missouri School of Mines and Metallurgy, 1931-1932; American Society of Civil Engineers Freeman Scholar in Europe, 1932-1933. Assistant Engineer, Metropolitan Water District of Southern California, 1933-1934; Assistant Engineer, U. S. Bureau of Reclamation (Denver), 1934-1936; Associate Engineer, U. S. Bureau of Reclamation (Denver), 1936-1937; Resident Engineer, U. S. Bureau of Reclamation, California Institute, 1937-

223 West Laurel, Sierra Madre

ARNOLD ORVILLE BECKMAN, PH.D.

Assistant Professor of Chemistry

B.S., University of Illinois, 1922; M.S., 1923; Ph.D., California Institute of Technology, 1928. Research Associate, Bell Telephone Laboratories, 1924-1926. Teaching Fellow, California Institute, 1923-1924; 1926-1928; Instructor, 1928-1929; Assistant Professor, 1929-

1970 Crescent Drive, Altadena

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Assistant Professor of Mathematics
Assistant Registrar

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. Instructor, California Institute, 1918-1931; Assistant Professor, 1931-

1500 Sinaloa Avenue

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Assistant Professor of Plant Physiology

A.B., University of Utah, 1931; Ph.D., California Institute of Technology, 1934. National Research Fellow in Biology at Utrecht and Zürich, 1934-1935. Research Assistant, California Institute, 1935-1936; Instructor, 1936-1938; Assistant Professor, 1938-

290 South Michigan Avenue

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Assistant Professor of Mechanical Engineering
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Director of Placements

B.S., California Institute of Technology, 1929; M.S., 1930; Ph.D., 1934. Trustee, American Society for Metals, 1938-. Assistant and Teaching Fellow, California Institute, 1929-1934; Instructor, 1934-1937; Assistant Professor, 1937-

Dabney House

FREDERICK J. CONVERSE, B.S.

Assistant Professor of Civil Engineering

B.S. in Mechanical Engineering, University of Rochester, 1914. Appraisal Engineer, Cleveland Electric Illuminating Company, Cleveland, Ohio, 1914-1915. Student Engineer, General Electric Company, Lynn, Massachusetts, 1915-1916. Instructor in Applied Mechanics, University of Rochester, 1916-1917. Engineer in Charge of Materials Tests, General Laboratories, Bureau of Aircraft Production, U. S. A., 1917-1918. Assistant Production Engineer, Gleason Gear Works, Rochester, New York, 1919. Designer, Bureau of Power and Light, Los Angeles City, 1920. Member of firm, Labarre and Converse, Consulting Foundation Engineers, 1932-1936. Instructor, California Institute, 1921-1933; Assistant Professor, 1933-

2167 Lambert Drive

ROBERT EMERSON, PH.D.*

Assistant Professor of Biophysics

A.B., Harvard University, 1925; Ph.D., University of Berlin, 1927. National Research Fellow in Biology, Harvard University, 1927-1929. Instructor in Biophysics, Harvard University, 1929-1930. California Institute, 1930-

1175 Woodbury Road

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Assistant Professor of Mineralogy and Mineragraphy

B.Sc., University of Manitoba, 1925; M.Sc., 1927; M.A., Harvard University, 1928; Ph.D., 1930. Assistant in Geology, University of Manitoba, 1925-1927; University of Manitoba Travelling Fellow, 1927-1928; Instructor in Economic Geology, Harvard University, 1928-1930; National Research Fellow, 1930-1931; Research Associate in Geology, Harvard University, 1931-1932; Geologist, International Nickel Company of Canada, Ltd., 1932-1935. California Institute, 1935-

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Assistant Professor of Biochemistry

A.B., Leland Stanford Junior University, 1925; M.A., 1926; Ph.D., 1928. Instructor in Chemistry, San Jose Teachers College, 1925-1927; Fellow of the American Petroleum Institute, Leland Stanford Junior University, 1927-1931. California Institute, 1931-

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

351 California Terrace

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Assistant Professor of Micropaleontology

A.B., Occidental College, 1926; A.M., Stanford University, 1928; Ph.D., 1934. Field geologist, Richfield Oil Company, 1928-1931. Assistant Geologist, United States Geological Survey, 1931-1937. Consulting Geologist, 1937-. Assistant Professor, California Institute, 1939-

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In charge of William G. Kerckhoff Marine Laboratory

A.B., Fresno State College, 1925; A.M., Stanford University, 1928. Instructor in Biology, Fresno State College, 1925-1928; Instructor in Zoology, Hopkins Marine Station of Stanford University, 1928-1929; Assistant Professor of Zoology, 1929-1932. California Institute, 1932-

Corona del Mar

JOHN H. MAXSON, PH.D.

Assistant Professor of Geology

B.S., California Institute of Technology, 1927; M.S., 1928; Ph.D., 1931. Teaching Fellow, California Institute, 1928-1931; Instructor, 1931-1938, Assistant Professor, 1938-. Geologist, Petrol Grubu, Maden Tetkik ve Arama Enstitusu, Republic of Turkey, 1936-1937; Research Associate, Carnegie Institution of Washington, 1933-. California Institute, 1928-

286 South Chester Avenue

FRANCIS WILLIAM MAXSTADT, PH.D.

Assistant Professor of Electrical Engineering

M.E., Cornell University, 1916; Certificate of E.E., 1916; M.S., California Institute of Technology, 1925; Ph.D., 1931. 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. Instructor, California Institute, 1919-1933; Assistant Professor, 1933-

1666 North Grand Oaks Avenue

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Assistant Professor of Physics

B.A., Pomona College, 1926; Ph.D., California Institute of Technology, 1931. Assistant in Physics, California Institute, 1928-1931; Research Fellow, 1931-1933; Instructor, 1933-1937; Assistant Professor, 1937-

1773 Oakdale Street

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Assistant Professor of Organic Chemistry

B.S., University of Wisconsin, 1931; Ph.D., 1934. Research Assistant, University of Wisconsin, 1929-1931; Fellow, 1931-1934; Research Associate, 1934-1935. Fellow of the General Education Board at the Rockefeller Institute for Medical Research, 1935-1936; Assistant in Chemistry, 1936-1937; Fellow of the Rockefeller Foundation at the University College Hospital Medical School, 1937-1938. Assistant Professor, California Institute, 1937-

CHARLES FRANCIS RICHTER, PH.D.

Assistant Professor of Seismology

A.B., Stanford University, 1920; Ph.D., California Institute of Technology, 1928. Research Assistant in Seismology, Carnegie Institution of Washington, 1927-1937. Assistant Professor, California Institute, 1937-

1820 Kenneth Way

HUNTER ROUSE, DR.-ING.[1]

Assistant Professor of Fluid Mechanics

S.B., Massachusetts Institute of Technology, 1929; S.M., 1932; Dr.-Ing., Technische Hochschule, Karlsruhe, Germany, 1932. Massachusetts Institute of Technology Traveling Fellow in Hydraulics, 1929-1931; Assistant in Hydraulics, 1931-1933; Instructor in Civil Engineering, Columbia University, 1933-1936; Cooperative Laboratory, Soil Conservation Service, 1936-. California Institute, 1936-

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B.S., California Institute, 1928; M.S., 1929; Ph.D., 1933. Assistant in Engineering, California Institute, 1928-1930; Instructor, 1930-1937; Assistant Professor, 1937-

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B.S., Colgate University, 1920; M.A., Princeton University, 1924; Ph.D., 1931. Instructor in English, Colorado College, 1924-1925. Instructor, California Institute, 1925-1931; Assistant Professor, 1931-

1672 Poppy Peak Drive

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Assistant Professor of History

B.A., University of Toronto, 1927; M.A., University of Alberta, 1930; Ph.D., Stanford University, 1938. Lecturer in History, Regina College, Saskatchewan, 1927-1928; Assistant in History, University of Alberta, 1928-1930; Research Assistant, Hoover War Library, Stanford University, 1930-1937; Research Associate, 1937; Instructor in History, Stanford University, 1935-1937. California Institute, 1937-

2650 Paloma Street

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Assistant Professor of Physics in Astrophysics

A.B., University of Kansas, 1926; M.S., University of Michigan, 1928; Ph.D., 1930. National Research Fellow, California Institute of Technology, 1932-1935; Research Fellow, 1932-1935; Senior Fellow in Research, 1935-1938; Assistant Professor, 1938-

1427 Monte Vista Street

JAMES HOLMES STURDIVANT, PH.D.

Assistant Professor of Chemistry

B.A., University of Texas, 1926; M.A., 1927; Ph.D., California Institute of Technology, 1930. Instructor, University of Texas, 1926-1927. Teaching Fellow, California Institute of Technology, 1927-1930; Research Fellow, 1930-1935; Senior Fellow in Research, 1935-1938; Assistant Professor, 1938-

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ALBERT TYLER

Assistant Professor of Embryology

A.B., Columbia University, 1926; A.M., 1927; Ph.D., California Institute of Technology, 1929. Assistant in Zoology, Columbia University, 1927-1928; National Research Fellow in Berlin and Naples, 1932-1933; Teaching Fellow, California Institute of Technology, 1928-1929; Instructor, 1929-1938; Assistant Professor, 1938-

1131 Lura Street

EDWARD DUNSTER KREMERS, M.D.

Consulting Physician

M.D., University of Michigan, 1903; Graduate, Army Medical School, 1910. Lt.-Col. U. S. Army, Retired. California Institute, 1930-

2315 Mar Vista Avenue, Altadena

MARSHALL YATES KREMERS, M.D.

Assistant to the Consulting Physician

A.B., Occidental College, 1930; M.A., University of California, 1932; M.D., 1935.

1510 Harding Avenue

HAROLD Z. MUSSELMAN, A.B.

Assistant Director of Physical Education and Manager of Athletics

A.B., Cornell College, 1920. Instructor in Science and Athletic Director, Sterling (Illinois) High School, 1920-1921. Instructor, California Institute, 1921-1935; Assistant Director, 1935-

824 East California Street

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; Director of Athletics, 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

FRANCIS DASHWOOD BODE, PH.D.*

Instructor in Geology

B.S., California Institute of Technology, 1930; M.S., 1931; Ph.D., 1934. Assistant in Geology, California Institute, 1930-1931; Teaching Fellow, 1931-1934; Assistant Curator in Vertebrate Paleontology, 1934-1936; Instructor in Geology, 1936-

ROBERT B. COREY, PH.D.

Senior Fellow in Chemical Research

B. Chem., University of Pittsburgh, 1919; Ph.D., Cornell University, 1924. Assistant in Inorganic Chemistry, Cornell, 1919-1922; Chemical Spectroscopy, 1922-1923; Instructor in Analytical Chemistry, 1923-1928; Assistant of the Rockefeller Institute for Medical Research, 1928-1930; Associate, 1930-1937. California Institute, 1937-

352 South Parkwood Avenue

*On leave of absence, 1938-39.

HARDIN CRAIG, JR., PH.D.
Instructor in History

B.A., Princeton University, 1929; M.A., Harvard University, 1931; Ph.D., 1937. Instructor in History, Hobart College, 1931-1933. California Institute, 1937-

1755 Orangewood Street

ANTHONIE VAN HARREVELD, M.D.
Instructor in Physiology

B.A., Amsterdam University, 1925; M.A., 1928; M.D., 1929. Assistant in Physiology, Amsterdam University, 1926-1932; Chief Assistant in Physiology, Utrecht University, 1932-1934. Research Assistant, California Institute, 1934-1935; Instructor, 1935-

515 South El Molino Avenue

LINDSAY HELMHOLZ, PH.D.
Instructor in Chemistry

Ph.D., Johns Hopkins University, 1933. Research Fellow, California Institute, 1933-1934; National Research Fellow, 1934-1936; Instructor, 1936-

1659 Oakdale Street

RICHARD H. HOPPER, M.A.
Instructor in Geology

B.A., University of California at Los Angeles, 1935; M.A., 1936. Teaching Fellow, University of California at Los Angeles, 1935-1936. Teaching Fellow, California Institute, 1936-1938; Instructor, 1938-. California Institute, 1936-

588 South Mentor Avenue

WALDEMAR ALEXANDER KLIKOFF, B.S.
Instructor in Aeronautics

B.S. in Naval Architecture and Marine Engineering, Massachusetts Institute of Technology, 1923. Structural and Aerodynamic Analysis Engineer with several aircraft manufacturers, 1924-1934; Lecturer in Aerostatics (part time), University of Detroit, 1930-1932; Associate Aeronautical Engineer, Bureau of Air Commerce, 1937-1938; Aeronautical Engineer, Civil Aeronautics Authority, 1937-. California Institute, 1934-

237 Sixteenth Street, Santa Monica

JOHANNES VAN OVERBEEK, PH.D.
Instructor in Biology

B.Sc., University of Leyden, 1928; M.S., University of Utrecht, 1932; Ph.D., 1933. Assistant in Botany, University of Utrecht, 1933-1934. Research Assistant, California Institute, 1934-1937; Instructor, 1937-

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B.S., California Institute of Technology, 1931; Ph.D., 1935. Geophysical Engineering Corp., 1935-1938; United Geophysical Co., 1938-. California Institute, 1931-

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Instructor in History and Research Fellow in Physics

B.S., California Institute of Technology, 1932; M.S., 1933; Ph.D., 1936. Lecturer in Physics, University of Southern California, 1938. Graduate Assistant and Teaching Fellow, California Institute, 1932-1936; Instructor, 1936-

426 South Michigan Avenue

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Instructor in Synoptic Meteorology

B.S. in Engineering Administration, Massachusetts Institute of Technology, 1928. Instructor, California Institute, 1938-

1881 Woodlyn Road, Altadena

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Instructor in Aeronautics

B.Aero.E., University of Minnesota, 1934; Ph.D., California Institute of Technology, 1938. Assistant in Aeronautics, California Institute, 1934-1937; Instructor, 1937-

196 South Sierra Bonita Avenue

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Librarian

California Institute, 1914-

1067 North Catalina Avenue

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A.B., University of California, 1933; M.A., 1935. Instructor in English, University of California, 1935; Lecturer, Cooper Institute, New York City, 1937. California Institute, 1937-

397 South Chester Avenue

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B.Aero.E., University of Minnesota, 1936. Assistant in Aeronautics, California Institute of Technology, 1936-1938; Instructor, 1938-

314 South Michigan Avenue

HOWELL NEWBOLD TYSON, B.S.

Instructor in Mechanical Engineering

B.S., Massachusetts Institute of Technology, 1920. Assistant Instructor in Thermodynamics, Massachusetts Institute of Technology, 1920-1921; Designer for Bureau of Power and Light, City of Los Angeles, 1921-1922; Managing Engineer, Industrial Engineering and Equipment Co., 1922-1929; Engineer, C. C. Moore & Co., 1929-1933. Instructor, California Institute, 1936-

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Instructor in Economics and Accounting
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B.S., California Institute of Technology, 1936; M.B.A., Harvard University, 1938. Instructor, California Institute, 1938-

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NATHANIEL W. WILCOX, A.B.

Instructor in Engineering Drawing

A.B., Harvard University, 1917. Instructor, California Institute, 1932-

369 South Lake Avenue

RESEARCH FELLOWS

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Research Fellow in Physics of the Carlsberg Fond, the Rask Oersted Fond, and the Danmarks Amerikanske Selskab.

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411 South Hudson Avenue

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Research Fellow in Physics

B.S., in E.E., University of Nebraska, 1931; M.S., 1933; Ph.D., California Institute of Technology, 1936. Assistant Professor of Physics, Occidental College, 1936-. Research Fellow, California Institute, 1933-

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Research Fellow in Physics

A.B., University of California at Los Angeles, 1927; M.S., California Institute of Technology, 1929; Ph.D., 1930. Instructor in Chemistry and Physics, Occidental College, 1930-1936; Assistant Professor, 1936-. Research Fellow, California Institute, 1935-

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B.S., California Institute of Technology, 1934; M.S., 1936; Ph.D., 1938. Research Fellow, California Institute, 1938-

2589 East Villa Street

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National Research Fellow in Medicine

B.A., Johns Hopkins University, 1935; Ph.D., Johns Hopkins University School of Medicine, 1938. Research Fellow, California Institute, 1938-

285 South Lake Avenue

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International Research Fellow of the Rockefeller Foundation in Biology

Dr. phil., Göttingen, 1930; Dr. habil., University of Berlin, 1936. Research Fellow, California Institute, 1937-

540 South Hill Avenue

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Research Fellow in Physics

D.Sc., German University of Prague, 1935. Assistant in Physics, University of Istanbul, 1935-1936. Research Fellow, California Institute, 1937-

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E.M., Colorado School of Mines, 1929; M.S., California Institute of Technology, 1933; Ph.D., 1935. Conservationist, U. S. Soil Conservation Service, 1937-. California Institute, 1935-

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Ph.D., University of Göttingen, 1927. Assistant in Theoretical Physics, University of Frankfurt (Germany), 1930-1933; Research Fellow, Institut Henri Poincaré, Sorbonne, Paris, 1933-1936; Research Division, United States Weather Bureau, 1938. Research Fellow, California Institute, 1937-

124 El Nido Avenue

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Research Fellow in Chemistry

B.A., Yale University, 1933; Ph.D., 1936. Research Fellow, California Institute, 1936-

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Standard Oil Company of California Technical Research Fellow

B.S., California Institute of Technology, 1929; M.S., 1932. Assistant Geologist, Oil Search Limited, Sydney, Australia, 1934-1935. Geologist, Inyaminga Petroleum (1934) Ltd., Portuguese East Africa, 1936-1937. California Institute, 1938-

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B.Eng.Physics, Ohio State University, 1933; Ph.D., California Institute of Technology, 1936. California Institute, 1933-

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ERWIN RUDOLF GAERTTNER, PH.D.

H. H. Rackham Postdoctoral Fellow in Physics
(University of Michigan)

B.S., University of Denver, 1932; M.S., University of Michigan, 1933; Ph.D., 1937. California Institute, 1937-

314 South Hill Avenue

CLIFFORD SYMES GARNER, PH.D.

Arthur A. Noyes Fellow in Chemistry

B.S., California Institute of Technology, 1935; Ph.D., 1938. California Institute 1938-

638 North Wilson Avenue

SYDNEY GOLDSTEIN, PH.D.

Leverhulme Research Fellow in Aeronautics; Fellow of St. John's College

B.A., Cambridge University, 1925; Ph.D., 1928; M.A., 1929. Fellow of the Royal Society, 1937. Lecturer in Mathematics, Manchester, 1929-1931. Lecturer in Mathematics, Cambridge, 1931-. (Stokes Lecturer, 1937-). Fellow of St. John's College, 1929-1932, 1933-. Research Fellow, California Institute, 1938-

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A.B., Cornell University, 1926; A.M., 1928; Ph.D., 1931. Graduate Assistant, Cornell, 1927-1931; Resident Doctor, 1931-1937. California Institute, 1937-

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B.S., California Institute of Technology, 1930; M.S., Ohio Wesleyan University, 1932; Ph.D., California Institute of Technology, 1935. California Institute, 1932-

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B.S., Occidental College, 1914; Ph.D., California Institute of Technology, 1931. Associate in Physics, University of California at Los Angeles, 1924-1928; Instructor, Occidental College, 1929-1930; Teaching Fellow, California Institute of Technology, 1930-1931; Assistant Professor, University of Hawaii, 1931-1935; Assistant Professor, Occidental College, 1935-1936; Acting Head of Department, 1936-1937; Associate Professor and Head of Department, 1937-. California Institute, 1936-

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American Can Company Fellow in Chemistry of Johns Hopkins University

B.S., California Institute of Technology, 1936; Ph.D., Johns Hopkins University, 1938. California Institute, 1938-

763 South Oakland Avenue

SPIRO KYROPOULOS, PH.D.

Research Fellow in Physics

Ph.D., University of Leipzig, 1911. Assistant in Biology, University of Göttingen, 1912-1913; Assistant in Physical Chemistry, 1913-1925; Research Fellow in Fluid Mechanics and Assistant in Physics, 1928-1931. Habilitation, 1931; Privat-docent of Physical Technology, 1931-1935. California Institute, 1937-

1936 Mill Road, South Pasadena

HENRI A. LÉVY, PH.D.

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314 South Hill Avenue

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Leonard G. Strater
Reese H. Taylor
Charles H. Thorne
Mrs. Joseph E. Tilt
Mrs. John Treanor
Mrs. John K. Urmston
Edward R. Valentine
W. L. Valentine
Mrs. W. L. Valentine
William W. Valentine
J. Benton Van Nuys
Charles B. Voorhis
Mrs. Paul M. Warburg
Thomas W. Warner
Mrs. Gurdon W. Wattles
Frederick W. Williamson
Philip Wiseman
Casey A. Wood
Archibald B. Young
Gerald C. Young

HISTORICAL SKETCH

The California Institute of Technology had its real origin in 1891, with the founding of Throop University. At that time the opportunities for obtaining systematic vocational training on the west coast were meager, if they existed at all. It was primarily to meet this need that the Hon. Amos G. Throop founded the institution to which he gave his name and to which he later left the bulk of his estate. Throop Polytechnic Institute—the name was changed in 1892—while it offered work of college grade, concentrated most of its energies on instruction in manual training, domestic science, and kindred subjects, preparing its graduates mainly for teaching positions which were opened by the addition of manual arts to the curricula of the public schools. And to round out its general educational program, Throop Polytechnic also maintained an academy and an elementary school.

Thus it continued for nearly two decades, with no change in its principal aims, and still housed in three buildings on a small campus in the present business section of Pasadena. The impulse toward change originated with Dr. George E. Hale, who had come to Pasadena to direct the building of the Mount Wilson Observatory of the Carnegie Institution of Washington. The need which had been met by the founding of Throop Polytechnic Institute was now being met by other institutions; Dr. Hale perceived a new and greater need, growing out of changed conditions; and he became enthusiastic over the possibility of developing an institution which would give sound engineering training, but which might in time, with the friendly association of the Mount Wilson Observatory, make Southern California a center for distinguished scientific work.

The possibility which he envisaged fired the enthusiasm and enlisted the support of a number of outstanding citizens of the community, notably Messrs. Arthur H. Fleming, Norman Bridge, Henry M. Robinson, James A. Culbertson, Charles W. Gates, and Hiram and John Wadsworth. Mr. Fleming and his daughter, Marjorie, pre-

sented the institution with twenty-two acres of land which, with the addition of eight acres later, comprise the present campus. The Flemings were also largely instrumental in providing the first building to be erected on the new site, the present Throop Hall. In 1910, under the presidency of Dr. James A. B. Scherer, the institute moved to its new quarters. A few years earlier the elementary school had been set up as a separate institution, the present Polytechnic Elementary School; and by 1911 the normal school and the academy had been discontinued.

For the first few years in its new location, Throop Polytechnic Institute—or Throop College of Technology as it was called after 1913—gave degrees only in electrical, civil, and mechanical engineering. Gradually, however, it was able to add to its objectives. In 1913, Dr. A. A. Noyes, who was founder and director of the Research Laboratory of Physical Chemistry at the Massachusetts Institute of Technology and who had also served as president of that institution, became associated on part-time with the College. In 1916 a chemical laboratory was assured. It was completed in 1917, and instruction and research in chemistry and chemical engineering were inaugurated under Dr. Noyes' direction. In that same year, Dr. Robert A. Millikan, then professor of physics at the University of Chicago, arranged to spend a part of each year at Throop, where, as Director of Physical Research, he was to develop a program of graduate work in physics.

The war necessitated a temporary diversion of energies. Numerous members of the faculty went into service, and undergraduate instruction was radically revised to meet the immediate needs of the national emergency. With the close of the war, however, normal activities were resumed, and in the next few years the institution entered on the most rapid and consistently sustained phase of its development. In 1919 Dr. Noyes resigned from the faculty of the Massachusetts Institute of Technology to give his whole time to Throop College. In 1920 the name was changed to the California Institute of Technology In that same year, Dr. Scherer resigned because of ill health.

Nineteen hundred and twenty-one was marked by developments which made it one of the most important years in the history of the Institute. When a laboratory of physics was assured by Dr. Norman Bridge, Dr. Millikan severed his connection with the University of Chicago to become director of the laboratory and Chairman of the Executive Council of the Institute. The setting up of the Executive Council, which was the principal feature of an administrative reorganization, was designed to achieve two results: to avoid the burden of single responsibility which a college presidency usually entails, and to bring about a closer relationship between the Board of Trustees and the faculty. The Executive Council, which under the Board of Trustees administers the affairs of the Institute, is composed of both trustees and faculty members, and as a body it discharges the duties ordinarily performed both by a college president and the executive committee of a board of trustees.

In the same year, 1921, financial stability was assured by Mr. Arthur H. Fleming's agreement to give the California Institute his personal fortune as permanent endowment. In November of that year, the Board of Trustees formulated in the "Educational Policies of the Institute" an explicit statement of the principles which were to govern the present conduct of the Institute and its future development. Recognition by the Southern California community of the value of these aims has resulted in a steady growth of the physical facilities and has made possible the addition of work in geology, biology, and aeronautics. There has been also, during the past fifteen years, a steady growth in enrollment, both in the undergraduate and graduate groups. But all of these developments have involved no changes of fundamental purpose; they have, in fact, only enabled that purpose to be fulfilled more completely.

EDUCATIONAL POLICIES

In pursuance of the plan of developing an institute of science and technology of the highest grade, the Trustees in 1921 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, astrophysics, 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 of physics, astrophysics, mathematics, chemistry, geology, geophysics, paleontology, and biology. A considerable proportion of the time of these courses shall be devoted to research. These will continue the training for the types of professional positions above referred to.

(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. 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.

(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.

(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 FACILITIES

THROOP HALL, 1910.

The administration building; erected with funds supplied by a large number of donors, and named for the Honorable Amos G. Throop, founder of Throop Polytechnic Institute, from which the California Institute developed.

GATES AND CRELLIN LABORATORIES OF CHEMISTRY: first unit, 1917; second unit, 1927; third unit, 1937.

The first two units were the gift of the late Messrs. C. W. Gates and P. G. Gates, of Pasadena; the third unit was the gift of Mr. and Mrs. E. W. Crellin, of Pasadena.

CULBERTSON HALL, 1922.

The Institute auditorium; named in honor of the late Mr. James A. Culbertson, trustee of the Institute and Vice-President of the Board 1908-1915.

NORMAN BRIDGE LABORATORY OF PHYSICS: first unit, 1922; second unit, 1924; third unit, 1925.
The gift of the late Dr. Norman Bridge.

HIGH-POTENTIAL RESEARCH LABORATORY, 1923.
Erected with funds provided by the Southern California Edison Company Ltd.

ENGINEERING RESEARCH LABORATORY AND HEATING PLANT, 1926.
Erected with funds provided in part by the late Dr. Norman Bridge and in part from other sources.

DABNEY HALL OF THE HUMANITIES, 1928.
The gift of the late Mr. Joseph B. Dabney and Mrs. Dabney, of Los Angeles.

SEISMOLOGICAL RESEARCH LABORATORY (of the Division of the Geological Sciences), 1928.

DANIEL GUGGENHEIM AERONAUTICAL LABORATORY, 1929.
Erected with funds provided by the Daniel Guggenheim Fund for the Promotion of Aeronautics.

WILLIAM G. KERCKHOFF LABORATORIES OF THE BIOLOGICAL SCIENCES: first unit, 1929; second unit, 1938.

The gift of the late Mr. William G. Kerckhoff and Mrs. Kerckhoff, of Los Angeles.

EXPERIMENTAL STATION (of the Division of Biology), Arcadia, California, 1929.

PLANT PHYSIOLOGY LABORATORY (of the Division of Biology), 1930.

WILLIAM G. KERCKHOFF MARINE BIOLOGICAL LABORATORY (of the Division of Biology), Corona del Mar, California, 1930.

ATHENÆUM, 1930.
The gift of Mr. and Mrs. Allan C. Balch, of Los Angeles.

STUDENT HOUSES, 1931.

Blacker House.

The gift of the late Mr. R. R. Blacker and Mrs. Blacker, of Pasadena.

Dabney House.

The gift of the late Mr. Joseph B. Dabney, and Mrs. Dabney, of Los Angeles.

Fleming House.

Erected with funds provided by some twenty donors, and named in honor of Mr. Arthur H. Fleming, of Pasadena, President of the Board of Trustees of the Institute 1918-1932.

Ricketts House.

The gift of Dr. and Mrs. L. D. Ricketts, of Pasadena.

ASTROPHYSICAL INSTRUMENT SHOP, 1931.

Erected with funds provided by the International Education Board and the General Education Board.

W. K. KELLOGG LABORATORY OF RADIATION, 1932.

The gift of Mr. W. K. Kellogg, of Battle Creek, Michigan.

ASTROPHYSICAL LABORATORY, 1932.

Erected with funds provided by the International Education Board and the General Education Board.

HYDRAULIC STRUCTURES LABORATORY, 1932.

ASTROPHYSICAL OPTICAL SHOP, 1933.

Erected with funds provided by the International Education Board and the General Education Board.

SOIL CONSERVATION LABORATORY, 1936.

Provided by the Department of Agriculture of the United States Government.

CHARLES ARMS LABORATORY OF THE GEOLOGICAL SCIENCES, 1938.
The gift of the late Mr. Henry M. Robinson and Mrs. Robinson, of Pasadena, in memory of Mrs. Robinson's father, the late Mr. Charles Arms.

SEELEY W. MUDD LABORATORY OF THE GEOLOGICAL SCIENCES, 1938.
The gift of Mrs. Seeley W. Mudd, of Los Angeles, in memory of her husband, the late Mr. Seeley W. Mudd.

TEMPORARY BUILDINGS

The Steam, Gas Engine, and Hydraulic Laboratories for undergraduate work in the fields of thermodynamics and hydraulics are housed in a building of temporary construction.

Another such building contains living quarters for graduate students, a restaurant for non-resident students, and a club-room for the Throop Club.

Other temporary structures contain a gymnasium locker room and showers, exercise rooms, and a practice room for the musical organizations of the Institute.

LIBRARIES

The library of the Institute comprises the General Library, housed in the Norman Bridge Laboratory of Physics, and six departmental libraries for physics, chemistry, geology, biology, aeronautics, and the humanities.

ATHENÆUM

The Athenæum, a structure in the Mediterranean style of architecture, fittingly furnished and equipped, with grounds attractively landscaped, is situated at the Hill Avenue end of the campus. The purpose of the donors, Mr. and Mrs. Allan C. Balch, was to provide a place and opportunity for contact between the distinguished foreign scientists and men of letters temporarily in residence from time to time at the California Institute, the Mount Wilson Observatory, and the Henry E. Huntington Library and Art Gallery, the staffs and graduate students of those institutions, and the patrons and friends of science and education in Southern California making up the California Institute Associates.

The Athenæum contains on the first floor a large and beautiful lounge, a library, a main dining-room, three small dining-rooms, and, adjoining the main dining-room—and planned so that the two rooms can be thrown together for large banquets—a room for scientific and other lectures, known as the "Hall of the Associates." On the upper floors are very attractively furnished rooms and suites, each with private bath, for visiting professors, members of the staffs and graduate students of the three institutions named, and other members of the Athenæum. An attractive writing room and lounge are provided on a mezzanine floor for the exclusive use of women. On the third floor a loggia and dressing rooms provide additional accommodations for graduate students.

STUDENT HOUSES

The four Student Houses are situated on the California Street side of the campus. Planned in the Mediterranean style to harmonize with the Athenæum, they were, like the latter building, designed by Mr. Gordon B. Kaufmann. While the four houses constitute a unified group, each house is a separate unit providing accommodations for about seventy-five students; each has its own dining-room and lounge, but all are served from a common kitchen.

All four houses have attractive inner courts surrounded by portales. Most of the rooms are single, but there is a limited number of rooms for two. All the rooms are simply but adequately and attractively furnished. The plans of the buildings are such that within each of the four houses there are groupings of rooms for from twelve to twenty students, with a separate entry for each group.

The completion of this first group of residence halls marks the initial step in a plan to meet the housing and living problems of the students in such a way as to develop a series of eight residence halls, "each to have its own distinctive atmosphere, each to be the center about which the loyalties developed in student days and the memories of student life shall cluster."

By action of the Board of Trustees, all undergraduate students are expected to live in the Student Houses unless permission is given by one of the Deans to live elsewhere. This permission will be given only when there are reasons of emergency or when there are no longer any vacancies in the Houses. Since the demand for rooms may exceed the supply, students newly entering the Institute must file room applications as soon as they are notified by the Registrar of admission to the Institute.

EXTRA-CURRICULAR OPPORTUNITIES

STUDENT ORGANIZATIONS AND ACTIVITIES

The undergraduate students are organized as the "Associated Students of the California Institute of Technology, Incorporated," of which all are members, to deal with affairs of general student concern, and with such matters as may be delegated to them by the faculty. Membership in the corporation entitles each student to (a) admission to all regular athletic or forensic contests in which Institute teams participate, (b) a subscription to the CALIFORNIA TECH, (c) a subscription to the BIG T, (d) one vote in each corporate election, and (e) the right to hold a corporate office. The executive body of the corporation is the Board of Directors, which is elected by the members in accordance with the provisions of the By-Laws. The Board conducts and supervises all student activities, makes awards for athletic and other extra-curricular activities, and has the sole power to authorize expenditure of corporation funds.

The honor system is the fundamental principle of conduct of all students; it applies to all scholastic and extra-curricular activities, and to relations between students and faculty as well as between students. To protect the honor system the members elect the Board of Control, which investigates breaches of the honor system, or cases of misconduct, and recommends disciplinary penalties 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, the Board of Directors of the Student Body, and the Board of Control.

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,

the BIG T, the annual, and the LITTLE T, the handbook. 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-Paleontology Club include men interested in these particular fields. Other organizations are the Walrus, the Cosmopolitan, the Photo, the Aero, and the Newman Clubs, and the Episcopalian Group.

In addition to national honorary fraternities there are four local honorary groups: the Beavers, the Drama Club, the Press Club, and the Varsity Club.

The Throop Club is a social organization for non-resident undergraduates. Graduate students are also eligible to membership. The center of the group's activity is the recently completed Throop Club lounge on the campus, made possible through friends of the Institute, the Institute, and members of the Throop 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.

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. 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 debates with other Southern California colleges, and in annual oratorical and extempore contests. Debates are also scheduled with near-by 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.

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 Professors Eagleson and Stanton of the English department.

To aid the student journalists in improvement in their technique a journalism course is offered during each of the three terms.

A Young Men's Christian Association has its office in Dabney Hall and performs many valuable services. Receptions for new students, hikes, bi-weekly luncheons, meetings, classes for the study of life and other problems are conducted by this organization. Its program and membership are open to all students at no expense.

LECTURES

A series of lectures is presented in the weekly Assembly, which all students are required to attend. These lectures are designed to be of general interest and deal with science, literature, the arts, and current economic and political history. The Humanities division offers occasional lectures by eminent authorities in philosophy, history, and literature. Weekly public lectures in science, illustrated by experiments, are given by the members of the Institute faculty in the lecture rooms of the Norman Bridge Laboratory of Physics and the Gates Chemical Laboratory. 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 students. They may also arrange to visit the Huntington Library and Art Gallery, and preceding the visits to the art gallery, members of the Institute staff give talks to small groups of students on the pictures exhibited there.

The Faculty Committee on Student Relations, in conjunction with the Board of Directors of the Student Body, arranges each year a series of lectures for the freshman emphasizing (a) social usage and Institute traditions; (b) the value of undergraduate activities and the recognition by the business world of the character and qualities developed through participation in those activities; (c) the fact that studies need not keep students from a reasonable participation in extra-curricular interests; and (d) the fact that every student can find at the Institute a wide range of activities from which to choose.

STUDENT HEALTH AND PHYSICAL EDUCATION

PHYSICAL EDUCATION

The work in physical education requires all undergraduate students to carry on a program designed to promote their physical development, and provides graduate students with opportunities for recreational exercise. 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 intercollegiate and intramural games and sports.

HEALTH SERVICE

A. PHYSICAL EXAMINATION AND VACCINATION

The Institute provides for undergraduates entering the Institute, without cost to them, a complete physical examination by a group of physicians at the Huntington Memorial Hospital.

Every student of the Institute (undergraduate and graduate) must be vaccinated upon admission or bring a certificate from a physician that he has been vaccinated not earlier than one month before admission.

Those students who refuse to be vaccinated will be denied admission to the Institute.

B. SERVICES OF THE INSTITUTE PHYSICIAN

1. The services of the Institute Physician are available for consultation and treatment at his office on the campus between the hours of 12:30 and 1:30 p.m. daily except Sunday, while the Institute is in session, without charge to undergraduate and graduate students.

2. Provided time is available, the services of the Institute Physician are available during his regular consulting hours on the campus for members of the staff, and employees of the Institute, and their immediate families and those of graduate students. A small fee is charged by the Institute for each such call.

3. Any members of the above groups will receive a 50% discount on all laboratory work done at the Huntington Memorial Hospital.

C. EMERGENCY HOSPITALIZATION FUND

In addition, in order to meet the hospital and certain other emergency medical and surgical expenses, incurred by students who develop serious illnesses which require immediate attention, or suffer accidents, an emergency hospitalization fee of three dollars ($3.00) a year is assessed against every undergraduate and every graduate student. This fee must be paid with the tuition charge for the first term of the academic year.

It is to be clearly understood that the Emergency Hospitalization Fund cannot adequately make provision in case of a serious epidemic; and furthermore because the amount of the annual emergency hospitalization fund fee is small, *this is not to be construed as a contract.*

The following regulations have been established:

1. The funds derived from this fee will be deposited at interest in a special account known as the Emergency Hospitalization Fund. The Institute will be the custodian of the fund. Money in this fund shall not be used for any other purpose than for the payment of surgical and medical expenses. Whether a case is an emergency or not will be decided by the Institute Physician. Whenever an emergency arises, the Institute Physician will decide whether hospitalization is necessary, and will then put into operation the provisions of the Emergency Hospitalization Fund.

Illnesses and injuries which are not emergencies do not come within the scope of the fund.

2. In any emergency case arising under the jurisdiction of the Institute Physician, and when necessary, hospital care will be allowed for a period not to exceed one month. Other necessary hospital expenses during this period of one month, such as the use of operating-room, surgical supplies and dressings, laboratory service, etc., will be allowed. Payment of surgical fees, anaesthetic fees and necessary special nursing fees will also be allowed whenever possible, provided the total amount of payment, exclusive of the hospital charge in any one case, shall not exceed one hundred dollars. Neither the Emergency Hospitalization Fund, nor the California Institute of Technology, is responsible for the payment of physicians', surgeons' and nurses' fees, etc., in excess of the above $100.

3. The fund is not available for those students who require, after returning to their classes, further attention or special equipment. No distinction will be made between injuries incurred in athletics or otherwise, in judging whether the case is an emergency or not, or the extent to which expenses will be paid out of the fund.

4. Whenever the expenses for emergency care in any one fiscal year are less than the total collected in fees for that year, the balance of money remaining shall be kept in the Emergency Hospitalization Fund, and shall remain deposited at interest to increase for the benefit of the fund. A balance kept over from one year will be used

to render emergency medical aid to the students in later years. It is probable that the plan can be liberalized by the building up of the fund in this manner.

5. Students are not required to accept the services of the Institute Physician, but may choose physicians and surgeons privately. Whomever they choose, whether the Institute Physician or not, they must pay for such services themselves without reference to the Emergency Hospitalization Fund.

6. The responsibility for securing adequate medical attention in any contingency, whether an emergency or not, is solely that of the patient. This is the case whether the patient is residing in one of the Student Houses, the Athenæum, or off the Institute grounds. Apart from providing the opportunity for free consultation with the Institute Physician at his office on the Institute grounds between 12:30 and 1:30 p.m. daily, unless otherwise stated, except Sunday, during term time, the Institute bears no responsibility for providing medical attention in case of illness.

7. Any expenses incurred in securing medical advice and attention in any case are entirely the responsibility of the patient. For instance: students who are ill and confined to their rooms in the dormitories or elsewhere, and are unable to visit the Institute Physician's office at the Institute, at the regular time, and who call in any physician, including the Institute Physician, are themselves solely responsible for the payment of all the bills incurred.

8. The Emergency Hospitalization Fund does not provide for the families of graduate or undergraduate students. The arrangements mentioned above for these classes will hold.

9. Donations to the Emergency Hospitalization Fund will be gratefully received.

10. The Faculty Committee on Student Health supervises, and authorizes, expenditures by the fund. All questions regarding the administration of this fund are to be referred to this Committee. The Committee will review the facts of every emergency case, and may, if they feel it desirable, recommend an extension of payments for specific purposes cited by the Committee.

REQUIREMENTS FOR ADMISSION TO UNDERGRADUATE STANDING

ADMISSION TO THE FRESHMAN CLASS

By action of the Trustees of the Institute the freshman class is limited to 160 students. These students are selected from the group of applicants on the basis of (a) high grades in certain required high school subjects and (b) satisfactory completion of entrance examinations in mathematics, physics, chemistry, and English. The specific requirements in each of these groups are described below.

HIGH SCHOOL CREDITS

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 and five units in Groups B and C. At least three of the latter must be in Group B.

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 complete scholastic record from an approved school[1].

ENTRANCE EXAMINATIONS

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 chemistry, physics, mathematics, and English. 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. Specimens or samples of the examination questions for admission to the freshman class of the Institute are not available for distribution.

Prospective freshmen are expected to take the entrance examinations in chemistry and English near the end of their junior year in high school, or one year prior to the date of expected admission to the Institute. The remaining examinations, in mathematics and physics, are ordinarily taken during March or April of the spring prior to expected admission. Those students who have failed, for sufficient reason, to take the chemistry and English examinations during the junior year may be permitted to take all four examinations during the spring prior to admission.

Regular entrance examinations will be held at the Institute Saturday, March 25, and Saturday, April 1, 1939. Applicants should report in the Lounge of Dabney Hall March 25, at 8:30 a.m. The examina-

[1]Incomplete scholastic records 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 United States History and Government must present their notebooks at the time of the examination. The schedule for 1939 is as follows: Tuesday, September 19, 9:00 a.m., mathematics; Wednesday, September 20, 9:00 a.m., history and foreign languages.

tions on March 25 will be chemistry and English and on April 1 mathematics and physics. The examinations in chemistry and English for high school juniors will be held in Dabney Hall on June 10, 1939.

Students living at a distance from Pasadena may, upon request, be allowed to take the entrance examinations under the supervision of their local school authorities. Arrangements for examinations in absentia should include a letter to the Registrar from the individual directing the tests stating that the required supervision will be given.

PHYSICAL EXAMINATION

Each applicant must pass a physical examination prior to admission to the Institute. These examinations will be conducted for the Institute by the staff of the Huntington Memorial Hospital. At the time of his registration each new student will be assigned an appointment for his examination. Registrations are tentative pending such examinations, and are subject to cancellation if the examinations are unsatisfactory. Students living at a distance are advised to consult their family physicians before coming to Pasadena in order to avoid unnecessary expense if physical defects exist which would prevent successful scholastic work. Every student entering the Institute for the first time must be vaccinated upon admission or bring a certificate from a physician that he has been vaccinated not earlier than one month before admission. Those students who refuse to be vaccinated will be denied admission to the Institute.

APPLICATION FOR ADMISSION

Application for admission to the Institute may be made at any time, but there is a distinct advantage in doing so by the first of March, or even earlier. This enables the Institute to make full use of all information available from high school sources. Applicants should submit their scholastic records before taking the entrance examinations. Each student taking the entrance examinations must have his high school mail a transcript of his final semester's work to this Institute as soon as possible after completion of his senior year.

Blanks for application for admission to the Institute will be provided upon request.

Final selections are ordinarily made and the applicants notified of their admission or rejection not later than June 1.

Upon receipt of the registration fee of $10.00 (which will be credited toward the first-term tuition), each accepted applicant will be sent a registration card which will entitle him to register, provided his physical examination is satisfactory. The registration card should be presented at the Dabney Hall Lounge September 19, 1939, at 1:30 p.m.

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

ADMISSION TO UPPER CLASSES BY TRANSFER FROM OTHER INSTITUTIONS

The Institute admits to its upper classes (i.e., sophomore year and beyond) a limited number of able men who have made satisfactory records at other institutions of collegiate rank. In general only students whose average grade corresponds to at least a B in courses in mathematics and science can expect to be permitted to take the entrance examinations.

A student who is admitted to the upper classes pursues a full course in one of the options in engineering or in science, leading to the degree of Bachelor of Science. The Institute has no special students. Men are admitted either as freshmen in accordance with the regulations set forth on pages 78 to 81, or as upper classmen in the manner described below. Those who have pursued college work elsewhere, but whose preparation is such that they have not had the substantial equivalent of any two of the following freshman subjects, English, mathematics, physics and chemistry, will be classified as freshmen and must be admitted as such. They may, however, receive credit for the subjects which have been completed in a satisfactory manner.

A minimum residence at the Institute of one scholastic year is required of all candidates for the degree of Bachelor of Science. See page 97.

Because of the very thorough, intensive study of mathematics and science required in the first two years, students from other colleges, unless of ability above the average of Institute students, cannot hope to transfer to the higher years of the Institute courses without incurring loss of time and 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.

An applicant for admission must present a transcript of his record to date showing in detail the character of his previous training and the grades received both in high school and college. In addition, he should file an application for admission; the necessary blanks for this will be forwarded from the Registrar's office upon request. If at all possible the transcript and application should be received not later than May. A supplementary transcript covering the work of the last term should be filed as soon as such grades are available. A personal interview is desirable. If this is not convenient during the regular college session, it is possible to arrange in advance for an interview during the Christmas, spring, or summer vacation periods.

Before their admission to the upper classes of the Institute all students are required to take entrance examinations in mathematics, physics and chemistry covering the work for which they desire credit, except that the examination in chemistry is required only of those desiring to pursue the course in science. Students must offer courses, both professional and general, substantially the same as those required in the various years at the Institute (see pages 169-181), or make up their deficiencies as soon as possible after admission. In case there is a question regarding either the quality or the extent of the previous work, examinations in the subjects concerned may be arranged.

Applicants are advised to read the descriptions of the freshman and sophomore courses, particularly those in physics, mathematics, and

chemistry, and to note that the work in freshman mathematics includes certain topics in differential and integral calculus. It is possible, however, for an exceptionally able student to cover outside of class, the necessary work in integral calculus and thus prepare himself for the entrance examination and the sophomore course in mathematics.

The examinations in mathematics, physics and chemistry taken by students planning to transfer to the third and fourth-year classes are the comprehensive 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 students in the Institute and those desiring to transfer from other institutions. For men planning to enter the sophomore year similar review examinations covering the work of the freshman year are required. A representative set of previous examination papers will be sent to approved applicants upon request. From a study of these and of the content of the courses at the Institute, prospective students may judge for themselves which examinations they are prepared to take. Students are not required to take all of the examinations for admission to the classification of a given year as junior or sophomore, but may take examinations in one or more subjects for admission to one class and in others for admission to the work of another class. Their ultimate classification will be determined by the Committee on Admission to Upper Classes on the basis of their previous record and of the results of all the examinations taken.

No fee is charged for the entrance examinations, but only those whose records are good will be permitted to write upon them. In order to be approved for admission to the examinations, a student's application and a transcript of his record must be on file at least ten days before the date of the examination. Applicants should not come to the Institute expecting to be admitted to the examinations, without first receiving definite permission to take them.

In 1939 the examinations will be held both in June and in September. Since the upper classes may be practically filled by those admitted

to the Institute following the examinations in June, applicants are strongly advised to take them at the earlier date. The schedule for 1939 is as follows:

June 3, 9 a.m. . . . . Chemistry	Sept. 15, 9 a.m. . . . Mathematics
June 9, 9 a.m. . . . Mathematics	Sept. 16, 9 a.m. . . . . Physics
June 10, 9 a.m. . . . . Physics	Sept. 16, 1 p.m. . . . . Chemistry

Applicants residing at a distance may take the June examinations under the supervision of their local college authorities, provided definite arrangements are made well in advance. Arrangements for examinations in absentia should include a letter to the Registrar from the person directing the tests stating that the required supervision will be given.

Those who write upon the June examinations will be notified of their admission or rejection about July 1; those taking the September examinations will be notified in time for registration. Upon the receipt of the registration fee of $10.00 (which will be credited toward the first-term tuition), each accepted applicant will be sent a registration card which will entitle him to register, provided his physical examination is satisfactory.

Applicants for admission to the third and fourth years whose credentials have been approved may take advantage of the summer 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.

Since the majority of the courses at the Institute continue throughout the year, new students are admitted in September only. For the same reason students whose status may be irregular cannot expect to complete their work at any time other than at the end of the college year in June.

The Institute offers no summer work. However, students who have a few deficiencies in non-professional subjects may be able to remove them by taking summer work at some other institution of collegiate

rank. The details of such summer work should be approved by the Registrar before the work is undertaken.

The attention of students planning to transfer to junior or senior standing is called to the fact that, until they have satisfactorily completed three full terms of residence at the Institute, they are subject to the same scholastic requirements as are freshmen and sophomores. See pages 95 and 96. In addition, they should note that to be permitted to register for any science or engineering options during their junior and senior years they must meet the scholastic requirements of the divisions concerned. See page 96.

Physical examinations and vaccination are required as in the case of students entering the freshman class. If reports of these examinations are delayed until after registration it will be understood that registrations are tentative pending such reports and are subject to cancellation if the reports are unsatisfactory.

Students transferring to any of the undergraduate classes (i.e., sophomore year and beyond) are required to pay a registration fee of $10 upon notification of admission to the Institute. This fee is automatically applied on the first term's tuition.

EXPENSES

The following is a list of student expenses at the California Institute of Technology for the academic year 1938-39, together with the dates on which the various fees are due. These charges are subject to change, at the discretion of the Institute, for 1939-40. The deposits listed, while uniform in the freshman year, will vary in subsequent years according to the individual course chosen. In addition to the total amount given, approximately $50 a year should be allowed for books and supplies.

Date	Fee	Amount Resident Student	Amount Non-Resident Student
Upon notification of admission to the Institute	Registration Fee	$ 10.00*	$ 10.00*
At time contract for Student House reservation is signed	Student House Deposit	10.00	
Sept. 5, 1938	1st instalment of Room and Board, payable in advance		
	15 meals a week	58.50	
	21 meals a week	69.00	
Sept. 20, 1938: Freshmen Sept. 23, 1938: Upperclassmen	Tuition, 1st term	100.00	100.00
	Associated Student Body Dues, 1st term	4.45	4.45
	Emergency Hospitalization Fee, 1938-39	3.00	3.00
	Subscription to the CALIFORNIA TECH	.55	.55
	Chemistry Breakage Deposit	15.00	15.00
	Drawing Padlock Deposit	2.00	2.00
	Physical Education Locker Padlock Deposit	1.00	1.00
	Locker Key Deposit	.50**	.50**
	Locker Rent, 1st term	.50**	.50**
	Parking Fee, 1st term	1.00**	1.00**
	Student House Telephone, 1st term	1.00	
	Student House Dues, 1st term	2.50	
	Student House Radio Fee, 1st term	.50**	
Nov. 7, 1938	2nd instalment of Room and Board		
	15 meals a week	58.50	
	21 meals a week	69.00	

*This fee is paid by Freshmen and by undergraduate students transferring from other institutions, and is automatically applied on the first term's tuition.

**Optional.

Date	Fee	Amount: Resident Student	Amount: Non-Resident Student
Jan. 3, 1939	Tuition, 2nd term	$100.00	$100.00
	Associated Student Body Dues, 2nd term	5.00	5.00
	Locker Rent, 2nd term	.50**	.50**
	Parking Fee, 2nd term	1.00**	1.00**
	3rd instalment of Room and Board		
	15 meals a week	58.50	
	21 meals a week	69.00	
	Student House Telephone, 2nd term	1.00	
	Student House Dues, 2nd term	2.50	
	Student House Radio Fee, 2nd term	.50**	
Feb. 13, 1939	4th instalment of Room and Board		
	15 meals a week	48.75	
	21 meals a week	57.50	
Mar. 27, 1939	Tuition, 3rd term	100.00	100.00
	Associated Student Body Dues, 3rd term	4.00	4.00
	Locker Rent, 3rd term	.50**	.50**
	Parking Fee, 3rd term	1.00**	1.00**
	5th instalment of Room and Board		
	15 meals a week	58.50	
	21 meals a week	69.00	
	Student House Telephone, 3rd term	1.00	
	Student House Dues, 3rd term	2.50	
	Student House Radio Fee, 3rd term	.50**	
May 8, 1939	6th instalment of Room and Board		
	15 meals a week	48.75	
	21 meals a week	57.50	

TOTAL

For student taking 15 meals	$693.50
For student taking 21 meals	753.00
For non-resident student	$340.00

Students withdrawing from the Institute during the first three weeks of a term, for reasons deemed satisfactory to the Institute, are entitled to a refund of tuition fees paid, less a reduction of 20% and a pro rata charge for the time in attendance.

EMERGENCY HOSPITALIZATION FEE

The emergency hospitalization fee, payable by each student at the beginning of each year, provides a certain amount of hospitalization and medical and surgical care in accordance with regulations pre-

**Optional.

scribed by the Board of Trustees and administered by the Institute Physician and the Faculty Committee on Student Health (see pages 75-77).

ASSOCIATED STUDENT BODY FEE

The Associated Student Body fee of $13.45 is payable by all undergraduate students. Of this fee $5.50 is used for the support of athletics, $3.00 is a subscription to the BIG T, and the remainder is budgeted by the Board of Directors of the Associated Student Body for other student activities. The subscription to the CALIFORNIA TECH, 55 cents a year, is collected from every undergraduate.

STUDENT HOUSES

Students in the Houses must supply their own blankets but bed linen and towels are furnished and laundered by the Institute.

Application for rooms in the Student Houses may be made by addressing the Comptroller of the Institute (see page 70).

SCHOLARSHIPS, PRIZES, AND STUDENT AID

FRESHMAN PRIZE SCHOLARSHIPS

Twelve or more freshman scholarships carrying stipends of $150 or $300 are awarded each year to members of the incoming freshman class. The recipients of these scholarships are selected by the Committee on Freshman Admission from the candidates who have passed the entrance examinations and otherwise satisfied the entrance requirements of the Institute.

The scholarships are 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 personal interviews. The awards are 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 are designated Blacker Scholars or Drake Scholars, in recognition of the donors of the scholarship funds, Robert Roe Blacker and Nellie Canfield Blacker, or Mr. and Mrs. A. M. Drake.

DRAKE SCHOLARSHIPS

In addition to the foregoing, Mr. and Mrs. A. M. Drake of Pasadena have 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

The Institute has established about thirty scholarships known as the Sophomore and Junior Prize Scholarships. These scholarships, which carry half tuition, are awarded at the end of each school-year to those students who as the result of their work, during the freshman

and sophomore years, are granted honor standing on the basis described on page 97 of this Catalogue. In addition, a smaller number of tuition grants may be awarded to students of exceptionally high standing who are in need of financial assistance.

It is expected that all students awarded scholarships or tuition-grants will maintain high scholastic standing. Failure to do so at any time during the school year may result in the termination of the award.

HARRIET HARVEY SCHOLARSHIP
WALTER HUMPHRY SCHOLARSHIP

Miss Harriet Harvey and the late Mrs. Emily A. Humphry made provision for two scholarships. The first of these, the Harriet Harvey Scholarship, is to be awarded preferably to a well-qualified candidate from the state of Wisconsin. If there is no such candidate the Institute may award the scholarship elsewhere.

The second, the Walter Humphry Scholarship, is to be awarded preferably to a well-qualified candidate from the state of Iowa. If there is no such candidate, the Institute may award the scholarship elsewhere.

LA VERNE NOYES SCHOLARSHIPS

Under the will of the late La Verne Noyes, of Chicago, funds are provided for paying the tuition, in part or in full, of deserving students needing this assistance to enable them to procure a university or college training. This is to be done without regard to differences of race, religion, or political party, but only for those who shall be citizens of the United States of America and either

First, shall themselves have served in the army or navy of the United States of America in the war into which our country entered on the 6th day of April, 1917, and were honorably discharged from such service, or

Second, shall be descended by blood from some one who has served in the army or navy of the United States in said war, and who either

is still in said service or whose said service in the army or navy was terminated by death or an honorable discharge.

The recipients are designated La Verne Noyes Scholars.

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.

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. A further gift of $5,000 has been made by Mr. and Mrs. Arthur Noble of Pasadena to establish the Noble Loan and Scholarship Fund.

In 1932, Mr. and Mrs. Willard C. Jackson established at the Institute the Thomas Jackson Memorial Loan Fund in memory of their son, a member of the sophomore class of that year, who died during the fall term, at the beginning of a very promising career. The original gift for this fund was $10,000 and the donors have since added $15,000 to this amount. Loans from the fund are made to undergraduate or graduate students of superior ability who are in need of such assistance to meet the expenses of their education.

Applications for loans should be made to the Comptroller of the Institute.

STUDENT EMPLOYMENT

The Institute tries to help students to find suitable employment when they cannot continue their education without thus supplementing their incomes. 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, before coming to the Institute, to the Secretary of the Institute Y. M. C. A. or the officer in charge of the National Youth Administration program conducted by the Institute.

The National Youth Administration program provides at the Institute during the year 1938-39 the sum of $1020 per month, which represents 68 units of $15 each per month, which amount may be earned by needy students assigned to socially desirable tasks, including research work carried on at the Institute.

PLACEMENT SERVICE

The Institute in cooperation with the Alumni Association maintains a Placement Office under the direction of a member of the faculty. With the services of a full-time secretary, this office assists graduates to find employment. Graduates who are unemployed or desire improvement in their positions should register with the Placement Secretary. It should be understood that the Institute assumes no responsibility in obtaining employment for its graduates, although the Placement Office will make every effort to find employment for those men who wish to make use of this service.

REGISTRATION AND GENERAL REGULATIONS

Registration for the second term, 1938-1939, will take place January 3, 1939 (9 a.m. to 3 p.m.); for the third term, March 27, 1939 (9 a.m. to 3 p.m.). Registration for the first term, 1939-1940, will take place, for freshmen, September 19, 1939 (1:30 p.m.), for transfers from other colleges, September 21, 22, 1939 (9 a.m. to 3 p.m.), and for other students, September 22, 1939 (9 a.m. to 3 p.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. 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.

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:

A denotes Excellent,
B denotes Good,
C denotes Satisfactory,
D denotes Poor,
E denotes Conditioned,
F denotes Failed,
inc denotes Incomplete.

In giving the grade *incomplete* the "inc" must be followed by a letter indicating the grade of work and by a number in parenthesis indicating approximately the percentage of the work completed. When so reported the grade of "inc" may, in summing grades, be provisionally considered to correspond to such a number of credits as the Registrar shall determine; but if reported without these specifications it shall not be counted. The instructor's reason for giving the grade and the manner by which the incomplete may be removed must be entered in the space provided for that purpose.

When an incomplete is given because of absence from examinations it may be removed by examinations only if the student has a leave of absence issued by one of the Deans covering the examinations missed.

It is recommended that the grade incomplete be given only in the case of sickness or other emergency which justifies the non-completion of the work at the usual time.

Conditioned indicates deficiencies other than incomplete that may be made up without actually repeating the subject. A grade of "D" is given when the work is completed.

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. Each student should consult with his instructor at least a week in advance of this date. Any condition not so removed automatically becomes a failure, unless otherwise recommended by the instructor at the time the condition is given.

Failed means that credit may be secured only by repeating the subject, except that in special cases the Registration Committee may, with the instructor's approval, authorize a removal of an "F" by three three-hour examinations.

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.

SCHOLASTIC REQUIREMENTS

All freshman and sophomore students are required to meet certain scholastic standards as outlined below. Students transferring from other colleges into the junior, senior, or Master of Science divisions are also subject to these restrictions until they have satisfactorily completed three full terms of residence at this Institute. In addition, students who have been reinstated to junior standing after having failed to make the required number of credits in the sophomore year are subject to these scholastic requirements in the junior year and also in the senior year if the junior work is not satisfactory.

Each course in the Institute is assigned a number of *units* corresponding to the total number of hours per week devoted to that subject, including classwork, laboratory, drawing, and field work, and normal outside preparation. *Credits* are awarded on the basis of the number of units multiplied by four if the grade received is "A," three if "B," two if "C" and one if "D": thus, a student receiving a grade of "B" in a twelve unit course receives 36 credits for this course.

Credits are not given for work in physical education or in assembly.

Probation. Any freshman, sophomore, or new transfer student who fails to receive 72 credits during any one term will be placed on probation. A student on probation must withdraw from all extra-curricular activities and outside employment or must reduce the number of subjects he is carrying sufficiently to enable him to meet the scholastic requirements in succeeding terms. His program of scholastic and outside activities must be arranged with and approved by his Dean.

Ineligibility for registration. A freshman, sophomore, or new transfer student is ineligible to register:

(a) If he fails during any one term to receive 54 credits.
(b) If, after being placed on probation, he fails during *any* subsequent term to receive 72 credits.
(c) If he fails for the school year to receive a total of 270 credits.

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. A reinstated student who again fails to fulfil the scholastic requirements for registration will be granted a second reinstatement only under very exceptional conditions.

Departmental regulations. Any student whose grade-point average (credits divided by units) is less than 1.9 in the subjects listed under his division* may, at the discretion of his department, be refused permission to continue the work of that option. Thus, a student finishing his junior year in electrical engineering, whose grade-point average

*The curriculum of the Institute is organized under six divisions, as follows:
Division of Physics, Mathematics, and Electrical Engineering.
Division of Chemistry and Chemical Engineering.
Division of Civil and Mechanical Engineering, Aeronautics, and Meteorology.
Division of the Geological Sciences.
Division of Biology.
Division of the Humanities.

in the freshman, sophomore, and junior courses in his *division* (including physics, mathematics, and electrical engineering) was less than 1.9, could be refused permission by the electrical engineering department to continue with *senior* courses in the electrical engineering option. Such disbarment, however, does not prevent the student from continuing in some other department provided permission is obtained, or from repeating courses to raise his average in his original option.

Freedom from scholastic restrictions. After a student has completed at least three full terms of residence at the Institute and has been registered for his junior year, he shall not be placed on probation nor shall he be refused registration on account of failure to receive a prescribed number of credits during the preceding term or terms, except that a student who is *reinstated* to enter the junior year is subject to the above-outlined scholastic requirements during his junior year, *and with the further exception that any junior or senior student who fails to make 54 credits in any one term is ineligible for registration.*

Graduation requirement. To qualify for graduation a student must complete the prescribed work in some one option of the course in engineering or of the course in science with an average grade of 1.9.

Residence requirement. All transfer students who are candidates for the Bachelor of Science degree must complete at least one full year of residence in the undergraduate school at the Institute immediately preceding the completion of the requirements for graduation. At least ninety of the units taken must be in subjects in professional courses. A full year of residence is interpreted as meaning the equivalent of registration for three terms of not less than 49 units each.

Honor standing. At the close of each school-year the Committee on Honor Students awards *honor standing* to approximately fifteen students who have completed the freshman year, and to ten to fifteen students who have completed the sophomore year. To each of these students is also awarded a *prize scholarship* carrying half tuition. These awards are based primarily on the scholastic records of the students. Any holder of such a scholarship who in any subse-

quent term fails to maintain a scholastic standard set by the Committee automatically loses his honor standing and scholarship for the remainder of the school-year.

Honor standing entitles the student to such special privileges and opportunities as excuse from some of the more routine work, instruction in "honor sections," and admittance to more advanced subjects and to research work, but a student in honor standing may not be admitted to an honor section in a particular subject unless he has obtained a grade of "B" or better in the work prerequisite to that subject.

A student will be *graduated with honor* who has received on the average throughout his course 130 credits per term which result from grades of "A" and "B," provided also that he maintains such an average through the three terms of the *senior* year. In addition, a student may be graduated with honor under joint recommendation of his department and the Honors Committee, and approval of the faculty.

Excess or less than normal units. If for any reason a student is carrying less than 40 units, the credits required (as stated on page 96) shall be prorated on the basis of 40 as a standard. For example, a freshman, sophomore, or new transfer carrying 30 units of work shall be expected to obtain three-fourths of 72, or 54 credits, to remain off probation.

Applications for registration in excess of the prescribed number of units, or for less than 25 units, must be approved by the Registration Committee.

Leave of absence. 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 November 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 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.

STUDY AND RESEARCH AT THE CALIFORNIA INSTITUTE

THE SCIENCES

ASTROPHYSICS

The General Education Board provided in 1928 for the construction by the Institute of an Astrophysical Observatory, now well under way, 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 investigators in the research laboratories of the Institute and in the neighboring Mount Wilson Observatory of the Carnegie Institution of Washington. This new project thus continues and extends in a more formal way 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, structure and motion of the galactic system; of the distance, motion, radiation, and evolution of stars; of the spectra of the brighter stars under very high dispersion; of the distance, motion, and nature of remote nebulæ; and of many phenomena bearing directly on the constitution of matter.

The new observatory will consist of two main features. One of these is the 200-inch telescope, with its building, dome, and auxiliary equipment, now being erected on Palomar Mountain in San Diego County. 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. Well-equipped shops for the development of new instruments have been erected on the campus, and the Astrophysical Laboratory has been completed, though some of its chief instruments are still in process of construction.

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, comprising four members of the Executive Council of the Institute, and also including Dr. Walter S. Adams, 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. The organization of the Observatory Council and the personnel of its advisory committees are shown on page 57 of this Catalogue.

Any great increase in the size of telescopes requires a long study of the most promising methods of making large paraboloidal mirrors.

After much experimental work, a new form of Pyrex glass was chosen as the best available material and a 120-inch disc was received in 1934. The 200-inch disc was received in 1936 and is now in process of being shaped up in the optical shop.

The extensive investigation of primary and auxiliary instruments, which forms such a vital part of the general scheme, has also made marked progress, through the active cooperation of many leading men of science and engineers. Microphotometers, radiometers, photoelectric cells and other instruments of various types have been carefully studied and tested in difficult research problems. The Research Laboratory of the Eastman Kodak Company has generously agreed to deal with many of the special photographic problems. The short focus spectrograph objective devised by Rayton has greatly increased the range of the 100-inch telescope and has made possible the recent researches of Hubble and Humason on the expanding universe. A new objective of still shorter focal length has been completed by Beck after the design of the British Scientific Research Association, and successfully tested on Mount Wilson. A very advantageous method of coating telescope mirrors with aluminum instead of silver has been applied by Dr. John Strong to several large mirrors, including the 36-inch Crossley reflector on Mount Hamilton and the 60-inch and 100-inch reflectors on Mount Wilson.

It is expected that, after the Astrophysical Laboratory on the campus has been completely 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.

It should be remembered that the number of positions open to able young men well trained in astrophysics and its related subjects is small. For this reason only those exceptionally well qualified for such work should undertake graduate study and research.

BIOLOGICAL SCIENCES

A division of Biology, rather than the traditional departments of Botany and Zoölogy, has been established, in order to emphasize the unity of the phenomena of living organisms rather than their manifold diversities. That there are many properties common to the two great branches of the living world has become abundantly manifest in recent years. For example, the same principles of heredity that obtain among flowering plants apply also to human traits, and in their response to light, animals and plants conform to common laws 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.

As in the other departments of the Institute, emphasis is placed primarily on research and graduate study; and, even in these directions, no attempt is made to cover at once the whole science of biology, but rather efforts are concentrated on the development of those of its branches which seem to offer the greatest promise as fields of research. Several groups of investigators have been organized in general physiology, biophysics, biochemistry, bio-organic chemistry, genetics and experimental embryology. 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.

The first unit of the William G. Kerckhoff Laboratories of the Biological Sciences contains over 60 rooms, including lecture rooms, seminar rooms, undergraduate laboratories, private research rooms, and four constant temperature rooms. For work in plant genetics

there is a ten-acre farm with greenhouses and laboratory located at Arcadia about five miles from the Institute.

A new laboratory devoted mainly to Biochemistry, Bio-organic Chemistry, and Animal and Plant Physiology has been completed during the course of the present year. It is the second unit of the William G. Kerckhoff Laboratories of the Biological Sciences and more than doubles the available space. There is a lecture room seating about 175 persons and a large library which is a memorial to Mr. William G. Kerckhoff for his generous gift to the Institute.

A marine station has also been established at Corona del Mar. The building contains four large rooms and several smaller ones which give ample opportunity for research work in experimental biology in general. The proximity of the marine station to Pasadena (about 50 miles) makes it possible to supply the biological laboratories with living materials for research and teaching. The fauna at Corona del Mar and at Laguna Beach, which is near-by, is exceptionally rich and varied, and is easily accessible.

There is a small laboratory near the Institute for the study of plant hormones and in connection with this there is to be constructed another laboratory for Plant Physiology, especially equipped for automatic control of light, heat and humidity.

CHEMISTRY AND CHEMICAL ENGINEERING

The Gates and Crellin Laboratories of Chemistry consist of three adjacent units. The first two are the gift of the late Messrs. C. W. Gates and P. G. Gates. The third unit, which was completed in 1937 and which affords new space approximately equal to that of the first two units, is the gift of Mr. and Mrs. E. W. Crellin.

These three units include laboratories used for undergraduate instruction in inorganic, analytical, physical, and organic chemistry, and instrumental analysis; they also include class-rooms, demonstration lecture rooms, and a chemistry library. The remaining space in these buildings is largely devoted to facilities for research. There are

numerous individual laboratories for inorganic, physical, and organic chemical research. Special research facilities include an instrument shop, a students' shop, storage battery rooms, and photographic dark rooms as well as the usual machinery, switchboard, and service rooms.

With the Gates and Crellin Laboratories is associated the Research Laboratory of Applied Chemistry, which is located in the Engineering Research Building. This research laboratory has available a variety of equipment for carrying on chemical reactions on a fifty or a hundred pound scale. The machinery for the various unit operations is as nearly like commercial plant equipment as is consistent with its size. The laboratory is especially well equipped for the investigation of the thermodynamic properties of fluids at moderately high pressures.

The undergraduate instruction is so arranged that in the last two years of the undergraduate course in science there are offered to students an Option in Chemistry and an Option in Applied Chemistry. These options, especially when followed by the fifth-year courses in these subjects, prepare students for positions as teachers and investigators in colleges and universities, as research men in the government service and in industrial laboratories and as chemists in charge of the operation and control of manufacturing processes, and, in the case of the fifth and sixth year Chemical Engineering Course, for positions involving the management and development of chemical industries on the chemical engineering side. For students who desire to enter the field of chemical research, for which there are now professional opportunities on both the scientific and applied sides, opportunities for more specialized study and research leading to the degree of Doctor of Philosophy are provided at the Institute in the fields of inorganic, analytical, physical, and organic chemistry.

First year chemistry, which is taken by all freshman students of the Institute, puts special emphasis on the fundamental principles of chemistry. For two terms this subject centers around the chemistry of acids, bases, salts, metals, and non-metals. The third term is devoted to elementary qualitative analysis, accompanied by special lectures in various fields of chemistry given by staff members of the

division. Provision is made for the execution in the laboratory of interesting and fruitful experiments closely coordinated with the lectures and classroom discussions.

The second-year work in chemistry, which is taken by all students in the course in science, consists on the laboratory side of gravimetric and volumetric, advanced qualitative, and electrometric analysis; in the class work emphasis is placed on the principles relating to mass-action, the ionic theory, oxidation, and the periodic law. In the second and third terms, and also in the subjects of physical and organic chemistry taken in the later years, the abler students, after a few weeks of introductory work, may undertake minor researches in place of the regular laboratory work.

The chemical subjects of the junior and senior year consist of courses in physical, advanced inorganic, organic, and applied chemistry. The junior and senior courses in physical chemistry, here known as "Chemical Principles," are not descriptive courses of the usual type; but from beginning to end are presented as a series of problems to be solved by the student. Problems are a feature in the subjects of organic and applied chemistry also.

The supervision of the research work of graduate students is distributed among the members of the staff of the Division of Chemistry and Chemical Engineering. In physical chemistry the lines of research now being actively pursued by graduate students in cooperation with the staff include the following: thermodynamic studies including low temperature calorimetry; rates of homogeneous reactions; photochemical reactions; band spectra and Raman spectra in their chemical relations; crystal and molecular structure determined by the diffraction of X-rays and of electrons and correlated with the newer quantum theories; and application of magnetic methods to chemical problems. In organic chemistry the main lines of research now in progress are investigation on plant hormones; studies of the Walden inversion; work on unsaturated compounds, with especial reference to isomerism, hydration, and complex formation; studies on the constitution of the phosphotides and cerebrosides; the syn-

thesis of disaccharides and alkylated monosaccharides; configurational studies on the mono- and di-hydroxy amino acids; the investigation of the α-hydroxy and α-alkoxy amines; and the study of the chemistry of blood.

The fifth-year course in Chemical Engineering leads to the degree of Bachelor of Science in Chemical Engineering in distinction to the Bachelor of Science degree without designation received for completion of the four-year course in Applied Chemistry. This fifth-year course contains an intensive problem study of chemical engineering, a laboratory course in the fundamentals of engineering measurement, a course in business economics, and elective studies in science and engineering. Upon completion of the fifth-year course the student becomes eligible to pursue sixth-year work leading to the degree of Master of Science in Chemical Engineering. Approximately one-half of the work of the sixth year is devoted to research either in Chemical Engineering or in Applied Chemistry, the other half being occupied with graduate course work arranged with the approval of the Division of Chemistry and Chemical Engineering.

Although Chemical Engineering is not offered as a major subject for the degree of Doctor of Philosophy, it may be presented as a minor subject in connection with the doctorate in Chemistry or in Mechanical Engineering. The lines of research being pursued in applied chemistry include the study of applications of the molecular still and the glass electrode to industrial processes, and those in chemical engineering include engineering thermodynamics, phase equilibrium of hydrocarbons at elevated pressures, thermal transfer, and fluid flow.

GEOLOGICAL SCIENCES

BALCH GRADUATE SCHOOL

Through the generosity of Mr. and Mrs. Allan C. Balch the Balch Graduate School of the Geological Sciences was established at the California Institute in 1929. This school comprises the staff offering instruction in the various branches of geology, vertebrate and inverte-

brate paleontology, geophysics and geophysical prospecting, and seismology, research in the last named field being conducted in cooperation with the Carnegie Institution of Washington.

Graduate courses in the geological sciences may be pursued either by students who have completed the four-year course at the Institute or by students from other colleges who present substantially the same preparation.

The curriculum outlined for undergraduate students provides a broad and thorough preparation in the basic sciences of physics, chemistry, and mathematics and in certain engineering subjects, followed by an introduction to the fundamental principles of geology, paleontology and geophysics. Fifth-year courses lead to the degree of Master of Science. During the senior year of the undergraduate curriculum in the geological sciences and throughout the fifth and later years much time is devoted to investigation and field work. Students desiring to become research workers in the geological sciences or professional geologists, paleontologists, or geophysicists should continue their studies at least two years beyond the master's degree as candidates for the degree of Doctor of Philosophy.

NEW GEOLOGICAL BUILDINGS

Two new buildings have recently been completed on the Institute campus for the geological sciences. Both structures are memorials to men who were very active in the mining industry. The eastern of the two is known as the Charles Arms Laboratory of the Geological Sciences and is the gift of the late Mr. Henry M. Robinson and Mrs. Robinson in memory of Mrs. Robinson's father. It is 125 feet in length by 56 feet in width, with a south wing about 45 feet by 40 feet to be used for museum purposes. The western of the two structures was given by Mrs. Seeley W. Mudd as a memorial to her late husband. Its dimensions are 166 feet by 56 feet. Each building has five floors and the total space available for instruction and research in the geological sciences will probably exceed that devoted to these purposes in any other institution in America. The internal

arrangement of the buildings is such as to provide suites of rooms adapted to and equipped for the different branches of the geological sciences. Adequate office space is available for all graduate students in geology, paleontology, and geophysics.

INSTRUCTION AND RESEARCH IN THE GEOLOGICAL SCIENCES

Professional careers comparable to those of physicists, chemists, attorneys, or physicians are open to those who complete successfully the curricula for training geologists, paleontologists, or geophysicists. Students who attain a master's degree in geology are prepared to join the geological staffs of oil or mining companies or federal or state geological surveys. For those desiring more complete training, or preparing for university posts, or planning to be consulting geologists, it is desirable that additional graduate work and research be undertaken, leading to the doctor's degree.

Exceptional opportunities for research in the geological sciences exist at the Institute. An almost unrivalled variety of rock types, geologic structures, and physiographic forms occurs within convenient reach of Pasadena. The relatively mild climate permits field studies throughout practically the entire year, and consequently field training is an unusually important part of the department program.

Stratigraphic and faunal studies may be pursued in the Cenozoic and Mesozoic sedimentary rocks of the Southern Coast Ranges, in which oil fields are located, and in the Mojave Desert region. Thick sections of Paleozoic sediments in southeastern California remain almost unexplored. Structural and physiographic problems in the Coast and Basin Ranges and along the coastal front await critical investigation and frequently involve an interpretation of folding and faulting on a large scale. The many productive oil fields in southern California afford exceptional opportunities to students interested in economic geology. 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.

Collections available from many invertebrate and vertebrate faunal horizons in the sedimentary record of western North America permit the student interested in paleontology to secure an intimate knowledge of the history of life. Attractive field and laboratory problems are presented by the sequence, correlation, and ecologic relationships of western faunas, their significance in an interpretation of geologic history, and by the structure, relationships and evolution of specific groups of fossil organisms.

A very wide range of graduate courses is offered in both theoretical geophysics and in geophysics as applied to prospecting for oil and other mineral substances. The geophysical staff comprises four members, devoting themselves to different phases of the subject. Instruction is given in seismic, gravity, electrical, magnetic and other methods of prospecting. Considerable geophysical equipment is available and is used for practical training, and the design and construction of instruments in the shop of the seismological laboratory receive attention. Geophysical researches of various types are constantly being carried on.

SEISMOLOGICAL RESEARCH LABORATORY

The Seismological Research Laboratory is located about three miles west of the Institute on a granite ridge affording firm bedrock foundation for the instrument piers. The investigations at the laboratory relate mainly to earth movements originating within a radius of about two hundred miles. The seismograms from six branch stations, built and maintained with the aid of cooperating agencies in southern California, contribute greatly to these studies.

While devoted mainly to research, the laboratory is open to qualified students registered at the California Institute who desire advanced training in seismology.

The laboratory is operated jointly by the California Institute and the Carnegie Institution of Washington. The general program of research is outlined by a committee consisting of J. P. Buwalda, chairman, and Messrs. J. A. Anderson, Arthur L. Day, Beno Gutenberg, and H. O. Wood.

TEACHING AND RESEARCH FELLOWSHIPS

Fellowships are available for properly qualified students who desire to pursue advanced work in geology, paleontology and geophysics, as in other branches of science; see pages 159-164.

MATHEMATICS

Work in pure mathematics leading to the degree of Doctor of Philosophy was initiated by the Institute in 1926-1927. Candidates for the degree are expected to acquire a reasonable familiarity with some of the major applications of mathematics to the physical sciences. The attention of those intending to take advanced courses in mathematics is particularly directed to the foreign language requirements for mathematical work beyond the bachelor's degree.

PHYSICS

UNDERGRADUATE WORK

The distinctive feature of the undergraduate work in physics at the California Institute is the creative atmosphere in which the student at once finds himself. This results from the combination of a large and very productive graduate school with a small and carefully selected undergraduate body.

Since the best education is that which comes from the contact of youth with creative and resourceful minds, the members of the staff of the Norman Bridge Laboratory of Physics have been from the beginning productive physicists rather than merely teachers. The instruction is done by the small group method, twenty to a section, save for one rather elaborate demonstration lecture each week throughout the freshman and sophomore years. All the members of the staff participate in these lectures and almost all give at least one undergraduate course. The entering freshman thus makes some contact in his first year with practically all of the members of the staff, and he has the opportunity to maintain that contact throughout

his four undergraduate years, and his graduate work as well, if he elects to go on to the higher degrees.

In order to provide the thorough training in physics required by those who are going into scientific or engineering work, two full years of general physics are required of all students. Those who desire to major in physics take during their junior, senior and fifth years intensive problem type courses that provide a more than usually thorough preparation for graduate work. For those who do not expect to go on into graduate work, an "Applied Physics Option" is provided, in which some of the mathematics and problem courses are replaced by engineering subjects. Many of the undergraduate students who elect physics are given also an opportunity to participate in some one of the thirty to sixty research projects which are always under way in the Norman Bridge Laboratory of Physics, and the graduate seminars are open to undergraduates at all times.

GRADUATE WORK

Graduate students should complete as soon as possible the courses required for admission to candidacy for the doctor's degree. (See pages 152-159.) These provide an unusually thorough grounding in the fundamentals of physics, and the student learns to use these principles in the solution of problems of all kinds. In general, also, graduate students should begin research during their first year and continue it through their whole graduate period.

The Norman Bridge Laboratory of Physics is equipped to carry on research in all the principal fields of physics. It provides 65 rooms for research in addition to class and lecture rooms, the physics library, offices, laboratories for advanced and undergraduate instruction, shops, switchboard, apparatus, storage-battery, and machinery rooms. Equipment for making liquid air, hydrogen, and helium has been installed, and liquid air and liquid hydrogen are available in sufficient quantities for low temperature researches. Special facilities for research in the field of radiation are provided in the W. K. Kellogg Laboratory of Radiation and the High-Potential Research Labora-

tory with their million-volt transformers and high potential X-ray equipment. In both laboratories important work in nuclear physics and various phases of high-voltage X-rays is being carried on.

The student may either select his own problem in consultation with the department or may work into some one of the research projects already under way. The list of "Publications of the Staff" on pages 124 to 140 of this Catalogue may be consulted for information regarding the type of work in progress. The average yearly output of the laboratory for many years has been from fifty to sixty major papers.

There are three general seminars or research conferences per week which are regularly attended by all research workers and all graduate students. In addition, there is a weekly theoretical seminar conducted for the benefit of those interested primarily in mathematical physics and several seminars on special fields of work such as "X-Radiation," "Nuclear Physics," "Metals," "Physics of Solids," and "Ultra-Short Electromagnetic Waves."

The main outlets for the graduates in physics of the Institute are positions in colleges and universities and in the increasing number of industrial research laboratories of the country.

ENGINEERING

Courses are offered at the Institute in Civil, Mechanical and Electrical Engineering. There are also courses in Aeronautics and Applied Chemistry, which are described under the respective heads of Aeronautics and Chemistry.

The plan of instruction in Engineering embodies a four-year course for the degree of Bachelor of Science, and a fifth year of graduate study, quite definitely outlined within the selected field, leading to the degree of Master of Science in Civil, Electrical, or Mechanical Engineering. The fifth year in Aeronautics or Meteorology leads to the degree of Bachelor of Science in Aeronautics or Meteorology; the sixth year, to the degree of Master of Science in Aeronautics or Meteorology. Additional work is offered leading to the degree of

Doctor of Philosophy. The civil, mechanical and electrical engineering groups are not separated until the third year, all students following the same program of the fundamental subjects, mathematics, physics and chemistry, supplemented by their general applications in surveying, mechanism, mechanics, strength of materials, direct and alternating currents, heat engines and hydraulics. The divergence between the different branches occurs in the third and fourth years when the study of the professional subjects of specialized nature is introduced. Subjects in the humanities—English, history, and economics—are included in each year of the curriculum.

The four-year undergraduate courses in engineering are well balanced foundations for entrance into many opportunities within the respective fields. However, those students who wish to prepare for careers in the more intensive technical phases of engineering and who have shown capacity to do advanced work are expected to take the fifth year, which represents additional professional subjects and work in both design and research. While the work of the fifth year is prescribed to a considerable extent, it offers time and encouragement for the student to engage in research in a field of his own selection under the guidance of a staff representing a wide range of experience and current activity.

AERONAUTICS AND METEOROLOGY

The Graduate School of Aeronautics and the Daniel Guggenheim Laboratory of Aeronautics connected with this school were established at the Institute with the aid of the Daniel Guggenheim Fund for the Promotion of Aeronautics in 1928. Since this time an intensive program of instruction and research has been pursued in the fields of Aeronautics, Meteorology and the allied sciences. The Director of the Laboratory, Dr. Theodore von Kármán, serves also as advisor for the Daniel Guggenheim Airship Institute in Akron, Ohio. The cooperation between the two institutions permits the inclusion of problems connected with "lighter-than-air" craft in the school's activities.

The following program of instruction and research is now in progress:

1. A comprehensive series of theoretical courses in aerodynamics, hydrodynamics, meteorology and elasticity, with the underlying mathematics, mechanics, thermodynamics and physics of metals.

2. A group of practical courses in airplane design conducted by the Institute's experimental staff in cooperation with practicing engineers in the vicinity.

3. A course in meteorology, with special reference to the problems of weather forecasting for aeronautical operations. The course includes an introduction to modern dynamic meteorology and to the theory and practice of weather forecasting and mapping, using the "air mass analysis" methods.

4. Experimental and theoretical researches on

   (a) the basic problems of flow in real fluids with regard to the scientific foundations of technical hydro- and aerodynamics;

   (b) the basic problems of Applied Mechanics which relate to the properties of materials and the theory of elasticity;

   (c) practical problems in aerodynamics and structures, especially as applied to aeronautics;

   (d) meteorological problems dealing in particular with the properties and behavior of air masses;

   (e) the development of meteorological instruments, especially of the radiometeorograph type.

The largest item of equipment available for experimental research 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 750 horsepower, direct-current motor drives a 15-foot propeller, and a wind velocity of considerably more than 200 miles per hour has been produced. A

complete set of aerodynamical balances permits the rapid testing of complete airplane models as well as the undertaking of all types of scientific investigations in the wind tunnel. A fluid mechanics laboratory contains several smaller wind tunnels and a considerable amount of auxiliary apparatus especially suitable for the study of the basic problems connected with turbulent flows. A large structures laboratory has been equipped with specially designed testing machines for researches dealing chiefly with the problems connected with the modern use of stressed skin or monocoque structures. A completely equipped photoelasticity laboratory is being used for researches on the distribution of stresses in various complicated types of structure. The practical work in synoptic meteorology is facilitated by a teletype installation connecting the laboratory with the U. S. Weather Bureau network of observing stations. Complete instrumental equipment is available for meteorological instruction and research. In addition to the above special types of equipment, shop facilities are available to students engaged in research problems.

The facilities of the Institute are available for students desirous of taking higher degrees, and for qualified workers who wish to carry out researches in the fields detailed above. A few fellowships can be granted to selected men.

As in the older divisions of physics, chemistry, and mathematics, emphasis is placed primarily upon the development of graduate study and research; but provision has also been made in the four-year undergraduate course in engineering for work leading to such graduate study and research. This affords a broad and thorough preparation in the basic science and engineering upon which aeronautics rests.

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 proficiency in Aeronautics or Meteorology, there may be awarded at the end of the first year the degree of "Bachelor of Science for the completion of a Course in Aeronautics (or Meteorology)" while the

degree of "Master of Science for the completion of a Course in Aeronautics (or Meteorology)" is granted after the complete two-year course.

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 Institute or who have had substantially the same preparation elsewhere.

Still more advanced study and research are 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.

CHEMICAL ENGINEERING

(See pp. 104 to 107.)

CIVIL ENGINEERING

The branches of Civil Engineering in which advanced work is offered include the control, development and conservation of water; the analysis of structures with particular reference to those types achieving economy through continuity of arrangement; the study of earthquake effects and means of resisting them; investigation of stresses in dams and the design of different types of dams; the study of the increasingly important problems of sanitation, sewage treatment and disposal works; the location, design, construction and operation of railroads and highways; and the study of soil mechanics as related to foundations, earth dams, stability of slopes, and other earthwork problems.

ELECTRICAL ENGINEERING

The field of electrical engineering affords opportunity for many choices of life work. Some of these require only the preparation provided in the four-year undergraduate courses, whereas adequate preparation for the more technical work incident to the design and operation of electrical equipment requires the completion of the five-year course. Still other fields of endeavor call for a knowledge of mathematics, physics, and electrical engineering far in excess of that obtainable in the four- and five-year courses. 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. These courses provide for advanced work in the application of mathematical analysis and physical laws to mechanical and electrical problems incident to electrical design and research, electric transients including lightning phenomena, high voltage production and transmission, electrical engineering problems involving the use of vacuum tubes, and problems relating to the generation and distribution of electrical power for lighting and industrial purposes.

Students desiring to become research men, college teachers or professional experts in electrical engineering may continue their work for the degree of Doctor of Philosophy.

This graduate work in electrical engineering also 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 provides special work for undergraduate students wishing to do a limited amount of research.

Of the several electrical engineering laboratories at the California Institute, the High-Potential Research Laboratory is the most outstanding. This building and the million-volt transformer were provided by the Southern California Edison Company, Ltd. The million-volt transformer, which was designed by Professor R. W. Sorensen,

has a normal rating of 1,000 kilovolt amperes but is capable of supplying several times the rated load at the above potential, with one end of the winding grounded, and a 2,000 kilovolt surge generator supplemented by cathode-ray oscillographs and other apparatus used in the study of electric surges (artificial lightning) and its effect upon electrical apparatus. This laboratory is used 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. The other facilities include well-equipped laboratories for undergraduate, graduate, and special research work in dynamo-electric machinery and electronics. Also, seven research rooms are available for graduate students working on special problems.

MECHANICAL ENGINEERING

Advanced work in Mechanical Engineering is offered in the following fields: machine design, involving the properties of materials and the processes of production; metallography, the structure of metallic alloys and effects of heat treatment; thermodynamics and power plant design and analysis; internal combustion engines; refrigeration; heating and ventilating; air conditioning; hydrodynamics; and hydraulic machinery.

HYDRAULIC ENGINEERING. Due to the recent establishment of research laboratories at the Institute covering several of the broader fields of hydraulic engineering, both from the hydraulic machinery and the hydraulic structures point of view, the opportunities for advanced study and research in such fields are exceptionally good. Researches are now being carried on or are just being completed in these laboratories in cooperation with the Metropolitan Water District of Southern California, the Bureau of Reclamation of the United States Department of the Interior, the Los Angeles County

Flood Control District, and the Soil Conservation Service of the United States Department of Agriculture.

HYDRAULIC STRUCTURES LABORATORY. The hydraulic structures laboratory is located out of doors adjoining the undergraduate hydraulic laboratory. At present the equipment includes: (a) A model basin of about 2000 square feet in which river, harbor, and beach problems can be studied. It is provided with a wave machine and an automatic tide machine which together make it possible to superimpose waves of various magnitudes, frequencies, and directions upon any desired tide cycle. This was constructed in cooperation with the Los Angeles Gas and Electric Corporation and the Los Angeles County Flood Control District. (b) A channel platform 10 feet wide and 100 feet long for studying high velocity flow. This platform can be adjusted to any gradient up to 12 per cent and is provided with a metered water supply of 6 cubic feet per second. It has been installed in cooperation with the Los Angeles County Flood Control District to study the phenomena encountered in flood control channels in foothill regions where the flow velocity is above the critical. (c) A concrete flume 5 feet wide, 5 feet deep, and 35 feet long for use in weir, spillway, and allied problems requiring a deep basin.

HYDRAULIC MACHINERY RESEARCH LABORATORY. The hydraulic machinery laboratory offers unique opportunities for research on centrifugal pumps and hydraulic turbines and for various other investigations in hydrodynamics. Included in the facilities are an electric dynamometer of special design capable of absorbing or delivering 500 h.p. and operating at speeds up to 5,500 r.p.m.; main service pumps capable of delivering 16 cu. ft. of water per sec. and developing heads up to 750 ft. of water; two pressure tanks of 1,000 cu. ft. capacity each and designed for a working pressure of 300 lbs. per sq. in.; two accurately calibrated volumetric measuring tanks of 300 and 1,000 cu. ft. capacity; and other smaller pumps and miscellaneous apparatus. Instrumental equipment designed by the Institute staff provides means for measuring pressures, rates of flow, torques,

and speeds with a precision of approximately 0.1 per cent. Included in this is a system of speed regulation for the dynamometer which insures constant speed independent of the load in steps of ½ revolution per minute from 500 r.p.m. to 5,500 r.p.m. To insure precision of measurements an independent time standard of the quartz crystal type has been installed.

Soil Conservation Laboratory. The Soil Conservation Laboratory is a cooperative undertaking with the Soil Conservation Service of the United States Department of Agriculture. Its objective is the study of the mechanism of the entrainment, transportation, and deposition of solid materials by flowing streams. To house that part of the work to be carried out on the campus a one-story building has been erected. It has a floor space of about 4,500 square feet and contains the equipment used in the study of the more fundamental aspects of soil erosion. This equipment includes: (a) a transportation flume designed to study primarily the flow of a fluid carrying a suspended load. It is of the closed circuit type and circulates both the water and the solids in suspension. It is about 70 feet long and has an adjustable gradient. The maximum rate of flow is 5 cubic feet per second. (b) A circulating type of flume for the study of rate of reduction of bed load. (c) A glass-walled flume for special studies. In addition to this apparatus, the building provides space for a fineness laboratory and shop space for the construction of models and instruments for use in the investigations. (d) For studies of field problems an outdoor model basin has been erected with provision for either clear or silt-laden flow. The length is 60 feet and the maximum rate of flow is 5 cubic feet per second.

THE HUMANITIES

One of the distinctive features of the California Institute is its emphasis upon the humanistic side of the curriculum. In the degree and genuineness of this emphasis the Institute has differentiated itself from other American schools of science, most of which accord little more than a gesture of recognition to the liberal arts. As a rule, in

schools of science and engineering, the professional studies monopolize nearly all the available time and money, leaving the humanities to take what it left, which often turns out to be very little.

The California Institute has been a pioneer in recognizing the desirability of providing 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 courses. As a result, it has been found possible to require every student to take, in each of his four undergraduate years, one or more courses of a humanistic character. 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 the same plane as in the professional subjects. 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 Hall of the Humanities, erected in 1928, was given by Mr. and Mrs. Joseph B. Dabney, of Los Angeles. It contains lecture rooms, a treasure room for the exhibition of pictures and other works of art, a library—reading room, conference rooms, together with a commodious lounge, which opens upon a walled garden of olive trees. 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 1937 an addi-

tional endowment of $750,000 was received from a donor who desires to remain anonymous.

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 Professor Edwin F. Gay, formerly of Harvard University, Professor Edward A. Whitney, of Harvard University, Professor Edward M. Earle, of the Institute for Advanced Study, Professor C. Bowie Millican, of New York University, Dr. Walter Lippmann, of New York, and Mr. Godfrey Davies and Dr. Louis B. Wright, of the Huntington Library. It is anticipated that with the opportunities for research in English Literature and American History which are afforded by the proximity of the Huntington Library, the instruction given at the Institute in these fields will be steadily strengthened by the association of visiting scholars.

PUBLICATIONS OF THE STAFF

OCTOBER 1, 1937, TO SEPTEMBER 30, 1938

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*Not available for distribution.

INFORMATION AND REGULATIONS FOR THE GUIDANCE OF GRADUATE STUDENTS

A. GENERAL REGULATIONS

I. REQUIREMENTS FOR ADMISSION TO GRADUATE STANDING

1. The Institute offers graduate work leading to two higher degrees, the degree of Master of Science,* and the degree of Doctor of Philosophy. 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 courses offered by the Institute. He must, moreover, have attained such a scholastic record and, if from another institution, must present such recommendations as to indicate that he is fitted to pursue with distinction advanced study and research.

2. Application for admission to graduate standing at the Institute for work toward either the master's or the doctor's degree should be made upon a form which can be obtained from the Dean of the Graduate School. The applicant should state the degree for which he wishes to work. 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. Since admission to graduate work will be granted to only 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 May. Admission may have to be refused to students who apply at a later date, solely on the basis of limited facilities in the department in which they wish to work. Students applying for admission

*In addition the Institute offers the higher degrees of Bachelor of Science in Aeronautics, in Meteorology, and in Chemical Engineering for a fifth year of work in those departments (see pages 184-185) under the conditions applying in general to the degree of Master of Science. For the degree of Master of Science in any of these three departments, a second year of graduate study and research is required.

may be required in advance to give evidence of their ability to pay the necessary tuition fees and support themselves during the proposed period of study. Students applying for assistantships or fellowships need not make separate application for admission to graduate standing, but should make application for appointment by February 15. See Section DI.

3. Admission to graduate standing does not of itself admit to candidacy for the degree of Master of Science or Doctor of Philosophy.

II. TUITION FEES

The tuition fee for graduate students pursuing courses of more than 32 units will be $300 a year, payable in three equal installments of $100 at the beginning of each term. Students desiring permission to register for 32 units or less should petition therefor on a blank to be obtained from the Registrar. If such reduced registration is permitted, the tuition will be at the rate of $75 a term for 25 to 32 units, and at the rate of $3 a unit for less than 25 units, with a minimum of $30 a term.

The payment of tuition by graduate students is required (a) without reference to the character of the work of the student, which may consist in the prosecution of research, in independent reading, or in the writing of a thesis or other dissertation, as well as in attendance at regular classes; (b) without reference to the number of terms in which the student has already been in residence; and (c) without reference to the status of the student as an appointee of the Institute, except that members of the academic staff of rank of Instructor or higher are not required to pay tuition. Graduate students who continue their researches during the summer are not required to pay tuition fees therefor.

An annual fee of $3 to assist in the defraying of expenses in cases of emergency requiring hospitalization is required.* No other fees are required of graduate students; but charges may be made for breakage and supplies. Students working in the chemical laboratories

* See page 75.

are required to make a deposit of $15 at the beginning of the school year to cover such charges. No degrees are awarded until all bills due the Institute have been paid.

In regard to *fellowships and assistantships,* see pages 159-164 of this catalogue. In addition, to students with high scholastic attainments there may be awarded *graduate scholarships* covering one-half or the whole of the tuition fee. For such students *loans* also may be arranged, for which application should be made to the Student-Aid Committee.

B. REGULATIONS AND REQUIREMENTS CONCERNING WORK FOR THE DEGREE OF MASTER OF SCIENCE

I. GENERAL REQUIREMENTS

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 169-181), 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.

Senior students at the Institute desiring to return for a fifth year should consult with the representative of the department in which they expect to do their major work, and make application for admission to work towards the master's degree on a form which can be obtained from the Dean of the Graduate School. Such students will be expected to present satisfactory scholarship qualifications, and to have demonstrated a capacity for doing advanced work.

All programs of study, and applications for candidacy for the degree of Master of Science*, shall be in charge of the Committee on

* See footnote, page 141.

Courses in Science (in case the advanced work is to be in Physics, Chemistry, Chemical Engineering, Mathematics, Geology, Paleontology, or Biology), or of the Committee on Courses in Engineering (in case the work is to be in Civil, Mechanical or Electrical Engineering, Aeronautics or Meteorology); and recommendations to the Faculty for the award of that degree shall be made by the appropriate committee, all such actions being taken in general after consideration and recommendation by the department concerned.

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 November fifteenth of the school year in which the degree is to be granted.

II. REGISTRATION

1. The regulations governing registration and student responsibilities as given for undergraduate students on page 89 of the catalogue apply also to fifth-year students.

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

3. 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.

4. Applications for registration in excess of the prescribed number of units must be approved by the Committee on Courses in

* See footnote, page 141.

Science or by the Committee on Courses in Engineering and consent will be conditioned upon the quality of work done in the preceding term.

III. SCHOLASTIC REQUIREMENTS

1. Scholastic requirements given on pages 95-98 of the catalogue for undergraduate students also apply to fifth-year students.

2. In the case of a student registered for a master's degree and holding a position as Assistant or Teaching Fellow, the actual number of hours per week required by the teaching shall be deducted from the total number of units for which the student may register.

IV. THESIS

Two final copies of theses must be filed with the Division concerned ten days before the degree is to be conferred. In the Division of the Geological Sciences and in the department of Mathematics, a complete first draft of theses presented in partial fulfillment of the requirements for the degree of Master of Science* must be submitted to the supervising instructor by the first of May.

C. REGULATIONS CONCERNING WORK FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

I. GENERAL REGULATIONS

The degree of Doctor of Philosophy is conferred by the Institute primarily in recognition of breadth of scientific attainment and of power to investigate scientific problems independently and efficiently, rather than for the completion of definite courses of study through a stated period of residence. 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 science or engineering. 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.

* See footnote, page 141.

Subject to the general supervision of the Committee on Graduate Study, the student's work for the degree of Doctor of Philosophy is specifically directed by the department in which he has chosen his major subject. Each student should consult his department concerning special divisional and departmental requirements. See Section VI.

With the approval of the Committee on Graduate Study, any student studying for the doctor's degree whose work is not satisfactory may be refused registration at the beginning of any term by the department in which the student is doing his major work.

II. REQUIREMENTS FOR ADMISSION TO WORK FOR THE DOCTOR'S DEGREE

With the approval of the Committee on Graduate Study, students are admitted to graduate standing by the department in which they choose their major work toward the doctor's degree. In the case of insufficient preparation, applicants for the doctor's degree may be required to register for the master's degree first. The master's degree, however, is in no sense a prerequisite for the doctor's degree. Students who have received the master's degree and wish to pursue further studies leading towards the doctor's degree must file a new application for admission to graduate standing to work towards that degree.

III. REGISTRATION

1. 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.

2. Before registering, the 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.

3. 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. *The student himself is charged with the responsibility of making certain that all grades to which he is entitled have been recorded.*

4. One term of residence shall consist of one term's work of not less than 45 units of advanced work 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, but in order to obtain such credit they must register therefor in advance.

5. 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 throughout the term, for a student of superior ability.

6. 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 for.

7. Graduate students studying for the doctor's degree 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 and Assistants will be allowed to register for not more than 45 units.

IV. GRADES IN GRADUATE COURSES

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

2. Grades for all graduate work are reported 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: "A" excellent, "B" good, "C" satisfactory, "D" poor, "E" conditioned, "F" 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.

V. GENERAL REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

1. *Major and Minor Subjects:* The work for the doctor's degree must consist of scientific research and advanced studies 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 which 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 by the departments in charge both of the major and of minor subjects, and must involve not less than 45 units of advanced study in each minor subject. Such advanced study must consist of courses which are listed as graduate courses.

2. *Residence:* At least three years of work in residence subsequent to a baccalaureate degree equivalent to that given by the Institute are required for the doctor's degree. Of this at least one year must be in residence at the Institute. It should be understood that these are minimum requirements, 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 such summer work in the office of the Registrar.

A graduate student who, by special arrangement, is permitted to conduct a portion of his research in the field, in government laboratories, or elsewhere off the campus, must file a registration card for this work in the office of the Registrar, in order that it may count in fulfillment of residence requirements. The number of units to be credited for such work shall be determined by the Dean of the Graduate School in consultation with the Chairman of the Division in which the student is carrying his major work; and a recommendation as to the proportion of the full tuition to be paid for such work shall be made by the Dean to the Executive Council.

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.

3. *Admission to Candidacy:* Any student admitted to work for the doctor's degree 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 recommendation 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. Members of the permanent Institute staff of rank higher than that of Assistant Professor are not admitted to candidacy for a higher degree. For special departmental regulations concerning admission to candidacy, see Section VI.

A regular form, to be obtained from the Dean of the Graduate School, is provided for making application for admission to candidacy. Such admission to candidacy must be obtained before the close of the first term of the year in which the degree is to be conferred, and must be followed by two terms of further residence before the degree is conferred. *The student himself is responsible for seeing that admission is secured at the proper time.*

4. *Examinations:* The French and German examinations, prerequisite to admission to candidacy for the degree of Doctor of Philosophy, will be given in September on the afternoon of the date set for registration of students transferring from other colleges, and on the afternoons of the first Fridays of December and of March. Candidates may, in place of the above, take the advanced undergraduate examinations offered at the end of each term. Students who have credit for courses in languages taken at the Institute and who have a grade above average may be exempted from further requirement after consultation with the language department.

Graduate students are permitted to audit all courses in the department of languages. In general, however, it is desirable for students without previous language study to take the class work in French and German for at least the first term rather than to depend upon studying it by themselves. Students expecting to file application for candidacy in December are advised to take the September examination, so that, if their preparation is inadequate, they may enroll for the fall term in one of the language courses. No fee is charged for these examinations.

Final examinations in their major and minor subjects are required of all candidates for the doctor's degree. These examinations, 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 they must take place at least two weeks before the degree is to be conferred. The examinations may be written or oral, or both, and may be divided into parts or given all at one time

at the discretion of the departments concerned. The student must petition for these examinations on a form obtained from the Dean of the Graduate School. For special departmental regulations concerning candidacy and final examinations, see Section VI.

5. *Thesis:* The candidate is required to submit to the Dean of the Graduate School 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.

With the approval of the department concerned, a portion of the thesis may consist of one or more articles published jointly by the candidate and members of the Institute staff or others. In any case, however, a substantial portion of the thesis must be the candidate's own exposition of his work. For special departmental regulations concerning theses, see Section VI.

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 Dean of the Graduate School, 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 Dean. *The candidate himself is responsible for allowing sufficient time for the members of his committee to examine his thesis.*

6. *Grades on Degree:* The doctor's degree is awarded with the designations "*summa cum laude*," "*magna cum laude*," "*cum laude*," or without designation.

VI. SPECIAL REQUIREMENTS FOR THE DOCTOR'S DEGREE

In agreement with the general requirements for the doctor's degree adopted by the Committee on Graduate Study, as set forth in Section V (pages 148-151), the various divisions and departments of the Institute have adopted the following supplementary regulations.

A. PHYSICS, MATHEMATICS, AND ELECTRICAL ENGINEERING

1a. *Physics.* To be recommended for candidacy for the doctor's degree in Physics the applicant must pass the following subjects with a grade of C or better:

Ph. 101 a b	Electricity and Magnetism
Ph. 103 a b	Analytical Mechanics
Ph. 105 a b	Optics
Ph. 107 a b c	Atomic Physics

and any two of the following subjects:

Ph. 101 c	Electricity and Magnetism
Ph. 103 c	Analytical Mechanics
Ph. 114	Principles of Quantum Mechanics
Ph. 115	Applications of Quantum Mechanics

and, in case the applicant's minor is in Mathematics, one of the following subjects:

Ma. 8 a b c	Advanced Calculus
Ma. 10 a b c	Differential Equations
Ma. 114 a b c	Mathematical Analysis

and, in case the applicant's minor is in Chemistry, one of the following subjects:

Ch. 21 a b c	Chemical Principles
Ch. 21 a together with Ch. 23 a b	Chemical Principles

1b. *Mathematics.* To be recommended for candidacy for the doctor's degree in Mathematics the applicant must pass the following subjects with a grade of C or better:

Ma. 101 a b c	Modern Algebra (including Galois Theory)
Ma. 201 or Ma. 205	Modern Analysis or Theory of Functions
Ma. 256	Modern Differential Geometry
Ma. 102	Introduction to Higher Geometry

and any *one* of the subjects, other than the purely mathematical, listed under requirements for admission to candidacy in Physics, preferably one of the following:

Ph. 101 a b c	Electricity and Magnetism
Ph. 103 a b c	Analytical Mechanics

and a subject in the mathematical quantum theory (to be selected from those offered from year to year).

1c. *Electrical Engineering.* To be recommended for candidacy for the doctor's degree in Electrical Engineering the applicant must pass the following subjects with a grade of C or better:

Ph. 101 a b c	Electricity and Magnetism

and one of the following subjects:

Ph. 103 a b c	Analytical Mechanics
AM. 1 a b together with	Applied Mechanics
AM. 1 c	Strength of Materials

and one of the following subjects:

Ma. 8 a b c	Advanced Calculus
Ph. 5 a b c	Introduction to Mathematical Physics
Ma. 8 a b together with	Advanced Calculus
Ma. 11	Differential Equations.

and the following subjects or their equivalents:

EE. 120	Alternating Current Analysis
EE. 122	Advanced Alternating Current Machinery
EE. 144	Transmission Lines
EE. 152	Dielectrics
EE. 162	Vacuum Tubes

2. An applicant may also satisfy the requirements described above 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.

Students who fail to meet at least one-half of these requirements by the end of their first year of graduate study will not be allowed to register for further work except when special permission is obtained from the department.

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

4. Candidates for the degree of Doctor of Philosophy with a major in Physics must take the final examination some time before the beginning of the term in which they expect the degree to be conferred.

5. A candidate for the degree of Doctor of Philosophy with a major in Mathematics must deliver a typewritten or printed copy of

his completed thesis, in final form, to the professor in charge on or before May 1 of the year in which the degree is to be conferred.

6. 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.

B. CHEMISTRY*

1. To be recommended for candidacy for the doctor's degree in Chemistry the applicant must give satisfactory evidence of proficiency by means of the following:

a. Candidacy examination in physical chemistry,
b. Candidacy examination in inorganic chemistry,
c. Candidacy examination in organic chemistry,
d. Candidacy examination in colloid and surface chemistry,
e. Written report on the progress of research.

The examinations will be mainly written but will be partly oral. They will cover their respective subjects substantially to the extent that these are treated in the undergraduate chemistry option; the proficiency expected is not less than that acquired by the abler undergraduates. A detailed informational knowledge is not so much desired as an understanding of general principles and a power to apply these to concrete problems.

The written report must be a satisfactory description of the applicant's 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.

2. It is expected that the applicant shall have studied mathematics and physics substantially to the extent that these subjects are covered in the first two years of the Institute undergraduate courses. In cases where the applicant's training is less extensive than this, the Division

* The doctor's degree is not awarded in Chemical Engineering at the present time, but students interested in this field may offer a minor in Chemical Engineering in connection with a major in Chemistry or Mechanical Engineering.

of Chemistry and Chemical Engineering may prescribe additional work in these subjects prior to recommending him as candidate.

3. After admission to candidacy a student must in general pursue advanced study and research for not less than four terms (counting equivalent summer work) before he will be recommended by the Division of Chemistry and Chemical Engineering for the final examination for the doctor's degree.

4. The final examination will consist in part of the candidate's oral presentation of a brief résumé of his research and its defense against attack, and in part of the defense of a set of propositions prepared by the candidate. The candidate may also expect questions not immediately related to his research or propositions.

The propositions should be about ten in number, of which about four should relate to the minor subject and to general branches of chemistry, and about six to the branch of chemistry of major interest to the candidate, including his research. The candidate may also include propositions not relating to his major and minor fields. The propositions, prepared by the candidate himself, should display his originality, breadth of interest, and soundness of training; the candidate will be judged on his selection and formulation of the propositions as well as on his defense of them. It is recommended that the candidate begin the formulation of his set of propositions early in his course of graduate study.

A copy of the set of propositions must be submitted to the Division of Chemistry and Chemical Engineering at least two weeks before the date set for the examination. A copy of the set of propositions must be submitted to the Dean of the Graduate School with each of the two copies of the thesis.

C. CIVIL AND MECHANICAL ENGINEERING, AERONAUTICS, AND METEOROLOGY

1a. *Civil Engineering.* To be recommended for candidacy for the doctor's degree in Civil Engineering the applicant must pass with a grade of C or better, the subjects prescribed and elected for the fifth year, or equivalent substitutions satisfactory to the department,

and such other advanced subjects as the department may require, and must pass special comprehensive oral or written examinations in the fields covered by these subjects.

1b. *Mechanical Engineering.* To be recommended for candidacy for the doctor's degree in Mechanical Engineering the applicant must pass the following subjects with a grade of C or better:

Ma. 11	Differential Equations

and one of the following:

EE. 226 a b	Engineering Mathematical Physics
Ma. 8 a b c	Advanced Calculus
Ma. 15 a b c	Higher Mathematics for Engineers and Physicists

and any one of the following three groups:

ME. 101 a b	Advanced Machine Design
ME. 110 a b c	Science of Metals
ME. 111 a b c	Metallography Laboratory
AE. 270 a	Elasticity Applied to Aeronautics
ME. 120, 121, 122	Heat Engines
Ph. 211	Thermodynamics
Hy. 100	Fluid Mechanics
Hy. 101	Hydraulic Machinery
AE. 266 a b and 267	Theoretical Aerodynamics

and also special comprehensive oral or written examinations in the fields covered by these subjects.

1c. *Aeronautics.* To be recommended for candidacy for the doctor's degree in Aeronautics the applicant must pass the following subjects with a grade of C or better:

Ma. 14	Vector Analysis
AE. 251 a b c	Aerodynamics of the Airplane
AE. 266 a b	Theoretical Aerodynamics I

and one of the following:

Ma. 114 a b	Mathematical Analysis
EE. 226 a b	Engineering Mathematical Physics

and also one of the following:

AE. 252 a b c	Airplane Design
Ph. 103 a b c	Analytical Mechanics
AE. 270 a b c	Elasticity Applied to Aeronautics

If any of the above subjects was taken elsewhere than at the Institute, the candidate will be required to pass special examinations indicating an equivalent knowledge of the subject.

1d. *Meteorology.* To be recommended for candidacy for the doctor's degree in Meteorology the applicant must pass the following subjects with a grade of C or better:

Ma. 14	Vector Analysis
AE. 266 a b	Theoretical Aerodynamics I
Ph. 211	Thermodynamics

and one of the following subjects:

Ma. 114 a b	Introduction to Mathematical Analysis
EE. 226 a b	Engineering Mathematical Physics
AE. 265 a b	Mathematical Methods Applied in Aeronautics

2. In general a student will find it necessary to continue his graduate study and research for two years after admission to candidacy, and will be expected to have had six months or more of practical work.

D. GEOLOGICAL SCIENCES

1. To be admitted to candidacy for the doctor's degree in the Division of the Geological Sciences the applicant must have shown more than average ability in mastering the previous geological, paleontological, and geophysical subjects.

2. The applicant for admission to candidacy may be required to take a qualifying examination which may be oral, or written, or both.

3. After admission to candidacy, students must in general pursue advanced study and research for a minimum of six terms, or approximately two years (counting each summer of field work as a term).

4. Candidates are required to take two oral examinations after admission to candidacy. The first, termed the general examination, tests knowledge in a specified number, but not all, of the various branches of geology and paleontology, and may be taken at any convenient time after admission to candidacy. The second, or final examination, is principally, but not entirely, a defense of the doctoral thesis and a test of the candidate's knowledge in the specialized fields of his major and minor subjects.

5. A first draft of the doctoral thesis with data, maps, and illustrations complete must be submitted to the professor in charge not

later than February 1. Two copies of the final, revised thesis must be filed by April 20 with the professor in charge and circulated among the members of the examining committee. Likewise on this date, the candidate must file and circulate a paper, prepared for publication in form acceptable to his examining committee, embodying the results of his research in whole or in part.

E. BIOLOGY

1. For admission to graduate study for the doctor's degree in Biology the undergraduate Biology Option must have been passed with good grades. Students who have taken other options in the Institute and students who come from other scientific institutes or universities must satisfy the Division of Biology that their previous work has been equivalent to that of the Biology Option.

2. The substitution of subjects other than those included in the Biology Option must in each case be passed on by at least a two-thirds vote of the Division of Biology. In each department a comprehensive written examination covering advanced work in the major and minor subjects will be held at least two terms before the degree is to be conferred and must be passed for admission to candidacy. A final oral examination covering principally the work of the thesis will be held at least two weeks before the degree is to be conferred.

2a. *Animal Physiology.* For the major, the subjects in animal physiology and other supplementary subjects of graduate rank must be taken. If there is one minor, it must be taken in Biology; if there are two minors, the second may be taken outside the Division of Biology.

2b. *Biochemistry.* Either the Biology or the Chemistry Option or its equivalent will be required. In either case, examinations in Chemical Principles and Organic Chemistry, set by the Division of Chemistry, must be passed satisfactorily; and an examination on biochemistry (based on Bi. 7a, b) must also be passed. Later, more advanced work (Bi. 110 and 102) will be required before the com-

prehensive examination is taken. At least one of the minors must be in another department of the Division of Biology.

2c. *Bio-organic Chemistry.* Either the Biology or the Chemistry Option or its equivalent will be required. Those who take the Biology Option should include Ch. 46a, b (Organic Chemistry Laboratory) either as an undergraduate or graduate subject. For graduate work in bio-organic chemistry, the subjects Bi. 115 (Chemistry of Bio-organic Substances) and Bi. 141 (Plant Chemistry) are both required. For the minor some field of biology or chemistry should be chosen.

2d. *Embryology.* The Biology Option or its equivalent will be required. In addition to the subjects and the research in the major and minor fields, advanced work in at least one other department of the Division of Biology will be required. The program of work will depend upon the preliminary training of the student and will be subject to the approval of those in charge of the major work.

2e. *Genetics.* The Biology Option or its equivalent will be required. As a part of the major, Bi. 125 should be taken for at least two years, and other subjects in related fields. For a minor, some other subject or subjects, either in the Division of Biology or in some other division of the Institute, should be taken, subject to the approval of those in charge of the major.

2f. *Plant Physiology.* The Biology Option or its equivalent will be required. The major should include Bi. 140, Bi. 141, and related subjects. For a minor, one or two other subjects in the Division should be chosen, with the approval of those in charge of the major.

D. OPPORTUNITIES FOR GRADUATE AND SCIENTIFIC WORK AT THE INSTITUTE

I. FELLOWSHIPS AND ASSISTANTSHIPS

The Institute offers in each of its divisions a number of Fellowships and Graduate Assistantships. These usually carry, as stipends, tuition ($300) with or without an additional grant.

Most of the major grants consist in providing, for a continuous period of ten months, board in the Athenæum (see pages 69 and 164) and lodging in the Athenæum loggia, the Dormitory, or the Student Houses. The purpose of this plan is to enable the Fellows and Assistants of the various divisions to live together under attractive and healthful conditions, and thus secure the great educational and social advantages that result from intimate contacts with one another, with members of the professorial staff of the Institute, and with others using the Athenæum.

Students from any university or college, who have completed their undergraduate work satisfactorily (see page 141), are eligible to apply for graduate assistantships and fellowships. In the award of such appointments preferred consideration will be given to students who have been accepted as candidates for the degree of Doctor of Philosophy.

Teaching Fellows and Graduate Assistants devote during the school year not more than fifteen hours a week to teaching or laboratory assistance of a character that affords 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, unless otherwise arranged by the division or department concerned; and the obligation to prosecute the research earnestly is regarded as no less binding than that of showing proper interest in the teaching and in the advanced study, which is also pursued so far as time permits. The appointments are for a period of ten months; and it is understood that the research work will be continued in the summer, at least until this period is completed.

Forms for making application for fellowships or assistantships may be obtained on request from the Dean of the Graduate School. In using these forms it is not necessary to make separate application for admission to graduate standing. When possible, these applications should reach the Institute by February 15, and notices of awards will be mailed to successful applicants on April 1. Appointments to

fellowships and assistantships are for one year only; and a new application must be filed before February 15 of each year by all who desire appointments for the following year, regardless of whether they are already holders of such appointments or not.

II. RESEARCH FELLOWSHIPS AND SCHOLARSHIPS

The character of various fellowships and scholarships available at the Institute is described below, but in making application graduate students should not designate any particular appointment.

1. **Institute Research Fellowships:** The Institute each year appoints as Research Fellows a number of men holding the degree of Doctor of Philosophy who desire to pursue further research work.

2. **National Research Fellowships:** These fellowships, 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. **Drake Fellowships and Scholarships:** The income from the Drake Fund, provided by the late Mr. and Mrs. Alexander M. Drake, is used to maintain fellowships and scholarships in such numbers and amounts as the Board of Trustees determine. The recipients are designated as Drake Fellows and Drake Scholars.

4. **Blacker Fellowships:** The Robert Roe Blacker and Nellie Canfield Blacker Scholarship Endowment Fund, established by the late Mr. R. R. Blacker and Mrs. Blacker, provides in part for the support of graduate men engaged in research work. The recipients are designated as Blacker Fellows.

5. **Henry Laws Fellowships:** The income from a fund given by the late Mr. Henry Laws is used to provide fellowships for research in pure science, preferably in physics, chemistry, and mathematics. The recipients are designated as Henry Laws Fellows.

6. **Caroline W. Dobbins Fellowships:** The income from the Caroline W. Dobbins Fellowships and Scholarships Fund, provided by the late Mrs. Caroline W. Dobbins, is used to maintain fellowships and scholarships at the Institute. The recipients are designated as Caroline W. Dobbins Fellows or Caroline W. Dobbins Scholars.

7. **Elizabeth Thompson Stone Scholarship:** A fund provided by the late Miss Elizabeth Thompson Stone is used to maintain at the Institute the Elizabeth Thompson Stone Scholarship.

8. **Bridge Fellowship:** The late Dr. Norman Bridge provided a fund, the income of which is used to support a research fellowship. The recipient is designated as the Bridge Fellow.

9. **George Ellery Hale Research Fellowships in Radiation Chemistry:** Dr. Arthur Amos Noyes, for many years Professor of Chemistry and Director of the Gates and Crellin Laboratories of Chemistry, by his will, gave to the Institute a fund to provide for certain research fellowships to be known as the "George Ellery Hale Research Fellowships in Radiation Chemistry," these fellowships to be available to competent young investigators who have received the degree of Doctor of Philosophy or have had a corresponding research training, and who will pursue, at the Institute, investigations in radiation chemistry (broadly interpreted to include the study of molecule structure by the methods of modern physics). These fellowships are to carry stipends, obligations and privileges similar to those of the National Research Fellowships.

10. **Noyes Fellowships:** Dr. Noyes further left his entire estate, after providing for certain specific bequests and annuities, to the Institute to constitute a fund to be known as the "Noyes Chemical Research Fund." The purpose of this fund, as stated in his will, is to provide for the payment of salaries or grants to competent persons to enable them to carry on scientific investigations in the field of chemistry at the Institute. Such persons shall have the status of members of the staff of the Institute, and shall devote their time and attention mainly to the execution at the Institute of experimental and theoret-

ical researches upon the problems of pure science (as distinct from those of applied science) in the field of chemistry. Dr. Noyes further provided that "no portion of the income of the said fund shall be used for the payment of tuition fees, nor for scholarships or fellowship grants to persons still registered as students, or in general for the education of persons as to existing knowledge; but on the contrary the whole thereof shall be used for promoting, in the manner aforesaid in the field aforesaid, the search for new or more exact knowledge by persons who have completed their period of formal study and are devoting at least one-half of their working time to scientific investigations."

Special Fellowship Funds

A considerable group of governmental units, industrial organizations, and private individuals have contributed funds for the support of Fellows engaged in fundamental researches related to their interests and activities. These include the United States Navy Department, United States Reclamation Service, United States Soil Conservation Service, Metropolitan Water Board of Southern California, Los Angeles County Flood Control District, Los Angeles County Harbor Board, Los Angeles County seismological interests, American Petroleum Institute, General Petroleum Corporation, Polymerization Process Corporation, Shell Oil Company, Standard Oil Company of California, Texaco Development Corporation, Union Oil Company of California, Consolidated Aircraft Corporation, Curtiss-Wright Corporation, Douglas Aircraft Co., Inc., Lockheed Aircraft Corporation, North American Aviation, Inc., Vultee Aircraft Division, Aviation Mfg. Corporation, Agfa-Ansco Corporation, Allis-Chalmers Manufacturing Company, Asphalt Institute, Caterpillar Tractor Co., Geo-Frequenta Corporation, Hughes Tool Company, Kelco Company, Lane-Wells Company, National Supply Company, Rare Metals Institute, Research Corporation of New York, A. O. Smith Corporation, Submarine Signal Company, Mr. Arnold Pfau, Dr. W. M. White, and the Mudd and Kellogg funds for research on cancer and carcinogenic substances.

The Rockefeller Bio-Organic Fund: This fund is contributed by the Rockefeller Foundation for the support of a group of post-doctorate men who are working on the problem of the molecular structure of organic substances.

The Carnegie Corporation Cosmic Ray Fund: This fund is given by the Carnegie Corporation and administered by the Carnegie Institution of Washington, D. C., for cosmic-ray researches carried on by a group of five or six men.

The Earhart Foundation has contributed funds for the whole program of meteorological research at the Institute, including the development and use of the radiometeorograph.

III. INSTITUTE GUESTS

Members of the faculties of other educational institutions and Research Fellows already holding the doctor's degree, who desire to carry on special investigations, may be invited to make use of the facilities of the Institute. Arrangement should be made in advance with the chairman of the division of the Institute concerned. 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.

IV. GRADUATE LIFE

The Athenæum (see page 69) affords opportunity for contact between the Associates of the Institute, distinguished foreign visitors, and members of the staffs and graduate students at the three adjacent institutions, the Mount Wilson Observatory, the Huntington Library, and the California Institute. It also provides living quarters for a limited number of men associated with the foregoing institutions, including specially economical sleeping quarters for about eighteen graduate students.

DESCRIPTION OF THE UNDERGRADUATE AND FIFTH-YEAR COURSES

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 trains, 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 co-ordinated 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.

Laboratory facilities are available for experimental work in hydraulics, thermodynamics, metallography, materials of construction, soil

mechanics, and electricity, including a high-voltage laboratory with a maximum rating of one million volts.

The fifth-year courses in Civil, Mechanical, and Electrical Engineering, and Aeronautics 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 water systems, sanitation works and structures; the Mechanical Engineering Course, with machine design, steam and gas engineering, and power-plant design and operation; the Electrical Engineering Course with the generation, transmission and utilization of electric power and the communication of intelligence by electrical means; and the Aeronautics 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 extensive 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 governmental laboratories and especially in the research and develop-

ment departments of the larger chemical, metallurgical, and electrical companies.

The Option in Applied Chemistry and the fifth-year and sixth-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 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 affords a preliminary training, with emphasis on the fundamental sciences, for those who desire to pursue graduate studies in medicine, sanitation, and the public health.

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.

Besides the subjects shown in the course schedules, students are required to take Assembly and Physical Education in each term of each of the four school years. Students who continue their undergraduate work beyond four years continue to take Physical Education throughout their undergraduate course. Freshmen attend in the second and third terms, in addition to the general assemblies, six orientation assemblies.

The subject numbers correspond to those given in the description of subjects on pages 187-257. The abbreviations denote the various branches of instruction as follows:

Aeronautics	AE
Applied Chemistry	A Ch
Applied Mechanics	AM
Applied Physics	A Ph
Assembly	As
Astronomy	Ay
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
Meteorology	My
Philosophy	Pl
Physical Education	PE
Physics	Ph
Thesis	Th

BOTH COURSES

FIRST YEAR, ALL THREE TERMS

		Units per Term
En 1 abc	English* (3-0-3)**	6
Ph 1 abc	Physics* (3-3-6)	12
Ch 1 abc	Chemistry* (3-6-3)	12
Ma 1 abc	Mathematics* (4-0-8)	12
H 1 abc	History (3-0-2)	5
D 1, 3 ab	Drawing*** (0-3-0)	3

*Students are required to pass, at the end of the sophomore year, comprehensive examinations in English and History, in Physics, and in Mathematics. Students taking the Options in Chemistry or Applied Chemistry are required to pass also a comprehensive examination in Chemistry.

**Number of hours devoted to class, laboratory, and preparation.

***D 1 is taken by all freshmen the first term, and D 3a, b, the second and third terms, respectively.

COURSE IN ENGINEERING

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

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 96.

SECOND YEAR

		Units per Term 1st	2nd	3rd
Ma 2 abc	Mathematics*† (4-0-8)**	12	12	8*
Ph 2 abc	Physics*† (3-3-6)	12	12	8*
Ma 2 d	Mathematics Review† (4-0-8)	..	..	4*
Ph 2 d	Physics Review† (3-3-6)	..	..	4*
H 2 abc	History*** (2-0-4)	6	6	6
CE 1	Surveying (3-4-4)	..	11 or	11
ME 1	Mechanism (3-3-3)	9 or	9 or	9
ME 3	Materials and Processes (3-3-5)	..	11 or	11
Ge 1a	Geology (3-3-3)	9	..	..
D 3c	Descriptive Geometry (0-3-0)	3 or	3	..
D 3d	Descriptive Geometry (0-3-0)	..	3 or	3
D 6a	Engineering Drawing (0-6-0)	6 or	6	..
D 6b	Engineering Drawing (0-6-0)	..	6 or	6

*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 each) during the three weeks preceding the opening of the fall term, provided not less than six students apply for it.

**Number of hours devoted to class, laboratory, and preparation.

***All students are required to pass a comprehensive examination in English and History at the end of the sophomore year.

COURSE IN ENGINEERING
ELECTRICAL ENGINEERING OPTION

(For First and Second Years, see pages 169 and 170)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 96.

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
AM 1 abc	Applied Mechanics (4-3-7)	14	14	14
Ch 6	Engineering Chemistry (3-0-6)	9	..	..
Ec 17	Accounting (3-0-6)	9	..	..
EE 2	Direct Currents (3-0-6)	..	9	..
EE 3	Direct Current Laboratory (0-3-3)	..	6	..
EE 4	Alternating Currents (3-0-6)	..	..	9
EE 5	Alternating Current Laboratory (0-3-3)	..	..	6
A: Ma 11	Differential Equations (3-0-6)	..	9	..
ME 15	Heat Engineering (3-3-6)	12	..	..
Hy 5	Hydraulics (3-3-6)	..	..	12
B: Ph 5 abc	Mathematical Physics (4-0-8)	12	12	12

FOURTH YEAR

	Humanities Electives* (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
Ec 2	Economics (4-0-6)	..	10	..
Ec 25	Business Law (3-0-3)	6	..	..
EE 6 ab	Electrical Machinery (2-0-4) (3-0-6)	..	6	9
EE 7	Electrical Engineering Laboratory (0-3-6)	..	..	9
EE 12	Electric Circuits (3-0-9)	12	..	..
EE 70 abc	Engineering Conferences	2	2	2
Ph 7 abc	Electricity and Magnetism (2-0-4)	6	6	6
Ph 9 ab	Electrical Measurements (0-3-1)	4	4	..
A†: EE 162	Vacuum Tubes (4-0-8)	..	12	..
ME 27	Mechanical Laboratory (0-3-6)	9	..	..
ME 18	Heat Engineering (3-0-7)	..	..	10
B†: EE 162	Vacuum Tubes (4-0-8)	..	12	..
ME 15	Heat Engineering (3-3-6)	12	..	..
Hy 5	Hydraulics (3-3-6)	..	..	12

*Humanities Electives

Pl 1	Philosophy (Soares)	En 10	Modern Drama (Stanton, Huse)
Pl 4	Ethics (Soares)	En 11	Literature of the Bible (MacMinn)
En 8	Contemporary Literature (Eagleson, Judy)	L 40	German Literature (Macarthur)
En 9	American Literature (MacMinn)	Pl 5	Sociology (Laing)

Students are required to take one term of Philosophy or Ethics, and choose two terms from the other electives. The assignment to each subject is 9 units (3-0-6).

†Options A and B in the fourth year are dependent upon the third year options, except for third term, when ME 18 or EE 162 may be substituted by students in either group.

COURSE IN ENGINEERING
CIVIL ENGINEERING OPTION

(For First and Second Years, see pages 169 and 170)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 96.

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
AM 1 abc	Applied Mechanics (4-3-7)	14	14	14
CE 2	Advanced Surveying (3-6-3)	12	..	..
Ch 6	Engineering Chemistry (3-0-6)	9	..	..
Ec 25	Business Law (3-0-3)	6	..	..
Hy 1 ab	Hydraulics (3-3-6) (3-0-6)	..	12	9
Ec 17	Accounting (3-0-6)	..	9	..
CE 4	Highway Engineering (3-0-3)	..	6	..
ME 20	Heat Engineering (2-3-4)	..	..	9
Ec 2	Economics (4-0-6)	..	..	10

FOURTH YEAR

	Humanities Electives* (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
CE 14 abc	Engineering Conferences (1-0-1)	2	2	2
AM 3	Testing Materials (0-3-3)	..	6	..
CE 8 abc	Railway Engineering	6	6	6
CE 10 abc	Theory of Structures	12	12	9
CE 12	Reinforced Concrete (3-3-6)	..	..	12
EE 8	Direct Currents (3-0-4)	7	..	..
EE 9	Direct Current Laboratory (0-3-2)	5	..	..
Hy 2	Hydraulics Laboratory (0-6-0)	6	..	..
EE 10	Alternating Currents (3-0-4)	..	7	..
EE 11	Alternating Currents Laboratory (0-3-2)	..	5	..
Ge 110	Engineering Geology** (2-2-5)	..	..	9

*See first footnote on page 171.

**Men anticipating fifth year may elect Ma. 11 (9 units) as an alternate.

COURSE IN ENGINEERING
MECHANICAL ENGINEERING OPTION

(For First and Second Years, see pages 169 and 170)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 96.

	THIRD YEAR	Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
AM 1 abc	Applied Mechanics (4-3-7)	14	14	14
Hy 1 a	Hydraulics (3-3-6)	12	..	..
Hy 1 b	Hydraulics (3-0-6)	..	9	..
Ch 6	Engineering Chemistry (3-0-6)	9	..	..
Ec 25	Business Law (3-0-3)	6	..	..
ME 15	Heat Engineering (3-3-6)	..	12	..
Hy 2	Hydraulics Laboratory (0-3-3)	..	6	..
ME 16	Heat Engineering (4-0-8)	..	..	12
Ec 17	Accounting (3-0-6)	..	..	9
ME 25	Mechanical Laboratory (0-3-3)	..	..	6
	FOURTH YEAR			
	Humanities Electives* (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
ME 50	Engineering Conferences (1-0-1)	2	2	2
AM 3	Testing Materials (0-3-3)	..	..	6
CE 9	Structures (3-3-5)	..	11	..
ME 5a	Machine Design (3-0-6)	9	..	..
ME 5b	Machine Design (3-3-3)	..	9	..
ME 5c	Machine Design (3-3-3)	..	..	9
ME 10	Metallurgy (2-0-4)	6	..	..
ME 17	Heat Engineering (3-0-6)	9	..	..
ME 26	Mechanical Laboratory (0-3-3)	..	6	..
EE 8	Direct Currents (3-0-4)	7	..	..
EE 9	Direct Currents Laboratory (0-3-2)	5	..	..
Ec 2	Economics (4-0-6)	..	10	..
EE 10	Alternating Currents (3-0-4)	..	..	7
EE 11	Alternating Currents Laboratory (0-3-2)	..	..	5
	Elective†	..	..	9

Men who attend the graduate school of aeronautics must substitute Ma. 11 (9 units) and Elective (3 units) for Me. 16 in the third term of the third year and in the fourth year must substitute:

Ma 8 abc	Advanced calculus (3-0-6)	9	9	9
ME 8	Machine Design (3-3-6)	12	..	..
AE 2 ab	Aircraft Structures	..	12	12
AM 3	Testing Materials Laboratory (0-3-3)	..	6	..
	Elective	..	2	6

*See first footnote on page 171.

†Ma 11, Differential Equations, advised for all who expect to take fifth year.

COURSE IN SCIENCE

FOR STUDENTS PREPARING FOR CHEMISTRY, APPLIED CHEMISTRY, PHYSICS, APPLIED PHYSICS, MATHEMATICS, GEOLOGY, PALEONTOLOGY, BIOLOGY, ASTRONOMY AND MEDICINE

(For First Year, see page 169)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 96.

	SECOND YEAR	Units per Term 1st	2nd	3rd
Ma 2 abc	Mathematics*† (4-0-8)	12	12	8*
Ph 2 abc	Physics*† (3-3-6)	12	12	8*
Ma 2d	Mathematics Review (4-0-8)	..	..	4*
Ph 2d	Physics Review (3-3-6)	..	..	4*
H 2 abc	History*** (2-0-4)	6	6	6
Ch 12 ab	Chemistry (2-6-2) (Except Ph., Ap.Ph. and Ma.)	10	10	..
Ge 1a	Geology (3-3-3)	9	..	..
Bi 1	Biology (3-3-3)	..	9	..
Ge 1b Bi 2 Ay 1	Paleontology (4-1-4) or Biology (3-4-2) or Astronomy (3-1-5)	..	..	9
	Options as below	..	..	10

OPTIONS

PHYSICS, APPLIED PHYSICS, AND MATHEMATICS
(Students in these options do not take Ch 12 ab)

Ma 3	Theory of Equations (3-0-7)	10	..	..
Ma 14	Vector Analysis (3-0-7)	..	10	..
Ch 11	Analytical Chemistry (2-6-2)	..	..	10

CHEMISTRY AND APPLIED CHEMISTRY

Ch 12c	Analytical Chem. and Chem. Review** (2-6-2)	..	..	10

BIOLOGY

Bi 4	Invertebrate Zoology (2-6-2)	..	..	10

GEOLOGY**

CE 1	Surveying (3-4-4)	..	..	11
D 5	Descriptive Geometry (0-3-0)	..	..	3
Ge 1c	Historical Geology (3-0-6)	..	..	9

*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 3 weeks preceding the opening of the fall term, provided not less than six students apply for it.

**Students in Geology do not take Mathematics the third term.

***All students are required to pass a comprehensive examination in English and History at the end of the sophomore year.

COURSE IN SCIENCE
PHYSICS OR ASTRONOMY OPTION

(For First and Second Years, see pages 169 and 174)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 96.

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ch 21 a Ch 23 ab	Chemical Principles (4-0-6)	10	10	10
Ph 5 abc	Introduction to Mathematical Physics (4-0-8)	12	12	12
Ma 10 abc	Differential Equations (3-0-6)	9	9	9

FOURTH YEAR

	Humanities Electives* (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
Ec 2	Economics (4-0-6)	..	10	..
L 35 a	German (4-0-6 or 3-0-3)	10	6**	6**
Ma 8 abc	Advanced Calculus (3-0-6)	9	9	9
Ma 118 ab	Introduction to Statistics (3-0-6)	9	..	..
Ch 43	Organic Chemistry (2-6-2)	..	..	10

PHYSICS OPTION

An average grade of 2 or better in Ph 5 abc is required for admission to Ph 101 abc

Ph 101 abc	Electricity and Magnetism (3-0-6)	9	9	9
Ph 9 abc	Electrical Measurements (0-3-1)	4	4	4

*See first footnote on page 171.

**Students may, with the approval of the language department and the Registrar, substitute French (L 1 a, b), 10 units, for German (L 35 b, c) in the second and third terms.

COURSE IN SCIENCE
APPLIED PHYSICS OPTION

(For First and Second Years, see pages 169 and 174)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 96.

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ch 21 a Ch 23 ab	Chemical Principles (4-0-6)	10	10	10
Ph 5 abc	Introduction to Mathematical Physics (4-0-8)	12	12	12
Ph 7 abc	Electricity and Magnetism (2-0-4)	6	6	6
Ph 9 abc	Electrical Measurements (0-3-1)	4	4	4

FOURTH YEAR

	*Humanities Electives** (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
Ec 2	Economics (4-0-6)	..	..	10
L 35 abc	German (4-0-6 or 3-0-3)	10	6**	6**
AM 1 abc	Applied Mechanics (4-3-7 or 4-1-7)	14	12***	12***
EE 8, 9	Direct Currents (3-3-6)	12	..	..
EE 10, 11	Alternating Currents (3-3-6)	..	12	..
ME 15 EE 162	Heat Engineering (3-3-6), or Vacuum Tubes (4-0-8)	..	12	..
Ma 11 Ch 43	Differential Equations (3-0-6), or Organic Chemistry (2-6-2)	..	..	9 or 10

*See first footnote on page 171.

**Students may, with the approval of the language department and of the Registrar, substitute French (L 1 a, b), 10 units, for German (L 35 b, c) in the second and third terms.

***Students in this option, with the approval of the applied mechanics department and of the Registrar, may register for the two additional hours of computing normally taken.

COURSE IN SCIENCE
MATHEMATICS OPTION

(For First and Second Years, see pages 169 and 174)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 96.

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ch 21 a	Chemical Principles (4-0-6)	10	..	..
Ma 4 ab	Analytic Geometry (3-0-7)	..	10	10
Ma 8 abc	Advanced Calculus (4-0-8)	12	12	12
Ma 10 abc	Differential Equations (3-0-6)	9	9	9

FOURTH YEAR

	Humanities Electives* (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
Ec 2	Economics (4-0-6)	..	10	..
L 35 a	German (4-0-6)	10	..	..
L 1 ab	French (4-0-6)	..	10	10
Ma 106 abc	Introduction to Theory of Functions of Real Variables	5	5	5
Ma 107	Conformal Representation	..	..	9
Ma 101 abc	Modern Algebra (3 lectures a week)	6	6	6
Ma 102 ab	Higher Geometry (3-0-6)**	9	9	..
Ma 201 a	Modern Analysis	15	..	..

*See first footnote on page 171.
**See note on Ma 102, page 210.

COURSE IN SCIENCE
CHEMISTRY OPTION

(For First and Second Years, see pages 169 and 174)

Students of the Chemistry or Applied Chemistry Option whose average grade (credits divided by units) in the required chemistry subjects of the sophomore or junior year is less than 1.9 will be admitted to the required chemistry subjects of the following year only with the special permission of the Division of Chemistry and Chemical Engineering.

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ch 21 abc	Chemical Principles (4-0-6)	10	10	10
Ch 26 ab	Physico-Chemical Laboratory (0-6-2 or 0-3-1)	..	8	4
Ch 41 abc	Organic Chemistry (3-0-5 or 2-0-4)	8	8	6
Ch 46 ab	Organic Chemistry Laboratory (0-6-0; 0-10-0)	6	6	10
Ch 16	Instrumental Analysis (0-6-2)	8	..	..

FOURTH YEAR

	Humanities Electives* (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
Ec 2	Economics (4-0-6)	..	..	10
L 35 abc	German (4-0-6 or 3-0-3)	10	6**	6**
Ch 22 ab	Thermodynamic Chemistry (2-0-4)	6	6	..
Ch 61 abc	Industrial Chemistry (2-0-4 or 2-0-2)	6	4	6
Ch 29	Colloid and Surface Chemistry (3-0-5)	..	..	8
A: Ch. 80-86	Chemical Research	5	5	9
Ch 13 ab	Inorganic Chemistry (2-0-2)	4	4	..
Ch 14 ab	Inorganic Chemistry Laboratory	8	12	..
B: Ch 80-86	Chemical Research	5	9	9
Ph 5 ab	Introduction to Mathematical Physics	12	12	..

*See first footnote on page 171.

**Students may, with the approval of the language department and of the Registrar, substitute French (L 1 a, b) 10 units, for German (L 35 b, c) in the second and third terms.

COURSE IN SCIENCE
APPLIED CHEMISTRY OPTION

(For First and Second Years, see pages 169 and 174)

Students of the Chemistry or Applied Chemistry Option whose average grade (credits divided by units) in the required chemistry subjects of the sophomore or junior year is less than 1.9 will be admitted to the required chemistry subjects of the following year only with the special permission of the Division of Chemistry and Chemical Engineering.

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ch 21 abc	Chemical Principles (4-0-6)	10	10	10
AM 2 ab	Applied Mechanics (4-0-8)	12	12	..
Ch 63 ab	Chem. Eng. Thermodynamics (2-0-4)	..	6	6
Ec 2	Economics (4-0-6)	..	..	10
Ch 26 ab	Physical Chemistry Laboratory (0-3-1)	..	4	4
Ch 16	Instrumental Analysis (0-6-2)	8	..	..

FOURTH YEAR

	Humanities Electives* (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
L 35 abc	German (4-0-6 or 3-0-3)	10	6**	6**
Ch 41 abc	Organic Chemistry (3-0-5 or 2-0-4)	8	8	6
Ch 46 ab	Organic Chemistry Laboratory (0-9-0)	9	9	..
Ch 29	Colloid and Surface Chemistry (3-0-5)	..	..	8
Ch 22a	Thermodynamic Chemistry (2-0-4)	6	..	..
Ch 61 abc	Industrial Chemistry (2-0-4 or 2-0-2)	6	4	6
EE 8, 9	Direct Currents (3-3-6)	..	12	..
EE 10, 11	Alternating Currents (3-3-6)	..	..	12

*See first footnote on page 171.

**Students may, with the approval of the language department and of the Registrar, substitute French (L 1 a, b) 10 units, for German (L 35 b, c) in the second and third terms.

COURSE IN SCIENCE
GEOLOGICAL SCIENCES OPTION*

(For First and Second Years, see pages 169 and 174)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 96.

THIRD YEAR

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ch 21 a / Ch 23 a	Chemical Principles (4-0-6)	10	10	..
CE 3	Plane Table Surveying (1-6-1)	..	..	8
Ge 3 abc	Mineralogy	12	12	12
Ge 14	Geologic Illustration	10	..	..
Ge 121 ab	Field Geology	..	10	10

FOURTH YEAR

	Humanities Electives** (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
Ec 2	Economics (4-0-6)	..	..	10
L 35 abc	German (4-0-6 or 3-0-3)	10	6***	6***
Ge 109	Structural Geology (4-0-6)	10	..	..
Ge 111 ab	Invertebrate Paleontology‡	8	10	..
Ge 112 ab	Vertebrate Paleontology (2-6-2)‡	..	10	10
Ge 105	Optical Mineralogy (2-6-2)‡	10	..	..
Ge 106 ab	Petrography‡	..	10	10
Ge 100	Geology Club	1	1	1
Ge 21, 22	Thesis‡	..	..	..

*Summer Field Geology required after both Junior and Senior Years.

**See first footnote on page 171.

***Students may, with the approval of the language department and of the Registrar, substitute French (L 1 a, b) 10 units, for German (L 35 b, c) in the second and third terms.

‡Students desiring to specialize in physical geology may take Ge 105 and Ge 106 in conjunction with one paleontology course. Those desiring to specialize in paleontology may take both Ge 111 and Ge 112, omitting Ge 105 and Ge 106. In either case the course not taken in the fourth year is to be taken in the fifth. Thesis units, Ge 21 or 22, arranged to bring total units per term to 50.

COURSE IN SCIENCE
BIOLOGY OPTION

(For First and Second Years, see pages 169 and 174)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in the subjects listed under his division may, at the discretion of his department, be refused permission to continue the work of that option. A fuller statement of this regulation will be found on page 96.

THIRD YEAR*

		Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ec 2	Economics (4-0-6)	..	10	..
Ch 41 ac	Organic Chemistry (3-0-5, 2-0-4)	8	..	6
Ch 21 a	Chemical Principles (4-0-6)	10	..	..
Ch 23 ab	Chemical Principles (4-0-6)	..	10	10
Bi 11	Entomology (2-3-3)	..	..	8
A: Courses offered in 1938-39 and every second year:				
Bi 3	Botany (2-9-3)	14	..	..
Bi 5 ab	Plant Physiology (3-6-3 and 2-4-2)	..	12	8
B: Courses offered in 1937-8 and every second year:				
Bi 12	Histology (1-6-2)	9	..	..
Bi 13	Mammalian Anatomy (1-2-2)	5	..	..
Bi 6	Embryology (2-8-2)	..	12	..
Bi 8	Advanced Genetics (2-3-3)	..	..	8

FOURTH YEAR

	Humanities Electives** (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	..
H 10	U. S. Constitution (1-0-1)	..	..	2
L 35 a	German (4-0-6)	10	..	..
L 1 ab	French (4-0-6)	..	10	10
Bi 16 ab	Animal Physiology (3-2-5)	10	10	..
Bi 7 ab	Biochemistry (2-4-4)	..	10	10
Bi 20	Biological Literature (0-0-4)	4	..	..
Bi 22	Research	..	..	10
	And one of the following:			
A: Courses offered in 1938-39, same as in third year		14	12	8
B: Courses offered in 1937-8, same as in third year		14	12	8

*Students taking the Biology Option are urged to take Bi 17 (Vertebrate Anatomy, 10 units), at Corona del Mar in the summer between their second and third years.

**See first footnote on page 171.

SCHEDULES OF COURSES FOR THE DEGREE OF MASTER OF SCIENCE

SUBJECTS COMMON TO ALL COURSES

		Units per Term 1st	2nd	3rd
H 100	Seminar in American History and Government			
En 100	or English Literature	9	9	9
Pl 100	or Philosophy			
Ec 100 abc	or Business Economics	12	12	12
	Engineering or Research Seminars	2	2	2
	Professional Subjects	42	42	42

ELECTRICAL ENGINEERING

	Subjects common to all courses	11	11	11
EE 120	Alternating Current Analysis	12	..	..
EE 122	Advanced Alternating Current Machinery	..	12	..
EE 144	Transmission Lines	..	..	12
EE 121 abc	Alternating Current Laboratory	6	6	6
EE 148	Specifications and Design	6	..	..
EE 160	Electric Transients	..	6	..
EE 152	Dielectrics	..	..	6
	Research or Thesis	12	12	12
	Electives, as below	6	6	6

ELECTIVES

EE 162	Vacuum Tubes	..	12	..
EE 128	Electric Traction	..	..	9
EE 156	Electrical Communication	6	..	..
EE 130	Light and Power Distribution	..	..	6
Ph 5 abc	Introduction to Mathematical Physics	12	12	12

CIVIL ENGINEERING

	Subjects common to all courses	11	11	11
CE 23	Statically Indeterminate Structures	12	..	..
CE 16	Masonry Structures	..	..	9
Ma 15 abc	Higher Mathematics for Engineers	9	9	9
CE 15	Irrigation and Water Supply	..	12	..
CE 21 abc	Structural and Civil Engineering Design	12	9	9
CE 17	Sewerage	..	..	9
AM 105	Soil Mechanics	6	..	..
CE 115	Foundations	..	6	..
	Research or Other Thesis	3	6	6

SUPPLEMENTARY SUBJECTS

CE 101 ab	Water Power Plant Design	10	10	..
CE 105 bc	Statically Indeterminate Structures	..	..	..
CE 107 abc	Geodesy and Precise Surveying	6	6	6
CE 108	Highway Problems	..	..	..
CE 110 bc	Sewage Treatment Plant Design	..	10	10
CE 114	Earthquake Effects upon Structures	..	..	..
Ge 110	Engineering Geology	..	..	9
AE 270	Elasticity	12	6	6
AE 273 abc	Synoptic Meteorology	12	12	12
Hy 100	Applied Hydrodynamics	..	12	..
Hy 103	Hydraulic Problems	..	..	6

MECHANICAL ENGINEERING

		Units per Term 1st	2nd	3rd
	Subjects common to all courses (page 182)	11	11	11
ME 110a	Science of Metals	6	..	..
ME 111a	Metallography Laboratory	6	..	..
ME 120	Heat Engineering	12	..	..
Ma 15	Higher Mathematics for Engineers			
	or	9	9	9
Ma 8	Advanced Calculus			
	Electives, as below	9*	36	36

ELECTIVES*

ME 101 ab	Advanced Machine Design	..	12	12
ME 110 bc	Science of Metals	..	6	6
ME 111 bc	Metallography Laboratory	..	6	6
ME 121, 122	Heat Engineering	..	12	12
Hy 100	Fluid Mechanics	..	12	..
Hy 101	Hydraulic Machinery	..	..	12
	Research or Thesis, as arranged			

AERONAUTICS

FIFTH YEAR

(Leading to the degree of Bachelor of Science in Aeronautics)

	Subjects common to all courses (page 182)	11	11	11
AE 251 abc	Aerodynamics of the Airplane	9	9	9
AE 252 abc	Airplane Design	12	12	12
AE 253 abc	Airplane Design and Testing Procedure	6	6	6
EE 226 ab	Engineering Mathematical Physics	15	15	..
or				
MA 114 ab	Mathematical Analysis	12	12	..
MA 14	Vector Analysis	..	..	12
AE 290 abc	Aeronautics Seminar	2	2	2
AE 260	Research in Aeronautics	..	..	..
	*Electives	..	..	..

SIXTH YEAR

(Leading to the degree of Master of Science in Aeronautics)

AE 254 abc	Advanced Problems in Airplane Design	9	9	9
AE 266 ab	Theoretical Aerodynamics I	12	9	..
AE 267	Theoretical Aerodynamics II	..	..	12
AE 270	Elasticity Applied to Aeronautics	12	6	6
AE 290	Aeronautics Seminar	2	2	2
AE 260	Research in Aeronautics	..	..	..
	Electives	..	..	..

*Ma 11 Differential Equations must be taken in the first term unless the student has already passed the course in the fourth year.

METEOROLOGY

FIFTH YEAR

(Leading to the degree of Bachelor of Science in Meteorology)

		Units per Term 1st	2nd	3rd
	Subjects common to all courses (page 182)	11	11	11
AE 273 abc	Synoptic Meteorology	12	12	12
AE 274 abc	Meteorological Laboratory	15	15	15
AE 276	Meteorological Instruments	6	..	..
AE 280	Research	..	..	..
AE 291 abc	Meteorological Seminar	2	2	2
Ph 91 abc	Introduction to Mathematical Physics	8	8	8

SIXTH YEAR

(Leading to the degree of Master of Science in Meteorology)

*AE 272 abc	Dynamic Meteorology	9	9	9
AE 274 abc	Meteorological Laboratory	15	15	15
AE 275	Structure of the Atmosphere	..	..	3
AE 280	Research	..	..	..
AE 291 abc	Meteorological Seminar	2	2	2
Ma 118 abc	Introduction to Statistics	9	9	9
	Electives	..	..	..

PHYSICS OR APPLIED PHYSICS

	Subjects common to all courses (page 182)	11	11	11

ELECTIVES

Ph 110 ab	Kinetic Theory	..	9	9
Ph 107 abc	Atomic Physics	9	9	9
Ph 108	Spectroscopy Laboratory	..	3	..
Ph 103 abc	Analytical Mechanics	12	12	12
Ph 105 ab	Optics	9	9	..
Ph 106 ab	Optics Laboratory	3	3	..
EE 162	Vacuum Tubes	..	..	12
Ma. 114	Mathematical Analysis	12	12	12
Ph 114	Principles of Quantum Mechanics	..	..	9
Ph 115	Applications of Quantum Mechanics	9	..	..
Ph 116	Relativistic Quantum Mechanics	..	9	..
Ma 118 abc	Introduction to Statistics	9	9	9
Ph 120	History of Physics Seminar	4-9	4-9	4-9
	Research	15	15	15

MATHEMATICS

	Subjects common to all courses (page 182)	11	11	11
	Courses open to graduates in Mathematics Curriculum, 45 units during the year.			
	Research	6	6	6
	Subjects in fifth-year Physics Course			

*AE 272 abc will replace Ph 91 abc on fifth year students' curricula when a one-year course is pursued.

CHEMISTRY

		Units per Term 1st	2nd	3rd
	Subjects common to all courses (page 182)	11-14	11-14	11-14
	Subjects chosen from the following electives to constitute a program of study approved by a member of the Division.			
Ch 113 ab	Inorganic Chemistry	4	..	4
Ch 122 ab	Thermodynamic Chemistry	6	6	..
Ch 129	Colloid and Surface Chemistry	..	..	8
Ch 166 abc	Chemical Engineering	3	..	9
Ch 167 abc	Chemical Engineering Laboratory	15	15	15
Ch 169	Research Manipulations	..	3	..
Ch 221 abc	The Nature of the Chemical Bond	6	6	6
Ch 222 abc	Seminar on Thermodynamics and Statistical Mechanics with Chemical Applications	6	6	6
Ch 223 ab	Kinetics of Homogeneous and Heterogeneous Reactions	6	6	..
Ch 226 abc	Introduction to Quantum Mechanics, with Chemical Applications	9	9	9
Ch 227 abc	The Structure of Crystals	6	6	6
Ch 228 abc	Crystal Structure Laboratory	..	..	..
Ch 229	Diffraction Methods of Determining the Structure of Molecules	6	6	6
Ch 230	Photochemistry	..	..	6
Ch 232	Radioactivity and Isotopes	..	..	6
Ch 234	Introduction to the Spectra of Molecules	6	..	..
Ch 241	Qualitative Organic Chemical Analysis	12	..	..
Ch 242	Quantitative Organic Chemical Analysis	..	12	..
Ch 243	Quantitative Organic Microanalysis	..	..	20
Ch 244 abc	The Reactions of Organic Compounds	6	6	6
Ch 245 abc	The Synthesis of Organic Compounds	6	6	6
Ch 246 abc	Theoretical Organic Chemistry	6	6	6
Ch 247	Advanced Organic Laboratory	..	..	..
Ch 251	Organic Chemistry	6	6	6
Ch 253	The Chemistry of Vitamins and Enzymes	..	..	4
Ch 180-186	Research	12-18	12-18	12-18

CHEMICAL ENGINEERING

FIFTH YEAR

(Leading to the degree of Bachelor of Science in Chemical Engineering)

	Subjects common to all courses (page 182)	11-14	11-14	11-14
Ch 166 abc	Chemical Engineering	12	12	12
Ch 167 abc	Chemical Engineering Laboratory	15	15	15
	Elective courses in Chemistry, Physics, Mathematics, and Mechanical Engineering.			

SIXTH YEAR

(Leading to the degree of Master of Science in Chemical Engineering)

Ch 186	Research	20-30	20-30	20-30
	Approved elective courses in Chemistry, Physics, Mathematics and Mechanical Engineering.			

GEOLOGICAL SCIENCES

		Units per Term 1st	2nd	3rd
	Subjects common to all courses	11	11	11
	Subjects chosen from the following electives to constitute a program of study approved by a Division representative	39	39	39
Ge 100	Geology Club	1	1	1
Ge 105	Optical Mineralogy**	10	..	..
Ge 106 ab	Petrography**	..	10	10
Ge 109	Structural Geology	10	..	..
Ge 110	Engineering Geology	..	..	9
Ge 111 ab	Invertebrate Paleontology**	8	10	..
Ge 112 ab	Vertebrate Paleontology**	..	10	10
Ge 121 ab	Field Geology	..	10	10
Ge 122	Spring Field Trip	..	..	1
Ge 123	Summer Field Geology	..	..	12
Ge 175	Elementary Geophysics	5‡	..	..
Ge 176	Elementary Seismology	5†	..	..
Ge 187	Research	..	..	..
Ge 200	Mineragraphy	8	..	..
Ge 201	Introduction to Economic Geology	5	..	..
Ge 202	Metalliferous Deposits	..	10	..
Ge 210	Advanced Petrology	..	8	..
Ge 211	Petrology (Seminar)	..	..	5
Ge 212	Non-Metalliferous Ore Deposits	..	..	10
Ge 213	Advanced Economic Geology (Seminar)	..	5‡	..
Ge 214	Advanced Economic Geology (Seminar)	..	5†	..
Ge 215	Mineralogy (Seminar)	5	..	..
Ge 216	Advanced Study	..	..	..
Ge 220	History of Geology	5‡	..	..
Ge 225	Geology of the Pacific Coast Region	6†	..	..
Ge 226	Geomorphology of Humid Regions	8	..	..
Ge 228	Geomorphology of Arid Regions	..	..	8
Ge 230	Geomorphology (Seminar)	..	..	5
Ge 289a	Structural Geology (Seminar)	5	..	..
Ge 289b	Physical Geology (Seminar)	..	..	5
Ge 290 ab	Vertebrate Paleontology (Seminar)	..	5	5
Ge 291 ab	Invertebrate Paleontology (Seminar)	5	5	..
Ge 261	Theoretical Seismology	6‡	..	..
Ge 262	Interpretation of Seismograms of Teleseisms	..	5‡	..
Ge 263	Field Work in Earthquakes and Interpretation of Seismograms of Local Earthquakes	..	..	5‡
Ge 265	Introduction to General Geophysics	..	6‡	..
Ge 270	Seismic Instruments	9	..	..
Ge 273	Applied Geophysics I	..	5†	..
Ge 274	Applied Geophysics II	..	6†	..
Ge 275	Applied Geophysics III	..	..	6†
Ge 278	Interpretation of Field Seismograms	..	..	5†
Ge 282	Geophysics (Seminar)	..	..	3
Ge 283	Geophysical Instruments (Seminar)	..	3	..
Ge 295 abc	Geophysics Research Conference	2	2	2

**The starred course not completed during the senior year is to be taken.

Symbols:

No symbol; course given every year.

‡Course given in 1940-1941.

†Course given in 1939-1940.

SUBJECTS OF INSTRUCTION

SUBJECTS IN SCIENCE

BIOLOGY

PROFESSORS: THOMAS HUNT MORGAN, HENRY BORSOOK, THEODOSIUS DOBZHANSKY, ALFRED H. STURTEVANT, FRITS W. WENT
ASSOCIATE PROFESSORS: ERNEST G. ANDERSON, STERLING EMERSON, A. J. HAAGEN-SMIT, CORNELIS A. G. WIERSMA
ASSISTANT PROFESSORS: JAMES BONNER, ROBERT EMERSON,[1] HUGH M. HUFFMAN, GEORGE E. MACGINITIE, ALBERT TYLER
INSTRUCTORS: ANTHONIE VAN HARREVELD, JOHANNES VAN OVERBEEK

For the study of biology, the Institute provides the following opportunities:

An option in biology has been introduced into the four-year undergraduate Course in Science. This option includes those fundamental biological subjects that are an essential preparation for work in any special field of pure or applied biology. This three-year course affords a far more thorough training in the basic sciences of physics, chemistry, and mathematics than students of biology, medicine, or agriculture commonly receive. Special opportunities are also offered for the pursuit of more advanced courses and extended researches leading to the degree of Doctor of Philosophy.

UNDERGRADUATE SUBJECTS

Bi. 1. Elementary Biology. 9 units (3-3-3); second term.
An introductory subject intended to give the student of general science some information about the fundamental properties of living things.
Instructors: Morgan, Borsook, Bonner.

Bi. 2. Genetics. 9 units (3-4-2); third term.
An introductory subject presenting the fundamentals of genetics in connection with some general biological problems, such as variation and evolution.
Instructor: Dobzhansky.

Bi. 3. General Botany. 14 units (2-9-3); first term.
A general survey of the morphology and life histories of plants.
Instructor: S. Emerson.

[1] On leave of absence until 1940.

Bi. 4. Invertebrate Zoology. 10 units (2-6-2); third term.
A survey of the main groups of invertebrates (excluding insects—see Bi. 11).
Instructor: MacGinitie.

Bi. 5 a, b. Plant Physiology. 12 units (3-6-3), second term; 8 units (2-4-2), third term.
A general study of water relations, growth and the chemical processes taking place in the living plant.
Instructors: Went, Bonner, van Overbeek.

Bi. 6. Embryology. 12 units (2-8-2); second term.
A subject in descriptive and experimental embryology, covering both vertebrates and invertebrates.
Instructor: Tyler.

Bi. 7 a, b. Biochemistry. 10 units (2-4-4); second and third terms.
A lecture course on the chemical constitution of living matter; and the chemical changes in animal physiology, with laboratory work illustrating principles and methods in current use.
Instructors: Borsook and Huffman.

Bi. 8. Advanced Genetics. 8 units (2-3-3); third term.
A more advanced subject than Bi. 2, dealing especially with mutation, crossing over, and chromosome aberrations.
Instructor: Sturtevant.

Bi. 11. Entomology. 8 units (2-3-3); third term.
A general survey of the structure and life histories of the insects, emphasizing the groups that present favorable material for experimental work.
Instructors: Dobzhansky and Sturtevant.

Bi. 12. Histology. 9 units (1-6-2); first term.
A subject in technique and in the microscopic structure of animals.
Instructor: Tyler.

Bi. 13. Mammalian Anatomy. 5 units (1-2-2); first term.
The dissection of a mammal.
Instructor: van Harreveld.

Bi. 16 a, b. Animal Physiology. 10 units (3-2-5); first and second terms.
A survey of comparative and mammalian physiology.
Instructors: Wiersma and van Harreveld.

Bi. 17. Vertebrate Anatomy. 10 units; summer.
This subject, given at the marine station at Corona del Mar, deals with the comparative anatomy of the vertebrates.
Instructor: MacGinitie.

Bi. 20. Biological Literature. 4 units (0-0-4); first term.
Assigned subjects and written reports. This subject is intended to give the student practice in the finding and use of original literature. Students may register for this subject with any member of the staff, after consultation.

Bi. 22. Research. 10 units; third term.
An opportunity will be given to follow special lines of research under direction. Students may register for this subject with any member of the staff, after consultation.

ADVANCED SUBJECTS

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 department will make careful selections of students of exceptional ability and aptitude in order to avoid the formal instruction that large numbers entail.

Bi. 100. Genetics Journal Club.
Meets twice monthly for presentation and discussion of current literature and original work.
In charge: Sturtevant.

Bi. 101. Biology Journal Club.
Meets twice monthly for reports on current literature of general biological interest.
In charge: Morgan.

Bi. 102. Biochemistry Seminar.
A seminar throughout the academic year on special selected topics and on recent advances.
In charge: Huffman.

Bi. 103. Plant Physiology Seminar.
Meets twice monthly.
In charge: Went.

Bi. 104. Genetics Seminar.
Reports and discussion on special topics.
In charge: Anderson.

Bi. 105. Experimental Embryology Seminar.
Reports on special topics in the field; meets twice monthly.
In charge: Tyler.

Bi. 110. Biochemistry.
Advanced work, with opportunity for research, is offered to graduate students who have completed work in General and Organic Chemistry.
Instructors: Borsook, Huffman.

Bi. 114 a, b, c. Chemistry of Bio-Organic Substances. 8 units (1-3-4); three terms.
A series of lectures on selected topics of organic chemistry which have special interest from a biological viewpoint. The lectures will be accompanied by laboratory exercises and demonstrations dealing with the chemical and physiological behavior of naturally occurring substances. The following topic is chosen for 1938-1939: "Terpenes and Terpenoïds." For undergraduates, prerequisite: Ch. 41 a, b, c. Ch. 46 a, b.
Instructor: Haagen-Smit.

Bi. 115. Chemistry of Bio-Organic Substances.
Advanced work with opportunity for research is offered to properly qualified graduate students.
Instructor: Haagen-Smit.

Bi. 117. Quantitative Organic Microanalysis. 20 units (0-20-0); second term.

Laboratory practice in the methods of quantitative organic microanalysis required for structure determinations of organic compounds. Students must obtain permission from the instructor before registering for this subject as the enrollment is necessarily limited.

Instructor: Haagen-Smit.

Bi. 120. Experimental Embryology. 6 units (1-0-5).

Lectures and discussion of the problems of embryonic development, including such topics as growth of the ovary, breeding habits of animals, fertilization, cleavage, organ formation, metamorphosis, regeneration, tissue culture, embryonic metabolism, etc.

The subject may be taken for two consecutive years since the subject matter will be duplicated only in alternate years.

Instructor: Tyler.

Bi. 121 a, b, c. Experimental Embryology Laboratory. Units to be decided by student and instructor; given any term.

The work will include certain classical experiments and instruction in the methods of studying embryonic metabolism, in transplantation, vital staining, etc.

Instructor: Tyler.

Bi. 125. Graduate Genetics. 9 units (2-0-7).

A course of advanced lectures, two per week, running through all three terms.

Instructors: Sturtevant, Anderson, Dobzhansky, S. Emerson.

Bi. 130. Biological Problems.

A course of lectures and reading, including such general topics as life cycles of protozoa and insects, secondary sexual characters and hormones; parthenogenesis, regeneration and grafting; the nature of biological theories, etc.

Instructor: Morgan.

Bi. 140 a, b, c. Plant Physiology. 6 units (2-0-4); first, second and third terms.

Reading and discussion of the main problems of plant physiology.

Instructors: Went, Bonner, van Overbeek.

Bi. 141. Plant Chemistry. 6 units (0-3-3); first, second and third terms.

Laboratory subject in the analysis of plant materials by macro- and microchemical methods.

Instructor: Bonner.

Bi. 160. Advanced Physiology. 12 units (0-8-4); first and second terms.

A subject in the methods of physiology, with special reference to those in nerve and muscle, with opportunity for research.

Instructors: Wiersma, van Harreveld.

Bi. 170. Research.

In special cases, not included in the preceding announcements, students doing advanced work in the department may register under this heading and receive a stated amount of credit. Students should consult with the instructor in charge of their major work before registering for this subject.

CHEMISTRY AND CHEMICAL ENGINEERING

PROFESSORS: LINUS PAULING, STUART J. BATES, JAMES E. BELL, ROSCOE G. DICKINSON, WILLIAM N. LACEY, RICHARD C. TOLMAN
ASSOCIATE PROFESSORS: RICHARD MCLEAN BADGER, HOWARD J. LUCAS, ERNEST H. SWIFT, DON M. YOST
RESEARCH ASSOCIATES: EDWIN R. BUCHMAN, JOSEPH B. KOEPFLI
ASSISTANT PROFESSORS: ARNOLD O. BECKMAN, CARL NIEMANN, BRUCE H. SAGE, JAMES H. STURDIVANT
SENIOR FELLOW IN RESEARCH: ROBERT B. COREY
INSTRUCTOR: LINDSAY HELMHOLZ

UNDERGRADUATE SUBJECTS

Ch. 1 a, b, c. Chemistry. 12 units (3-6-3); first, second, and third terms. Lectures, recitations and laboratory exercises dealing with the general principles of chemistry. The first and second terms are devoted to the preparation and properties of substances and to the fundamental laws and theories of chemistry.

The subject matter for the third term is qualitative analysis of the common metals accompanied by lectures in various fields of chemistry by different members of the division staff.

Instructors: Bell, Helmholz, Yost, Badger and Teaching Fellows.

Ch. 11. Quantitative Chemical Analysis. 10 units (2-6-2); third term. Prerequisite: Ch. 1 c.

Laboratory practice in certain typical methods of gravimetric and volumetric analysis, supplemented by lectures and problems emphasizing the principles involved.

Text: *Chemical Analysis,* Swift.

Instructor: Swift.

Ch. 12 a, b. Analytical Chemistry. 10 units (2-6-2); first and second terms.

Prerequisite: Ch. 1 c.

Laboratory practice in the methods of gravimetric and volumetric, and advanced qualitative analysis, supplemented by lectures and problems in which the principles involved in the laboratory work are emphasized.

Text: *Chemical Analysis,* Swift.

Instructor: Swift.

Ch. 12 c. Analytical Chemistry and Chemistry Review. 10 units (2-6-2); third term.

Prerequisite: Ch. 12 b.

Advanced qualitative analysis and a study of special methods of chemical analysis, including electrometric methods. Analyses of selected alloys, minerals, and other materials will be made. Students may be assigned individual problems for investigation. The class exercises are devoted to a discussion and review of the general principles of analytical and inorganic chemistry. The examination in this subject covers the chemistry work of the whole sophomore year.

Instructor: Swift.

Ch. 13 a, b. Inorganic Chemistry. 4 units (2-0-2); third and first terms.
Prerequisite: Ch. 12 b, 21 a, b.

The chemical and physical properties of the elements are discussed with reference to the periodic system and from the view-points of atomic structure and radiation-effects. Such topics as coordination compounds, the liquid ammonia system, the compounds of nitrogen, the halides, and selected groups of metals are taken up in some detail. The class work is supplemented by problems which require a study of current literature.

Instructor: Yost.

Ch. 14 a, b, c. Inorganic Chemistry Laboratory. 8 units (0-8-0), third term; 5 units (0-5-0), first term; 8 units (0-8-0), second term.
Prerequisite: Ch. 12 c, 21 a, b.

This subject consists of laboratory work upon selected research problems in inorganic chemistry, often in relation to the rarer elements.

Instructors: Swift, Yost.

Ch. 16. Instrumental Analysis. 8 units (0-6-2); first term.
Prerequisite: Ch. 12 c.

Laboratory practice designed to familiarize the student with special analytical apparatus and methods, used both for process control and for research.

Text: *Instrumental Methods of Chemical Analysis,* Lacey.

Instructor: Beckman.

Ch. 21 a, b, c. Chemical Principles. 10 units (4-0-6); first, second, and third terms.
Prerequisites: Ch. 12 b; Ph. 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 elements of thermodynamics; 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.

Text: *Chemical Principles,* Noyes and Sherrill.

Instructors: Bates, Dickinson.

Ch. 22 a, b. Thermodynamic Chemistry. 6 units (2-0-4); 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: *Chemical Principles,* Noyes and Sherrill.

Instructor: Bates.

Ch. 23 a, b. Chemical Principles. 10 units (4-0-6); second and third terms.
Prerequisite: Ch. 21 a.

A selection of topics from Ch. 21 b, c, and from Ch. 22 a, b. This is a continuation of Ch. 21 a, adapted to the needs of Science Course students in the Physics and Biology Options.

Text: *Chemical Principles,* Noyes and Sherrill.

Instructor: Dickinson.

Ch. 24 a, b. Physical Chemistry. 10 units (4-0-6); first and second terms.
Prerequisites: Ch. 12 a, b; Ma. 2 a, b; Ph. 2 a, b, c, d.
A discussion of selected topics in physical chemistry, adapted to the needs of Science Course students in the Geology Option.
Text: *Physical Chemistry for Colleges,* Millard.
Instructor: Garner.

Ch. 26 a, b. Physical Chemistry Laboratory. 8 units (0-6-2) or 4 units (0-3-1), second term; and 4 units (0-3-1), third term.
Prerequisites: Ch. 12 a, b; Ch. 21 a.
Laboratory exercises to accompany Ch. 21.
Text: *Laboratory Experiments on Physico-Chemical Principles,* Sherrill.
Instructors: Badger, Yost.

Ch. 29. Colloid and Surface Chemistry. 8 units (3-0-5); third term.
Prerequisite: Ch. 22.
Class-room exercises with outside reading and problems, devoted to the properties of surfaces, and interfaces, and to the general principles relating to disperse systems with particular reference to the colloidal state. Supplementary laboratory work can be provided if desired.
Texts: *Colloid Chemistry,* Thomas, and mimeographed notes.
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 c.
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: *Organic Chemistry,* Lucas.
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 synthesis and the physical and chemical properties of the more important compounds of carbon.
Text: *Outlines in Organic Chemistry,* Moore and Hall.
Instructor: Lucas.

Ch. 46 a, b. Organic Chemistry Laboratory. 9 units (0-9-0) or 12 units (0-12-0), first term; 6 units (0-6-0) or 9 units (0-9-0), second term.
Prerequisite: Ch. 12.
Laboratory exercises to accompany Ch. 41 a, b. The preparation and purification of carbon compounds and the study of their characteristic properties. Qualified students may pursue research work.
Text: Mimeographed notes, Lucas.
Instructors: Lucas and Teaching Fellows.

Ch. 61 a, b, c. Industrial Chemistry. 6 units (2-0-4), first and third terms; 4 units (2-0-2), second term.

Prerequisites: Ch. 21 a, b.

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: *Industrial Chemistry,* Riegel.

Instructor: Beckman.

Ch. 62. Engineering Chemistry. 9 units (3-0-6); first term.

Prerequisite: Ch. 1 a, b, c.

Reading, discussion and problems dealing with the application of chemical principles to engineering problems and the relations of engineering to the chemical industries.

Text: *Chemistry of Engineering Materials,* Leighou.

Instructor: Beckman.

Ch. 63 a, b. Chemical Engineering Thermodynamics. 6 units (2-0-4); second and third terms.

Prerequisite: Ch. 21 a.

Class exercises and problems in engineering thermodynamics studied from the point of view of the chemical engineer.

Instructor: Lacey.

Ch. 80-86. Chemical Research.

Opportunities for research are afforded to undergraduate students in all the main branches in chemistry; thus, in analytical or inorganic chemistry (Ch. 80), in physical chemistry (Ch. 82), in organic chemistry (Ch. 84), and in applied chemistry (Ch. 86). 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 Option 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. 113 a, b. Inorganic Chemistry. 4 units; third and first terms.

Selected groups of inorganic compounds will be considered from modern physicochemical 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), and their molecular structure and valence relations.

Instructor: Yost.

Ch. 122 a, b. Thermodynamic Chemistry. 6 units; first and second terms.

This subject is the same as Ch. 22 a, b.

Text: *Chemical Principles,* Noyes and Sherrill.

Instructor: Bates.

Ch. 129. Colloid and Surface Chemistry. 8 units; third term.
This course is the same as Ch. 29.
Texts: *Colloid Chemistry*, Thomas, and mimeographed notes.
Instructor: Badger.

Ch. 166 a, b, c. Chemical Engineering. 12 units (3-0-9); first, second, and third terms.
Prerequisites: Ch. 61; Ch. 63 a, b.
Problems and discussions designed to bring the student in touch with the problems involved in carrying out chemical reactions efficiently on a commercial scale. The basic operations of chemical industry (such as heat production, heat transfer, mixing, filtration, distillation) are studied both as to principle and practice.
Text: *Principles of Chemical Engineering*, Walker, Lewis, McAdams, and Gilliland.
Instructor: Lacey.

Ch. 167 a, b, c. Chemical Engineering Laboratory. 15 units (0-15-0); first, second, and third terms.
Prerequisites: Ch. 21, Ch. 61, Ch. 63.
A course of laboratory work to give training in the methods and technique fundamental to engineering measurements and research encountered by the chemical engineer.
Instructors: Sage, Lacey.

Ch. 169. Research Manipulations. 3 units; second term.
Laboratory exercises in glass-blowing and machine shop operations for research students. Class-room discussions on topics of general interest for research in physical chemistry, such as high-vacuum technique, electrical apparatus including applications of vacuum tube circuits, and the measurement of pressure, temperature and radiant energy.
Students must obtain permission from the instructor before registering for this subject as the enrollment is necessarily limited.
Instructor: Beckman.

Ch. 180-186. Chemical Research.
Opportunities for research in analytic and inorganic chemistry (180), physical chemistry (182), organic chemistry (184), and applied chemistry and chemical engineering (186) are offered to candidates for the degree of Master of Science. The main lines of research in progress are tabulated under Ch. 280-286.

Ch. 221 a, b, c. The Nature of the Chemical Bond (Seminar). 6 units; first, second, and third terms.
This subject comprises the detailed non-mathematical discussion of the electronic structure of molecules and its correlation with the chemical and physical properties of substances.
It is planned that the seminar be held in 1938-39, and every third year thereafter.
Text: *The Nature of the Chemical Bond*, Pauling.
In charge: Pauling.

Ch. 222 a, b, c. Seminar on Thermodynamics and Statistical Mechanics, with Chemical Applications. 6 units; first, second, and third terms.

A thorough discussion of the fundamental principles and methods of thermodynamics and statistical mechanics, followed by their application to the practical problems of modern chemistry, including the calculation of thermodynamic properties of substances from spectroscopic and structural data.

This seminar will be held in 1939-40, and every third year thereafter.

In charge: Dickinson, Yost, Badger.

Ch. 223 a, b. Kinetics of Homogeneous and Heterogeneous Reactions (Seminar). 6 units; first and second terms.

Lectures and discussions relating to homogeneous and heterogeneous chemical reactions, absorption, and contact catalysis.

This seminar will be held in 1940-41, and every third year thereafter.

In charge: Dickinson, Badger.

Ch. 224 a, b, c, d. Statistical Mechanics (Seminar). 6 units; four 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 and the relations between statistical mechanics and thermodynamics.

Text: *Principles of Statistical Mechanics*, Tolman.

In charge: Tolman.

Ch. 226 a, b, c. Introduction to Quantum Mechanics, with Chemical Applications. 9 units; first, second, and third terms.

A review of Lagrangian and Hamiltonian mechanics and of the old quantum theory is first given, followed by the discussion of the development and significance of the new quantum mechanics and the thorough treatment of the Schrödinger wave equation, including its solution for many simple systems such as the rotator, the harmonic oscillator, the hydrogen atom, etc. During the second and third terms various approximate methods of solution (perturbation theory, the variation method, etc.) are discussed and applied in the consideration of the resonance phenomenon, the structure of many-electron atoms and of simple molecules, the nature of the covalent chemical bond, the structure of aromatic molecules, and other recent chemical applications.

It is planned that this subject be given in 1939-40, and every third year thereafter.

Text: *Introduction to Quantum Mechanics, with Applications to Chemistry*, Pauling and Wilson.

Instructor: Pauling.

Ch. 227 a, b. c. The Structure of Crystals. 6 units; first, second, and third terms.

The following topics are discussed:

The nature of crystals and X-rays and their interaction. The various experimental methods of investigation—Bragg, Laue, oscillation, Weissenberg, etc. The theory of space groups and the use of symmetry in the determination of the structures of crystals. The detailed study of representative structure investigations. The various known crystal structures and their relation to the physical and chemical

properties of substances. The quantitative treatment of X-ray diffraction. Fourier-series methods of structure investigation.

It is planned that this subject be given in 1940-1941, and every third year thereafter.

Instructors: Sturdivant, Pauling.

Ch. 228 a, b, c. Crystal Structure Laboratory. Units determined by the instructor; any term.

Practical instruction is given in the methods of determining the structure of crystals with X-rays.

Instructor: Sturdivant.

Ch. 229. Diffraction Methods of Determining the Structure of Molecules. 6 units.

A discussion of the diffraction of X-rays and electron waves by gases, liquids, glasses, and crystals.

Instructors: Pauling, Sturdivant.

Ch. 230. Photochemistry. 6 units; third 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. 232. Radioactivity and Isotopes. 6 units; third term.

Lectures and discussions on natural and artificial radioactivity. The fundamental particles and isotopes. The applications of natural and artificial radioactive substances and isotopes to the study of chemical and biochemical reactions are discussed.

Instructors: Dickinson and Yost.

Ch. 234. Introduction to the Spectra of Molecules. 6 units; first term.

The theory of the structure of the spectra of both the diatomic and the simpler polyatomic molecules is presented, and the transition rules and their relation to the symmetry elements of molecules are discussed. Emphasis is laid on the methods of interpreting and analyzing molecular spectra, and it is shown how from an analysis one obtains information regarding the structure and other properties of a molecule of interest to the chemist. Problems are given in the interpretation of actual data.

Instructor: Badger.

Ch. 241. Qualitative Organic Chemical Analysis. 12 units; first term.

A laboratory study of the class reactions of carbon compounds and practice in the methods of identifying unknown substances.

Instructor: Lucas.

Ch. 242. Quantitative Organic Chemical Analysis. 12 units; second term.

Practical studies in the quantitative analysis of organic compounds, including the semi-micro estimation of carbon, hydrogen, nitrogen, halogens, sulfur, acetyl, and methoxyl.

Instructors: Niemann, Lucas.

Ch. 243. Quantitative Organic Microanalysis. 20 units (0-20-0); third term.

Laboratory practice in the methods of quantitative organic microanalysis required for structure determinations of organic compounds. Students must obtain permission from the instructor before registering for this subject as the enrollment is necessarily limited.

Instructor: Haagen-Smit.

Ch. 244 a, b, c. The Reactions of Organic Compounds. 6 units; first, second, and third terms.

A consideration of the typical reactions exhibited by the various functional groups in relatively isolated conditions and under conditions where the reaction may be influenced by the unique structure of the molecule or by other coexistent functional groups. Lectures and discussions.

This subject will be presented in 1939-40 and every third year thereafter.

Instructors: Niemann, Buchman, Lucas.

Ch. 245 a, b, c. The Synthesis of Organic Compounds. 6 units; first, second, and third terms.

A systematic treatment of the practical synthesis of organic compounds including historical examples of the various types of synthesis.

This subject will be presented in 1940-41 and every third year thereafter.

Instructors: Niemann, Buchman, Koepfli, Lucas.

Ch. 246 a, b, c. Theoretical Organic Chemistry. 6 units; first, second, and third terms.

A consideration of the basic theories of organic chemistry including valence, stereochemistry, the structure of organic molecular compounds and organic radicals, tautomerism, intramolecular rearrangements, the structure of aliphatic and aromatic compounds, and the mechanism of organic reactions.

This subject will be presented in 1941-42 and every third year thereafter.

Instructors: Lucas, Niemann, Buchman.

Ch. 247. Advanced Organic Laboratory. Units to be arranged; any term.

Laboratory practice in the synthesis of typical organic compounds.

Instructors: Lucas, Niemann, Buchman, Koepfli.

Ch. 251 a, b, c. Organic Chemistry (Special Topics). 6 units; first, second, and third terms.

A series of lectures and discussions on selected topics of organic chemistry that have special interest from a theoretical, industrial, or biological view-point.

Instructor: Lucas.

Ch. 253. The Chemistry of Vitamins and Enzymes. 4 units; third term.

Lectures on recent advances in knowledge of the chemical nature of vitamins and related substances.

Text: *Fermente, Hormone, Vitamine,* Ammon and Dirscherl.

Instructor: Buchman.

Ch. 255 a, b, c. Chemistry of Bio-Organic Substances. 8 units; three terms.
A series of lectures on selected topics of organic chemistry which have special interest from a biological view-point. The lectures will be accompanied by laboratory exercises and demonstrations dealing with the chemical and physiological behavior of naturally occurring substances. For undergraduates, prerequisite: Ch. 41 a, b, c. Ch. 46 a, b.
Instructor: Haagen-Smit.

Ch. 256. Chemistry of Bio-Organic Substances.
Advanced work with opportunity for research is offered to properly qualified graduate students.
Instructor: Haagen-Smit.

Ch. 261. Phase Equilibria in Applied Chemistry. 6 units (2-0-4); first term.
Prerequisites: Ch. 21, 61.
Problems and discussions relating to industrial applications involving heterogeneous equilibria.
Instructors: Lacey and Sage.

Ch. 262 a, b. Thermodynamics of Multi-Component Systems. 8 units (2-0-6); second and third terms.
Prerequisites: Ch. 63 or ME. 16.
A presentation of the background necessary for a working knowledge of the thermodynamics of multi-component systems from the engineering view-point. The work includes numerous problems relating to the application of these principles to industrial practice.
Instructor: Sage.

Ch. 280-286. Chemical Research.
Opportunities for research are offered to graduate students in all the main branches of chemistry, namely, in analytical and inorganic chemistry (280), physical chemistry (282), organic chemistry (284), and applied chemistry and chemical engineering (286).

The main lines of research now in progress are:

Chemical analysis of the rarer elements.
Free-energies, equilibria, and electrode-potentials of reactions.
Low temperature calorimetry.
Study of crystal structure and molecular structure by diffraction of X-rays and electron waves.
Application of quantum mechanics to chemical problems.
Application of magnetic methods to chemical problems.
Mechanism of homogeneous reactions.
Chemical reactions produced by atoms and molecules excited by radiations.
Application of radioactive indicators to chemical problems.
Band spectra and Raman spectra in their chemical relations.
The Walden inversion.
Isomerism, hydration and complex formation of unsaturated compounds.
Vitamin B_1 analogs.
Viscosity of gases and liquids at high pressures.

Solubility of gases in liquids at high pressures.
Properties of underground protective coatings.
High vacuum distillation.
Thermodynamic studies of hydrocarbons.
Flow of fluids through porous media.
Rate of attainment of equilibrium in heterogeneous systems.
The synthesis of hydrocarbons containing three- and four-membered rings.
Studies on the constitution of the phosphotides and the cerebrosides.
The synthesis of fluorine analogs of thyroxine and a study of their role in animal metabolism.
Studies on the mechanism of the in-vivo oxidation of glycosides.
The synthesis of disaccharides and of alkylated monosaccharides.
Configurational studies on the mono- and di-hydroxy amino acids.
The synthesis and properties of the α-hydroxy and α-alkoxy amines and their role in biological reactions.
The study of plant hormones and related substances of physiological importance.
The chemistry of protozoa.
Chemical genetics.

For a fuller survey of the researches in progress, see publications of the Gates and Crellin Laboratories of Chemistry (pages 130-132).

Ch. 290-296. Chemical Research Conferences.
Each 2 units, except Ch. 293; given all three terms.

Ch. 290. General Research Conference in Chemistry.

Ch. 291. Crystal and Molecular Structure.

Ch. 292. Photochemistry.

Ch. 293. Band Spectra and Molecular Structure. 1 unit.

Ch. 294. Organic Chemistry.

Ch. 296. Applied Chemistry. Second and third terms.

These conferences consist of reports on the investigations in progress in the laboratory and on other researches which have appeared recently in the literature. They are participated in by all men engaged in related lines of research in the laboratory, and are conducted by the chemistry professors connected with the respective branches.

GEOLOGY, PALEONTOLOGY, AND GEOPHYSICS

PROFESSORS: JOHN P. BUWALDA, BENO GUTENBERG, CHESTER STOCK
ASSOCIATE PROFESSORS: HUGO BENIOFF, IAN CAMPBELL
ASSISTANT PROFESSORS: HORACE J. FRASER, ROBERT MINSSEN KLEINPELL, JOHN H. MAXSON, CHARLES F. RICHTER
INSTRUCTORS: FRANCIS D. BODE,[1] RICHARD H. HOPPER, RAYMOND A. PETERSON

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 field trips.
Text: *Text-book of Geology*, Part I, Longwell, Knopf and Flint.
Instructors: Buwalda, Hopper, and Teaching Fellows.

Ge. 1 b. Elementary Paleontology. 9 units (4-1-4); third 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: *Organic Evolution*, Lull.
Instructors: Stock, Drescher.

Ge. 1 c. Historical Geology. 9 units (3-0-6); third term.
Prerequisite: Ge. 1 a.
A consideration of the geologic history of the earth, as shown by the changing patterns of land and sea and by the succession of faunas and floras. Conferences, lectures, and occasional field trips.
Text: *Historical Geology*, R. C. Moore.
Instructor: Maxson.

Ge. 3 a, b, c. Mineralogy. 12 units (3-6-3); each term.
Prerequisites: Ge. 1 a; Ch. 12 a, b.
A comprehensive course dealing with the materials of the earth's crust. The first part of the course constitutes an introduction to crystallography; the body of the course is concerned with physical, chemical and determinative mineralogy, and with the genesis, occurrence, association, extraction and use of minerals; the last part of the course deals especially with mineral aggregates (rocks), their classification, field determination, and geologic occurrence. This course is designed to give a working knowledge of the geographic occurrence and the geologic factors controlling the formation of mineral and ore deposits, and in conjunction with Ge. 121 a, knowledge of lithology sufficient for the needs of the beginning field geologist.
Text: *Mineralogy*, Kraus, Hunt and Ramsdell, 3rd edition.
Instructors: Fraser (Ge. 3 a, b), Campbell (Ge. 3 c), Henshaw.

[1] On leave 1938-1939.

Ge. 14. Geologic Illustration. 10 units (0-10-0); first term.

Freehand sketching of landscape forms and visible geologic structures in the field developing both line and shading technique in representation. Also classroom exercises utilizing various mediums. Training in the drawing of block diagrams illustrating land forms and geologic structure sections in perspective. Problems in projection.

Text: *Block Diagrams,* Lobeck.

Instructor: Willoughby.

Ge. 21. Senior Thesis Problem in Geology. Units to bring total load per term to 50.

Prerequisite: Ge. 121 a.

The student investigates a limited geologic problem 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. Last date for acceptance of thesis, May 25.

Instructors: Maxson, Hopper.

Ge. 22. Senior Thesis Problem in Paleontology. 8 units, first or third terms; 6 units, second term.

Prerequisites: Ge. 111 a, b, or Ge. 112 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.

UNDERGRADUATE OR GRADUATE SUBJECTS

Ge. 100. Geology Club. 1 unit; all terms.

Presentation of papers on research in geological science by the students and staff of the Division of Geological Sciences, and by guest speakers.

Required of all senior and graduate students in the Division.

Ge. 102. Oral Presentation. 1 unit; first and third terms.

Training in the technique of oral presentation. Practice in the effective organization and delivery of reports before groups.

Required of all senior and graduate students in the Division.

Instructor: Jones.

Ge. 105. Optical Mineralogy. 10 units (2-6-2); first term.

Prerequisites: Ge. 1, 3.

Study of optical mineralogy and use of the petrographic microscope in the identification of minerals.

Text: *Thin Section Mineralogy,* Rogers and Kerr.

Instructors: Fraser, Jahns.

Ge. 106 a, b. Petrography. 10 units (2-6-2); second and third terms.

Prerequisites: Ge. 3 a, b, c, Ch. 21 a, 23 a.

A systematic study of rocks; the identification of their constituents by application of the polarizing microscope; interpretation of textures; problems of genesis; qualitative and quantitative classifications. Occasional field trips will be arranged.

Text: *Petrology of the Igneous Rocks,* Hatch and Wells.

Instructors: Campbell, Jahns.

Ge. 109. Structural Geology. 10 units (4-0-6); first term.
Prerequisite: Ge. 121 a.
A consideration of the structural features of the Earth's crust; folds, faults, joints, foliation.
Text: *Structural Geology*, Nevin.
Instructor: Buwalda.

Ge. 110. Engineering Geology. 9 units (2-2-5); third term.
Prerequisite: Ge. 1 a.
A discussion of those geological conditions that affect particular engineering operations, such as tunnelling, the building of dams, the retention of water in reservoirs, foundation excavation, harbor work, control of erosion and landslides, materials of construction, etc. Lectures and assigned reading.
The course is planned primarily for civil engineers.
Instructor: Buwalda.

Ge. 111 a, b. Invertebrate Paleontology. 8 units (1-6-1), first term; 10 units (2-6-2), second term.
Prerequisites: Ge. 1 a, b, c.
Morphology and geologic history of the common groups of fossil invertebrates, with emphasis on progressive changes in structures and their significance in evolution and in adaptive modifications. Laboratory, conferences, lectures, and occasional field trips.
Texts: *Tertiary Faunas*, Davies; *Invertebrate Paleontology*, Twenhofel and Shrock.
Instructor: Popenoe.

Ge. 112 a, b. Vertebrate Paleontology. 10 units (2-6-2); second and third terms.
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. 115. Micropaleontology. 8 units (1-3-4); second term, 1938-1939.
Prerequisites: Ge. 111 a, b.
Introduction to the morphology and classification of the foraminifera. Their use in stratigraphic correlation with special reference to the Tertiary of California.
Texts: *The Foraminifera, their Classification and Economic Use*, Cushman; *A Manual of the Foraminifera*, Galloway.
Instructor: Kleinpell.

Ge. 121 a, b. Field Geology. 10 units (1-8-1); second and third terms.
Prerequisites: Ge. 1 a, b, c, 3 a.
An introduction to the principles and methods used in geologic mapping. Field technique in determining rock types and their distribution, and in interpreting geologic relationships and structures. Practical experience in deciphering the geologic history of a region. To these ends a representative Coast Range area is mapped in detail and a report in professional form is prepared on its stratigraphy, structure and

history. The field work, selected textbook assignments, and special geologic problems and computations are discussed in weekly class meetings.

Students taking this course are expected to go on the Annual Spring Field Trip described under Ge. 122.

Text: *Field Geology*, Lahee.

Instructors: Hopper, Maxson.

Ge. 122. Spring Field Trip. 1 unit; week between second and third terms.

Brief studies of various localities in the Southwest representative of important geologic provinces. Trips are conducted in successive years to Owens and Death Valleys where excellent Paleozoic sections are exposed, and Basin Range structure and morphology may be observed; to the Salton Basin and Lower California where the San Andreas fault and the Peninsular Range may be studied; to the San Joaquin Valley and the mountains to the west where important Tertiary formations are exposed and typical Coast Range structure may be seen; and to the Grand Canyon of the Colorado River where a fascinating record of Archean, Algonkian and Paleozoic geologic history may be investigated.

Required of junior, senior, and graduate students in the Division of Geological Sciences.

Instructors: Buwalda, Maxson.

Ge. 123. Summer Field Geology. 12 units.

Intensive field 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 in even-numbered years. As an occasional alternative an expedition will be conducted to localities important in California geology. The interpretations of classical localities afforded in the literature will be studied in the field. The subject begins immediately after Commencement (about June 12th). Required at the end of both the Junior and the Senior year for the bachelor's degree in the Geology course.

Instructors: Buwalda, Maxson, Hopper.

Ge. 175. Elementary Geophysics. 5 units (2-0-3); third term 1938-1939, first term 1940-1941.

A survey of pure and applied geophysics designed mainly for geological, engineering, and other students who do not expect to enroll in specialized subjects in this field.

Instructor: Peterson.

Ge. 176. Elementary Seismology. 6 units (3-0-3); first term, 1939-1940.

A survey of the geology and physics of earthquakes.

Instructor: Richter.

Ge. 187. Research.

Original investigation, designed to give training in methods of research, to serve as theses for higher degrees, and to yield contributions to scientific knowledge. These may be carried on in the following fields: (m) mineralogy, (n) general areal geology, (o) stratigraphic geology, (p) structural geology, (q) physiography, (r) petrology, (s) vertebrate paleontology, (t) invertebrate paleontology, (u) seismology, (v) economic geology, (w) general geophysics, (x) applied geophysics.

GRADUATE SUBJECTS

Ge. 200. Mineragraphy. 8 units (1-6-1); first term.
Prerequisites: Ge, 3, 105, 106, 121.
Technique of identification of opaque minerals in polished sections by means of etching and microchemistry.
Texts: *Microscopic Determination of Ore Minerals,* M. N. Short; U. S. G. S., Bull. 825, or new bulletin when issued; *Mineral Deposits,* 4th edition, Lindgren.
Instructors: Fraser, Dreyer.

Ge. 201. Introduction to Economic Geology. 5 units (2-0-3); first term.
Prerequisites: Ge. 3, 105, 106, 121.
A study of the factors affecting and controlling the deposition of ores.
Text: *Mineral Deposits,* 4th edition, Lindgren.
Instructor: Fraser.

Ge. 202. Metalliferous Deposits. 10 units (2-6-2); second term.
Prerequisites: Ge. 200, 201.
A study of the most important metalliferous deposits with respect to geographic distribution, structure, alteration, and mode of formation. The laboratory work will consist of a study of ore suites in polished and thin sections.
Text: *Mineral Deposits,* 4th edition, Lindgren.
Instructors: Fraser, Dreyer.

Ge. 210. Advanced Petrology. 8 units; second term.
Prerequisite: Ge. 106 a, b.
A continuation and amplification of Ge. 106 a, b; dealing especially with the sedimentary rocks in 1938-39; with the metamorphic rocks in 1939-1940.
Texts: *Sedimentary Petrography**, Milner; *Metamorphism,* Harker.
Instructors: Campbell, L. A. Lewis.

Ge. 211. Petrology (Seminar). 5 units; third term.
Discussion of classic and current literature with consideration of recent advances in the field of petrology. Occasional conferences on research problems are included.
In charge: Campbell.

Ge. 212. Non-Metalliferous Ore Deposits. 10 units (2-6-2); third term.
Prerequisite: Ge. 3, 106.
A study of the economically valuable non-opaque minerals: their geographic and geologic occurrence, and methods of extraction and utilization. In the laboratory, the subject will be extended to include also a study of the non-opaque minerals associated with metalliferous deposits, thus affording the student greater familiarity with typically altered country rock than is possible within the scope of Ge. 106 a, b.
Text: *Mineral Deposits,* 4th edition, Lindgren.
Instructors: Campbell, Dreyer.

*A new text by Pettijohn and Krumbein will be used if it appears in time.

Ge. 213. Advanced Economic Geology (Seminar). 5 units; second term, 1938-1939.

Prerequisite: Ge. 202.

Discussion of current literature with particular reference to metalliferous deposits of the North American Continent.

In charge: Fraser, Snow.

Ge. 214. Advanced Economic Geology (Seminar). 5 units; second term, 1939-1940.

Prerequisite: Ge. 202.

Discussion and investigation of factors involved in ore estimation and economics of mining.

In charge: Fraser, Snow.

Ge. 215. Mineralogy (Seminar). 5 units; first term.

Prerequisite: Ge. 200.

Discussion of current literature and special problems related to mineralogy.

In charge: Fraser, Wilson.

Ge. 216. Advanced Study.

Students may register for not to exceed 8 units of advanced study in fields listed under Ge. 187. Occasional conferences; final examination.

Ge. 220. History of Geology. 5 units; first term of 1940-1941.

A study of the development of the geological sciences. The evolution of fundamental theories as influenced by earlier and contemporary geological investigators.

This brief subject presents a connected sequence of the development of geological ideas and thereby aids in gaining a perspective of the science.

Lectures, assigned reading, and reports.

Instructor: Maxson.

Ge. 225. Geology of the Pacific Coast Region. 6 units (2-0-4); first term, 1939-1940.

An intensive review of the geomorphology, stratigraphy, and structure of the region most accessible from the California Institute, including Arizona, Nevada, and California. Presents an organized concept of the geologic history of the Colorado Plateau Province, the Basin and Range Province, and the Coast Range Province. Lectures, mainly by staff members personally familiar with the regions discussed, and assigned reading.

Instructors: Staff of the Division of the Geological Sciences.

Ge. 226. Geomorphology of Humid Regions. 8 units (2-2-4); first term.

Prerequisites: Ge. 109, 121 a, b.

Nature of erosional processes in a humid climate and the topographic features developed. Sequence of land forms in the normal physiographic cycle. Principles of marine erosion and the shoreline cycle. The glacial cycle.

Lectures, assigned reading. Field trips to the San Gabriel and San Bernardino Ranges for stream erosion, to selected strips of the California coast, and to the glacial terrane of the high Sierras in the vicinity of the Palisades Glacier.

Instructor: Maxson.

Ge. 228. Geomorphology of Arid Regions. 8 units (2-2-4); third term.
Prerequisite: Ge. 226.
Processes of erosion in an arid climate. Land forms of arid regions and their modes of origin. The arid cycle of erosion in the Basin Range Province.
Lectures, assigned reading. Field trips to the Mojave Desert and Death Valley.
Instructor: Maxson.

Ge. 230. Geomorphology (Seminar). 5 units; third term.
Discussion of research and current literature of geomorphology.
In charge: Maxson.

Ge. 289 a. Structural Geology (Seminar). 5 units; first term.
Critical review of literature dealing with some part of the field of structural geology.
In charge: Buwalda.

Ge. 289 b. Physical Geology (Seminar). 5 units; third term.
Study and critical discussion of current contributions to geologic knowledge.
In charge: Buwalda.

Ge. 290 a, b. Vertebrate Paleontology (Seminar). 5 units; second and third terms.
Discussion of progress and results of research in vertebrate paleontology. Critical review of current literature.
In charge: Stock.

Ge. 291 a, b. Invertebrate Paleontology (Seminar). 5 units; first and second terms.
Conferences on research in invertebrate paleontology and reviews of literature. Discussions of particular aspects of invertebrate paleontology with special reference to the Pacific Coast.
In charge: Popenoe.

GEOPHYSICS

Advanced Calculus or Differential Equations or Introduction to Mathematical Physics is a prerequisite for all of the following subjects in Geophysics except Ge. 265, for which the requirement is a thorough knowledge of calculus and physics.

Ge. 261. Theoretical Seismology. 6 units (2-0-4); first term, 1940-1941.
Studies and conferences on the principles of physical seismology.
Instructor: Gutenberg.

Ge. 262. Interpretation of Seismograms of Teleseisms. 5 units (0-2-3); second term, 1938-1939, 1940-1941.
Prerequisite: Ge. 261.
Instructor: Gutenberg.

Ge. 263. Field Work in Earthquakes and Interpretation of Seismograms of Local Earthquakes. 5 units (0-2-3); third term, 1938-1939, 1940-1941.
Prerequisite: Ge. 261.
Instructor: Richter.

Ge. 265. Introduction to General Geophysics. 6 units (2-0-4); second term, 1938-1939, 1940-1941.
Structure of the earth; gravity and isostasy; tides; movement of the poles; elastic properties; temperature; density.
Instructor: Gutenberg.

Ge. 270. Seismic Instruments. 9 units (1-3-5); first term.
Description and theory of seismographs. Laboratory experiments.
Instructor: Benioff.

Ge. 273. Applied Geophysics I. 5 units (2-0-3); first term, 1939-1940.
Methods of seismology applied to geological problems and prospecting.
Instructor: Gutenberg.

Ge. 274. Applied Geophysics II. 6 units (3-1-2); second term, 1939-1940.
Measurements of gravity applied to geological problems and prospecting.
Instructor: Peterson.

Ge. 275. Applied Geophysics III. 6 units (2-2-2); third term, 1939-1940.
Measurements of earth magnetism and of electricity applied to geological problems and prospecting.
Instructor: Peterson.

Ge. 278. Interpretation of Field Seismograms. 5 units (0-2-3); second term, 1939-1940.
Prerequisite: Ge. 273.
Instructor: Gutenberg.

Ge. 282. Geophysics (Seminar). 3 units; third term.
Prerequisite: At least two subjects in Geophysics.
Discussion of papers in both general and applied geophysics.
In charge: Gutenberg, Buwalda, Peterson, Richter.

Ge. 283. Geophysical Instruments (Seminar). 3 units; second term.
Prerequisite: Ge. 270.
Discussion of papers relating to geophysical field and station instruments.
In charge: Benioff.

Ge. 295 a, b, c. Geophysics Research Conference. 2 units; all terms.
Prerequisite: Ge. 282 and 283.
Discussion of geophysical problems. For advanced students.
In charge: Gutenberg, Buwalda, Benioff, Peterson, Richter.

For research see Ge. 187. For Physics of the Atmosphere see Meteorology.

MATHEMATICS

PROFESSORS: HARRY BATEMAN, ERIC T. BELL, ARISTOTLE D. MICHAL, HARRY C. VAN BUSKIRK
RESEARCH ASSOCIATE: DINSMORE ALTER, Statistics
ASSOCIATE PROFESSORS: MORGAN WARD, LUTHER E. WEAR
ASSISTANT PROFESSOR: WILLIAM N. BIRCHBY.

UNDERGRADUATE SUBJECTS

NOTE: Students intending to take the mathematics option must indicate their choice at the beginning of their sophomore year.

Ma. 1 a, b, c. Freshman Mathematics. 12 units (4-0-8); first, second and third terms.

Includes the fundamentals of plane analytical geometry, certain topics in college algebra, the usual topics of the differential calculus, except partial differentiation and an introduction to integration.

Text: *A Basic Course in Analysis,* Vol. 1, Van Buskirk, Wear and Birchby.

Ma. 2 a, b, c. Sophomore Mathematics. 12 units (4-0-8); first and second terms; 8 units third term.

Includes solid analytical geometry, partial differentiation, technique of integration, definite integral, multiple integration, infinite series, applications to geometry and physics.

Text: *A Basic Course in Analysis,* Vol. 2, Van Buskirk, Wear and Birchby.

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.

Subjects 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. 10 units (3-0-7); first term.

Includes the elementary theorems in the roots of an equation, solution of numerical equations, determinants, symmetric functions, resultants and discriminants.

Instructors: Wear, Dilworth.

Ma. 4 a, b. Analytic Geometry. 10 units (3-0-7); second and third terms.

Prerequisites: Ma. 1 and 2.

Aims to acquaint the student majoring in mathematics with the basic ideas and methods of Higher Geometry. Subjects treated include: Homogeneous coordinates, line coordinates, cross-ratio, projective coordinates, point curves and line curves, projective and metric properties of conics, correlations.

Text: *Higher Geometry,* Graustein.

Instructor: Wear.

Ma. 8 a, b, c. Advanced Calculus. 9 or 12 units (3-0-6) (4-0-8); first, second and third terms.

Prerequisites: Ma. 1, Ma. 2.

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 to be announced later.

Instructors: Birchby, Arnold.

Ma. 10 a, b, c. Differential Equations. 9 units (3-0-6); first, second and third terms.

Prerequisite: Ma. 2 a, b, c, d.

An introductory course in differential equations, designed to be helpful both to the student of mathematics and the student of science or engineering.

Text: *Differential Equations*, Ford.

Instructor: Wear.

Ma. 11. Differential Equations. 9 units (3-0-6); second or third term.

Prerequisite: Ma. 2 a, b, c, d.

An abridged course in Differential Equations for students in Engineering.

Text: *Differential Equations*, 2nd edition, Cohen.

Instructors: Wear, Yood.

Ma. 12. Probability and Least Squares. 6 units (2-0-4); first term.

Prerequisites: Ma. 1, Ma. 2.

A study of the fundamental principles of probability and their application to statistical data, adjustment of observations, and precision of measurements.

Text: *Theory of Errors and Least Squares*, Bartlett.

Instructor: Alter.

Ma. 14. Vector Analysis. 12 units (4-0-8); second or third term.

Prerequisites: Ma. 2 a, b, c, d.

Elementary vector operations (addition, multiplication) and their application to problems of geometry and physics are treated.

Instructors: Ward, Sears, Dilworth.

Ma. 15 a, b, c. Higher Mathematics for Engineers and Physicists. 9 units; first, second and third terms.

Prerequisites: Ma. 1, Ma. 2.

An alternative course to Ma. 8, Advanced Calculus, covering about the same range of subjects. Intended primarily for Engineers and Applied Physicists who do not expect to use advanced theory.

Text: *Higher Mathematics for Engineers and Physicists*, Sokolnikoff.

Instructors: Birchby, Arnold.

UNDERGRADUATE OR GRADUATE SUBJECTS

NOTE: Those of the following courses for which there is a demand will be given periodically.

Ma. 101 a, b, c. Modern Algebra. 6 or 9 units; first, second and third terms.

Prerequisite: Ma. 8, reading knowledge of German.

Instructor: Bell.

Ma. 102 a, b, c. Introduction to Higher Geometry. 9 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.

NOTE: If all three terms are not included in the undergraduate course, graduate students in mathematics must complete this subject in the fifth year.

Instructor: Wear.

Ma. 106 a, b, c. Introduction to Theory of Functions of Real Variables. 5 units; first, second and third terms. Required for graduation (B.S.) in mathematics.

Prerequisite: Ma. 8 a, b, c.

Postulational treatment of real number system, descriptive properties of point sets, continuous and discontinuous functions, derivatives and differentials. Riemann integration, functions of several real variables, implicit functions.

Instructors: Michal, Ward.

Ma. 107. Conformal Representation. 9 units (3-0-6); second term.

Prerequisites: Ma. 8, 10.

Riemann's problem, work of Schwarz and Christoffel. Applications to physical problems. Associated variation problems.

Instructor: Ward.

Ma. 110 a, b, c. Introduction to Theory of Numbers. 6 units; first, second and third terms.

Prerequisite (third term): Reading knowledge of German.

This course will cover selected topics in elementary number theory.

Texts: *Introduction to Theory of Numbers,* Dickson; *Vorlesungen,* Landau.

Instructor: Ward.

Ma. 111. Elementary Theory of Tensors. 9 units.

Prerequisites: Ma. 8, 10.

Fundamental properties of tensors, differential forms, covariant differentiation, geodesic coordinates, Riemannian differential geometries.

Instructor: Michal.

Ma. 113 a, b, c. Geometry. 12 units; first, second and third terms.

Prerequisite: Ma. 2 a, b, c, d.

Algebraic geometry; projective geometry; differential geometry; tensor analysis and its applications to numerous geometrical problems; non-Euclidean geometry; Riemannian differential geometry; geometry of dynamics; hyperspace; elementary group theory and its geometrical applications.

Texts: *Applications of the Absolute Differential Calculus,* McConnell; *Riemannian Geometry,* Eisenhart; collateral reading.

Instructor: Michal.

Ma. 114. Mathematical Analysis. 12 units; first, second and third terms.

This course will be offered every alternate year, and covers essentially the same topics as Ma. 201.

Prerequisites: Ma. 8, 10, and reading knowledge of German.

Instructor: Ward.

Ma. 118 a, b, c. Introduction to Statistics. 9 units; first, second and third terms.

Prerequisites: At least a year of calculus, and a laboratory course in some science.

First term: Curve fitting by moments, correction for lack of high contact and for histogram group, introduction to the Pearson family of frequency curves, including the "normal" curve. Second term: Continuation of frequency curves, coefficients of relationships, including multiple correlation. Third term: Tests of goodness of fit, cycle analysis.

Instructor: Alter.

GRADUATE SUBJECTS

NOTE: For all subjects numbered above 200, except 201a, a reading knowledge of French and German is required.

Ma. 201 a, b, c. Modern Analysis. 15 units; first, second and third terms. Prerequisites: Ma. 8, 10.

Theory of convergence, integration and residues, expansions of functions in infinite series, asymptotic and divergent series. Fourier series. Differential equations and function theory, integral equations, the gamma function and the zeta function, the hypergeometric function and related functions of mathematical physics, elliptic functions, ellipsoidal harmonics.

NOTE: The first term will satisfy the requirement in Complex Variable for those taking a minor in mathematics.

Instructor: Bateman.

Ma. 202 a, b, c. Modern Theory of Differential Equations. 12 units; first, second and third terms.

Prerequisites: Ma. 10, 107, and reading knowledge of German.

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.

Instructor: Ward.

Ma. 204 a, b, c. Geometrical Transformations and Invariants. 15 units; first, second and third terms.

Prerequisite: Graduate standing.

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. 205 a, b, c. Theory of Functions. 15 units; first, second and third terms.

Theory of convergence and infinite processes, properties of continuous and discontinuous functions, functions of limited variation, selected topics on analytic functions, point sets, measure of point sets, Stieltjes integrals, Lebesgue integrals, Fourier series and integrals, orthogonal functions, convergence in the mean, geometry of Hilbert space.

Text: *The Theory of Functions,* Titchmarsh.

Instructor: Michal.

Ma. 209 a, b, c. Functionals and Functional Equations. 15 units; first, second and third terms.

Prerequisite: Graduate standing in Mathematics, including a course in Analysis.

Functional operations; permutable functions, functions of composition; integral equations, integro-differential equations; differentials of functionals, functional equations with functional derivatives; infinite matrices; Stieltjes and Lebesgue integrals; abstract spaces.

Instructor: Michal.

Ma. 251 a. Seminar (I) in Algebra and the Theory of Numbers. 9 units; third term.

Prerequisite: Graduate standing.

In charge: Bell.

Ma. 251 b. Theory of Algebraic Numbers. 9 units; third term. Alternates with Ma. 251 a.

Prerequisite: Graduate standing.

Instructor: Bell.

Ma. 251 c, d, e. Mathematical Logic. 15 units; first, second and third terms.

Instructor: Bell.

Ma. 252 a, b, c. Seminar in Continuous Groups. 9 units; first, second and third terms.

Prerequisite: Graduate standing in Mathematics.

Lie's theory of r-parameter groups; differential geometry of the group manifold. Groups of functional transformations; invariant functionals; differential geometries of function spaces.

In charge: Michal.

Ma. 253. Seminar in Foundations of Abstract Algebra. 6 units; first, second, and third terms.

Prerequisite: Graduate standing.

Decomposition theorems in rings and hypercomplex systems. Evaluation theorems, and p-adic numbers. Modern structure and lattice theory, Boolean rings and algebras.

In charge: Ward.

Ma. 254 a, b, c. Seminar in Modern Theories of Integration. 6 units; first, second and third terms.

Prerequisite: Graduate standing in Mathematics, including a course in Function Theory.

Stieltjes and Lebesgue integrals with applications to the algebra and geometry of functionals.

In charge: Michal.

Ma. 255 a, b, c. Methods of Mathematical Physics. 15 units; first, second and third terms.

Prerequisites: Ma. 8, 10.

Integral equations in which the kernel is a Green's function, Fourier series and integrals, Sturm-Liouville functions. Methods of Volterra, Fredholm and Hilbert for dealing with integral equations. Laplace's type of equation and the Heaviside calculus, calculus of variations, matrices and bilinear forms. Partial differential equations and the related simple solutions. Expansions in series of orthogonal functions.

Instructor: Bateman or Ward.

Ma. 256 a, b, c. Modern Differential Geometry. 9 units; first, second and third terms.

Prerequisite: Graduate standing.

Riemannian and Non-Riemannian geometries. Theory of parallel displacement of tensors. Affine differential geometry. Projective differential geometry. Continuous groups and their applications to geometry. Contemporary researches in differential geometry.

Instructor: Michal.

Ma. 257 a, b, c. Seminar in Abstract Spaces. 6 units; first, second and third terms.

Prerequisite: Graduate standing.

Metric spaces, linear vector spaces; topological spaces; abstract polynomials; general function theories; analysis and geometry in abstract spaces; connections with abstract algebra and the theory of functionals; analysis of selected papers of Frechet, Riesz and Banach; contemporary researches; applications to mathematical problems in modern theoretical physics.

In charge: Michal.

Ma. 258 a, b, c. Partial Differential Equations of Mathematical Physics. 12 units; first, second and third terms.

Prerequisites: Ma. 8, 10.

Illustration of general methods by consideration of ordinary linear equations. The simple wave-equation, the potential equation. Applications of the integral theorems of Stokes and Green. Reduction to variation problems and the solution of such problems by direct methods. Use of difference equations to obtain approximate solutions. Use of simple solutions expressed as products. Properties of the special functions introduced in this way. Solution of initial and boundary problems by various methods.

Instructor: Bateman.

Ma. 260. Reading.

Occasionally advanced work is given by a reading course under the direction of an instructor. Hours and units by arrangement.

Ma. 261. Research.

By arrangement with members of the staff, properly qualified graduate students are directed in research. Hours and units by arrangement.

PHYSICS

PROFESSORS: ROBERT A. MILLIKAN, HARRY BATEMAN, IRA S. BOWEN, PAUL S. EPSTEIN, WILLIAM V. HOUSTON, CHARLES C. LAURITSEN, J. ROBERT OPPENHEIMER, RICHARD C. TOLMAN, EARNEST C. WATSON

ASSOCIATE PROFESSORS: CARL D. ANDERSON, JESSE W. M. DUMOND, ALEXANDER GOETZ, S. STUART MACKEOWN, GENNADY W. POTAPENKO, WILLIAM R. SMYTHE, FRITZ ZWICKY

ASSISTANT PROFESSORS: H. VICTOR NEHER, JOHN D. STRONG

RESEARCH FELLOWS: WILLIAM A. FOWLER, ERWIN R. GAERTTNER, JOSEF J. JOHNSON, SETH H. NEDDERMEYER, WILLIAM H. PICKERING

UNDERGRADUATE SUBJECTS

Ph. 1 a, b, c. Mechanics, Molecular Physics, Heat, and Sound. 12 units (3-3-6); 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, Heat, and Sound,* Millikan, Roller and Watson.

Instructors: Watson, DuMond, Neher, Strong, Gaerttner and Teaching Fellows.

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: Anderson, Lauritsen, Pickering and Teaching Fellows.

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, e/m, h, and other fundamental constants will be performed. Open only to students on honor standing, sophomore year.

Instructor: Anderson.

Ph. 5 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 practice in the solution of problems.

Instructors: Houston and Townes.

Ph. 7 a, b, c. Electricity and Magnetism. 6 units (2-0-4); first, second and third terms.

Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; Ma. 2 a, b, c, d.

A subject in theoretical electricity and magnetism, primarily for electrical engineering students. Ph. 9 a, b (Electrical Measurements) must accompany this course.

Text: *Principles of Electricity,* Page and Adams.

Instructor: Mackeown.

Ph. 9 a, b, c. Electrical Measurements. 4 units (0-3-1); first, second and third terms.

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 Electrical Measurements,* Smythe and Michels.

Instructors: Smythe and Assistants.

Astronomy 1. Introduction Course in Astronomy. 9 units (3-1-5); third term.

This subject is intended to give the student sufficient familiarity with general astronomy to enable him to read with ease most of the semi-popular books dealing with various phases of the subject.

Text: *Astronomy,* Baker.

Instructor: Johnson.

UNDERGRADUATE OR GRADUATE SUBJECTS

Ph. 91 a, b, c. Introduction to Mathematical Physics. 8 units; first, second and third terms.

This subject is the same as Ph. 5 a, b, c but with reduced credit for graduate students.

Instructors: Houston and Fowler.

Ph. 101 a, b, c. Electricity and Magnetism. 9 units (3-0-6); first, second and third terms.

Prerequisites: Ma. 8 a, b, c, or 10 a, b, c, and an average grade of 2 in Ph. 5 a, b, c.

A problem subject 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: *Static and Dynamic Electricity,* Smythe.

Instructor: Smythe.

Ph. 103 a, b, c. Analytical Mechanics. 12 units (4-0-8); first, second and third terms.

Prerequisites: Ph. 5 a, b, c; Ma. 8 a, b, c, or 10 a, b, c.

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; elementary hydrodynamics and elasticity.

Text: *Dynamics,* Webster.

Instructor: Zwicky.

Ph. 105 a, b. Optics. 9 units (3-0-6); first and second terms.

Prerequisites: Ph. 5 a, b, c; Ma. 8 a, b, c, or 10 a, b, c.

A problem subject dealing with the fundamental principles of geometrical optics, of diffraction, interference, the electromagnetic theory of light, etc., and their experimental verification. Ph. 106 a, b (Optics Laboratory), should accompany this course.

Text: *Theory of Optics,* Drude.

Instructor: Bowen.

Ph. 106 a, b. Optics Laboratory. 3 units (0-3-0); first and second terms.

Advanced laboratory work in light, consisting of accurate measurements in diffraction, dispersion, interference, polarization, spectrophotometry.

Text: *Manual of Advanced Optics,* Taylor.

Instructor: Bowen.

Ph. 107 a, b, c. Atomic Physics. 9 units; first, second and third terms.

Prerequisites: Ph. 5 a, b, c; Ma. 8 a, b, c, or 10 a, b, c.

An outline of the experimental and theoretical basis of modern atomic physics, which covers electron theory, spectroscopy and nuclear physics.

Instructors: Millikan, Bowen, Anderson.

Ph. 108. Spectroscopy Laboratory. 3 units; second term.

A laboratory subject in the measurement and classification of spectral lines to accompany Ph. 107 b.

Instructor: Bowen.

Ph. 110 a, b. Kinetic Theory of Matter. 9 units; second and third terms.

Prerequisites: Ph. 1 a, b, c, d; Ma. 2 a, b, c, d.

During the first term, the fundamentals of the kinetic theory of gases are treated from both the theoretical and the experimental viewpoint (Clausius, Maxwell, Boltzmann, van der Waals, Knudsen equations). During the second term more advanced problems of the constitution of matter are discussed in the form of a seminar (liquefaction of gases, low temperature phenomena, specific heats, thermal expansion, crystallization, plasticity).

Instructor: Goetz.

Ph. 114. Principles of Quantum Mechanics. 9 units; third term.

Prerequisites: Ph. 5 a, b, c; Ma. 8 a, b, c, or 10 a, b, c.

An outline, developed by means of problems, of the experimental and theoretical basis of quantum mechanics, including the idea of states, principle of indetermination the Schrödinger equation, methods of approximate solution, electron spin, and Pauli principle.

Instructor: Houston.

Ph. 115. Applications of Quantum Mechanics. 9 units; first term.

Prerequisite: Ph. 114.

The application of non-relativistic quantum mechanics to problems in various fields of physics. The subjects treated will be determined partly by the interests of the class.

Instructor: Houston.

Ph. 116. Relativistic Quantum Mechanics. 9 units; second term.
Prerequisite: Ph. 114.
A study of Dirac's relativistic equation for an electron in an external field together with selected topics from recent developments of relativistic quantum mechanics.
Instructor: Houston.

Ph. 120. Seminar on the History of Physics. 4-9 units; first, second and third terms.
Assigned reading and written and oral reports on selected topics in the history of physics. Students will be expected to make the acquaintance of as many as possible of the original memoirs of the great physicists and to study at least one such memoir very thoroughly. Reports will consist of illustrated lectures, biographies, critical studies, translations, bibliographies, etc. Recommended for all students who expect to teach.
Texts: *History of Science*, Dampier; *Rise of Modern Physics*, Crew.
In charge: Watson.

Ph. 142. Research in Physics. Units in accordance with the work accomplished. Approval of the department must be obtained before registering.

GRADUATE SUBJECTS

Ph. 211. Thermodynamics. 12 units; first term.
Prerequisites: Ph. 1 a, b, c, 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.
(Not given in 1938-39.)
Instructor: Epstein.

Ph. 221. Potential Theory. 15 units; third term.
Prerequisites: Ma. 8 a, b, c, 10 a, b, c.
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 1938-39.)
Instructor: Bateman.

Ph. 222. Theory of Electricity and Magnetism. 12 units; first term.
Prerequisites: Ph. 101 a, b, c; Ma. 8 a, b, c, 10 a, b, c.
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. 223. Theory of Electromagnetic Waves. 12 units; second term.
Prerequisites: Ph. 101 a, b, c; Ma. 8 a, b, c, 10 a, b, c.
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. 224. Theory of Sound. 9 units; second term.

Prerequisites: Ph. 2 a, b, c, d; Ma. 2 a, b, c, d.

Vibrations of strings, rods, plates and of the larynx. Resonators, horns and musical instruments. Theories of hearing. The acoustics of an auditorium. The propagation of sound. Reflection, refraction and absorption of sound.

(Not given in 1938-39.)

Instructor: Bateman.

Ph. 225. Theory of Electrons. 12 units; second term.

Prerequisites: Ph. 101 a, b, c, 222; Ma. 8 a, b, c, 10 a, b, c.

Retarded potentials. Radiation of a point charge. Theory of dielectrics. Electron theory of dia-, para- and ferro-magnetism. Phenomena in moving bodies and experimental foundations of the theory of relativity.

Instructor: Epstein.

Ph. 226. Heat Radiation and Quantum Theory. 12 units; second term.

Prerequisites: Ph. 101 a, b, c, 103 a, b, c, 211; Ma. 8 a, b, c, 10 a, b, c.

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 1938-39.)

Instructor: Epstein.

Ph. 228. Modern Aspects of the Quantum Theory. 12 units; third term.

Prerequisites: Ph. 103 a, b, c, 107 a, b, c, 229; Ma. 8 a, b, c, 10 a, b, c.

The course is devoted to a review of recent developments in the quantum theory, especially in the fields of the theory of radiation and of the electron theory of metals. The subject matter varies from year to year.

Instructor: Epstein.

Ph. 229. Quantum Mechanics. 12 units; second and third terms.

Schrödinger's equation and matrix calculus. Applications to spectroscopy and atomic structure. Transformation theory. Dirac's electron equation. Fundamentals of the theory of the electromagnetic field and second quartization.

Instructor: Epstein.

Ph. 232. Physics of Ultra-Short Electromagnetic Waves. 6 units (2-0-4); first and second terms.

Propagation of waves. Maxwell's dispersion and absorption in semi-conductors and metals. Electronic and dipolar dispersion and absorption in dielectrics. Dispersion and absorption in electrolytes. Waves along wires and dispersion in magnetic substances.

Experimental results on dispersion and absorption of ultra-short waves in dielectrics, electrolytes and magnetic substances.

Instructor: Potapenko.

Ph. 234. Topics in Theoretical Physics. 9 units (3-0-6); third term.

The content of this subject will vary from year to year. Typical topics: Theory of atomic collisions; relativistic quantum theory; theory of radiation; statistical mechanics. In 1936-37 the course dealt with recent contributions to the theory of

atomic nuclei; the problem of nuclear stability; nuclear collisions and transmutations; the interaction of neutrons with nuclei; nuclear radiative processes; and the phenomenological theory of beta-ray decay.

Instructor: Oppenheimer.

Ph. 236 a, b, c. Introduction to the Theory of Relativity. 6 units; first, second and third 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. Applications to thermodynamics and cosmology.

Text: *Relativity, Thermodynamics and Cosmology*, Tolman.

(Not given in 1938-39.)

Instructor: Tolman.

Ph. 237. Astrophysics. 6 units (2-0-4); first and second terms.

Prerequisites: The fundamental courses in physics.

Mechanics and thermodynamics of stellar bodies, constitution of stars, stellar atmospheres and their spectra, evolution of the planetary system and of stellar systems, time scales, characteristics of extragalactic nebulæ and their apparent velocities of recession, evolution of the universe, etc.

(Not given in 1938-39.)

Instructor: Zwicky.

Ph. 238. Seminar on Theoretical Physics. 4 units; first, second and third terms.

Recent developments in theoretical physics for specialists in mathematical physics.

In charge: Epstein.

Ph. 239. Research Conference on the Physics of Solids. 2 units; first, second and third terms.

Recent developments in the field of the solid state, crystallization, physics of colloids, low temperature.

In charge: Goetz.

Ph. 240. Seminar on X-Radiation. 4 units; first, second and third terms.

Meets once a week for reports and discussions of problems in X-Radiations. Standard texts on X-rays are followed in the first term as an outline only; the reports being amplifications and additions to the material of the text as drawn from the original papers of workers in the field. During the second and third terms advanced reports are made on current problems and on fundamental classical work.

In charge: DuMond.

Ph. 241. Research Conferences in Physics. 4 units; first, second and third terms.

Meets twice a week for a report and discussion of the work appearing in the literature and that in progress in the laboratory. Advanced students in physics and members of the physics staff take part.

In charge: Millikan and Houston.

Ph. 242. Research in Physics. Units in accordance with the work accomplished. Opportunities for research are offered to graduate students in all the main branches of physics. See "Publications of the Staff," pages 119-122, for a survey of researches actually in progress. The student should consult the department and have a definite program of research outlined before registering.

Ph. 245. Seminar on Ultra-Short Electromagnetic Waves. 4 units (2-0-2); first and second terms.

Recent developments in methods of generation of ultra-short waves. Modern methods of physical measurements in high frequencies.

In charge: Potapenko.

Astronomy and Physics Club.

The club, consisting of physicists and astronomers of the Institute and of the Mount Wilson Observatory, meets on the first Friday in each month 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 journals.

SUBJECTS IN ENGINEERING

AERONAUTICS

PROFESSORS: THEODORE VON KÁRMÁN, HARRY BATEMAN
ASSOCIATE PROFESSORS: ARTHUR L. KLEIN, IRVING P. KRICK, CLARK B. MILLIKAN
ASSISTANT PROFESSOR: ERNEST E. SECHLER
INSTRUCTORS: W. A. KLIKOFF, PAUL E. RUCH, WILLIAM R. SEARS, H. J. STEWART

UNDERGRADUATE SUBJECTS

AE. 2 a, b. Aircraft Structures. 12 units; second and third terms.
Prerequisite: AM. 1 c.

A subject adapted for students planning to take post-graduate work in Aeronautics. The course includes the analysis of forces by analytical and graphical methods and the calculation of stresses in beams, girders, columns, shafts and simple trusses of timber, steel and light alloys; study of continuous beams; beams under combined lateral and axial loads; trusses with redundant members; effect of flexure and direct stress; deflections in beams and trusses; tapered columns; circular rings; thin wall structures; loads upon an airplane.

Text: *Aircraft Structures,* Vols. 1 and 2, Niles Newall.
Instructor: Klikoff.
See also ME. 8.

FIFTH-YEAR AND ADVANCED SUBJECTS

AE. 251 a, b, c. Aerodynamics of the Airplane. 9 units; first, second and third terms.
Prerequisites: AM. 1 a, b, c, AM. 3.

Airfoils, wings, and tail groups, stability and control, drag, performance and spinning.

Texts: *Principles of Flight,* Stalker; *Technical Aerodynamics,* Wood; *Engineering Aerodynamics,* Diehl.
Instructor: Millikan.

AE. 252 a, b, c. Airplane Design. 12 units; first, second and third terms.
Prerequisites: AM. 1 a, b, c, AM. 3, CE. 11.

The solution of problems connected with the structural design and analysis of complete airplanes, with special emphasis being placed on the problems dealing with monocoque construction. AE. 252 must be taken concurrently with or subsequently to 251.

Texts: *Airplane Structures,* Niles and Newell; *Strength of Materials,* Boyd; *Airplane Design,* K. D. Wood.
Instructor: Sechler, with the assistance of engineers from neighboring aircraft companies.

AE. 253 a, b, c. Airplane Design and Testing Procedure. 6 units; first, second and third terms.

Prerequisites: AM. 1 a, b, c, AM. 3, CE. 11.

253a, drafting room technique, factory methods, factory equipment, materials used; 253b, control systems, flap systems, landing gears, power plants, and non-structural components; 253c, performance prediction, performance reduction, flight testing.

Instructor: Klein, with the assistance of engineers from neighboring aircraft companies.

AE. 254 a, b, c. Advanced Problems in Airplane Design. 9 units; first, second and third terms.

Prerequisites: AE. 251, 252, 253.

254a, study of specific problems in airplane design; 254b, advanced problems concerning the aerodynamical design of airplanes; 254c, the design of flying boats and seaplanes.

Instructor: Klein.

AE. 255. Wind Tunnel Operation and Technique. 6 units; first, second or third terms.

A one-term course given each term covering pressure and velocity measuring instruments, balances, model suspensions, wind tunnel calibrations and correction factors, data reduction and presentation, extrapolation of model results to full scale. Experiments on various aerodynamic phenomena are carried out by the students in a special wind tunnel constructed for instruction purposes.

Instructor: Sears.

AE. 260. Research in Aeronautics.

Theoretical and experimental research in one of the following fields: fluid mechanics; elasticity, including photoelasticity; structures and aerodynamics.

AE. 266 a, b. Theoretical Aerodynamics I. Perfect Fluids. 12 units, first term; 9 units, second term.

Prerequisites: Ma. 14; 114 a, b, or EE. 226 a, b, or Ma. 8 a, b, c (12 units).

Hydrodynamics of perfect fluids as applied to aeronautics, potential motion, circulation, laws of vortex motion, elements of conformal transformation, streamline bodies, airfoils, three dimensional wing theory, monoplanes, biplanes, interference.

Texts: *The Elements of Aerofoil and Airscrew Theory,* Glauert; *Applications of Modern Hydrodynamics to Aeronautics,* Prandtl.

Instructor: Kármán, Millikan, or Sears.

AE. 267. Theoretical Aerodynamics II. Real Fluids. 12 units; third term.

Prerequisites: AE. 266 a, b.

Hydrodynamics of viscous fluids, laminar motion in pipes and channels, turbulence and Reynolds' criterion, similarity laws, theory of drag, discontinuous flow and vortex streets, theory of skin-friction, boundary layer, general theory of turbulence.

Instructor: Kármán or Millikan.

AE. 268. Hydrodynamics of a Compressible Fluid. 12 units; one term.
Prerequisites: AE. 266 a, b.

Relation of the equations to the kinetic theory of gases, theory of jets and of the Venturi tube, motion with a velocity exceeding the velocity of sound, shock waves, cavitation.

Instructor: Bateman.

AE. 269 a, b, c. Advanced Problems in Theoretical Aerodynamics. 9 units; first, second and third terms.

A seminar course in the applications of theoretical aerodynamics to aeronautical problems for students who have had AE. 266 and AE. 267.

Instructors: Kármán, Millikan.

AE. 270 a, b, c. Elasticity Applied to Aeronautics. 12 units, first term; 6 units, second and third terms.

Prerequisites: Ma. 109 a, b, or AE. 265 a, b; AM. 1 a, b, c, 3.

Analysis of stress and strain. Hookes law. Theory of bending and torsion. Stresses in thin shells. Theory of elastic stability. Vibrations and flutter.

Instructors: Kármán, Sechler.

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.

APPLIED MECHANICS

PROFESSOR: FREDERIC W. HINRICHS, JR.
ASSISTANT PROFESSOR: FRED J. CONVERSE

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: *Engineering Mechanics,* Volumes I & II, Timoshenko and Young.
Instructors: Converse and assistants.

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: *Elements of Strength of Materials,* Timoshenko and MacCullough; *Steel Construction,* A. I. S. C., or *Carnegie Pocket Companion.*
Instructors: Hinrichs, Converse, and assistants.

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 Applied Chemistry 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: *Engineering Mechanics,* Volume I, Timoshenko and Young; *Elements of Strength of Materials,* Timoshenko and MacCullough; *Steel Construction,* A.I.S.C., or *Carnegie Pocket Companion.*
Instructor: Hinrichs.

AM. 3. Testing Materials Laboratory. 6 units (0-3-3); second or third term.
Prerequisite: AM. 1 c.
Tests of the ordinary materials of construction in tension, compression, torsion, and flexure; determination of elastic limit; yield point; ultimate strength, and modulus of elasticity; experimental verification of formulas derived in the theory of strength of materials.
Instructors: Converse and assistant.

ADVANCED SUBJECTS

AM. 105. Soil Mechanics. 6 units (2-2-2); first term.
A study of the physical and mechanical properties of soils, and the determination of principles which govern their behavior under load. The application of these principles to problems of foundations and of earthwork engineering.
Instructor: Converse.

CHEMICAL ENGINEERING

(See Chemistry and Chemical Engineering, page 191)

CIVIL ENGINEERING

PROFESSORS: FRANKLIN THOMAS, ROMEO R. MARTEL
ASSOCIATE PROFESSOR: WILLIAM W. MICHAEL
ASSISTANT PROFESSOR: FRED J. CONVERSE

UNDERGRADUATE SUBJECTS

CE. 1. Surveying. 11 units (3-4-4); 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, use of calculating machines, topographic mapping and field methods.

Text: *Surveying*, Bouchard.

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*, Bouchard.

Instructor: Michael.

CE. 3. Plane Table Surveying. 8 units (1-6-1); third term.

A subject 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.

Text: *Surveying*, Bouchard.

Instructor: Michael.

CE. 4. Highway Engineering. 6 units (3-0-3); second 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: *Highway Design and Construction*, Bruce.

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.

Instructor: Thomas.

CE. 8 b. Railway Surveying. 6 units (2-0-4); second term.
Prerequisite: CE. 1.
The theory of railway, highway and ditch location and surveys; problems relating to curves, grades, earthwork and track layout, including a study of the mass diagram as applied to railway and highway 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. 11 units (3-3-5); second term.
Prerequisite: AM. 1 c.
An abridged subject 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.
Instructor: Michael.

CE. 10 a. Theory of Structures. 12 units (3-3-6); first term.
Prerequisite: 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: *Structural Theory,* Sutherland and Bowman.
Instructor: Martel.

CE. 10 b, c. Theory of Structures. 12 units (3-3-6), second term, and 9 units (3-0-6), third term.
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: *Structural Design in Steel,* Shedd.
Instructor: Martel.

CE. 12. Reinforced Concrete. 12 units (3-3-6); 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,* Caughey.
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.
The technique of effective oral presentation of reports is emphasized through criticisms of the reports from the standpoint of public speaking by a member of the department of English.
Instructors: Michael, Eagleson.

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: *Water Supply and Utilization,* Baker and Conkling.

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: *Design of Masonry Structures,* Williams.

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 and Eddy.

Instructor: Thomas.

CE. 21 a. Structural Design. 12 units (0-12-0); 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.

Instructor: Thomas.

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. 9 units (0-9-0); third term.
Prerequisites: CE. 15, 21 a, b.

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.

Instructor: Thomas.

CE. 23. Statically Indeterminate Structures. 12 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: *Continuous Frames of Reinforced Concrete,* Cross and Morgan.

Instructor: Martel.

CE. 30 a, b, c. 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. 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 Prof. Martel; Soil Mechanics and Foundations under the direction of Prof. Converse.

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. 105 b, c. Statically Indeterminate Structures. 12 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.

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.

Instructor: Thomas.

CE. 111. Water Treatment Plant Design. Units to be based upon work done; any term.

Preparation of a layout and design of the general features of a plant to effect the purification and softening of water as may be required in specific circumstances. Includes design of typical structural features of the plant.

Instructor: Thomas.

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.

Instructor: Thomas.

CE. 113. Underground Water Investigations. Units to be based upon work done; any term.

A study of the relation between rainfall, runoff, percolation, and accumulations of ground water. Investigation of the location, extent, and yield of underground reservoirs.

Instructor: Thomas.

CE. 114. Analysis of Earthquake Effects Upon Structures. Units to be based upon work done; any term.

A comparison of analytical study and experimental effects of vibrations on simple structures with the effects of earthquakes upon buildings.

Instructor: Martel.

CE. 115. Foundations. 6 units; second term.

The application of the principles of soil mechanics to problems of foundations and earthwork engineering.

Instructor: Converse.

DRAWING

INSTRUCTORS: HOWELL N. TYSON, NATHANIEL W. WILCOX

D. 1. Freehand Drawing. 3 units (0-3-0); first term.
The study of geometrical forms and their representation by means of freehand perspective. Training in pencil rendering is given and the fundamental principles of perspective are illustrated by simple architectural and engineering studies. Emphasis is placed on careful observation and accurate drawing.
Instructors: Wilcox, Okun, Snelling.

Descriptive Geometry, D. 3 a, b, c, d and D. 4 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. 3 a. Descriptive Geometry. 3 units (0-3-0); second term.
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: *Geometry of Engineering Drawing*, Hood.
Instructor: Wilcox.

D. 3 b. Descriptive Geometry. 3 units (0-3-0); third term.
Prerequisite: D. 3 a.
A continuation of D. 3 a, covering the geometrical relationships of lines and planes.
Text: *Geometry of Engineering Drawing*, Hood.
Instructors: Tyson, Wilcox.

D. 3 c. Descriptive Geometry. 3 units (0-3-0); first or second terms.
Prerequisite: D. 3 b.
A continuation of D. 3 b, covering problems involving curved lines and the intersection and development of surfaces.
Text: *Geometry of Engineering Drawing*, Hood.
Instructor: Tyson.

D. 3 d. Descriptive Geometry. 3 units (0-3-0); second or third terms.
Prerequisite: D. 3 c.
A continuation of D. 3 c, covering more complicated problems involving single curved surfaces, warped and double curved surfaces, and mining problems.
Text: *Geometry of Engineering Drawing*, Hood.
Instructor: Tyson.

D. 5. Descriptive Geometry. 3 units (0-3-0); third term.
Prerequisites: D. 3 a, b.
This course is planned primarily for geology students and includes practical problems in mining and earth structures.
Text: *Geometry of Engineering Drawing*, Hood.

D. 6 a. Engineering Drawing. 6 units (0-6-0); first or second term.
Prerequisite: D. 1, 3 a, b.
This course is designed to give the student a general knowledge of the most important types of engineering drawings. Instruction is given in the proper use of drafting equipment and in the fundamental principles of drafting and lettering. The accepted standards for both machine and structural drawing are given, and plates are drawn which illustrate the use of these standards. The student is also given basic training in making pictorial drawings and engineering charts and graphs.
Text: *Drafting for Engineers, second edition,* Svensen.

D. 6 b. Engineering Drawing. 6 units (0-6-0); second or third term.
Prerequisites: D. 1, 3 a, b, c, 6.
This is a continuation of the course described above.
Text: *Drafting for Engineers,* second edition, Svensen.
Instructor: Tyson.

D. 7. Advanced Engineering Drawing. Maximum of 6 units. Elective; any term.
Prerequisites: D. 3 a, b, c, d, 6 a, b.
The study and execution of drawings of machines or equipment designed by upper-class students in the engineering department.
Instructor: Tyson.

ELECTRICAL ENGINEERING

PROFESSOR: ROYAL W. SORENSEN
ASSOCIATE PROFESSORS: FREDERICK C. LINDVALL, S. STUART MACKEOWN
ASSISTANT PROFESSOR: FRANCIS W. MAXSTADT

UNDERGRADUATE SUBJECTS

EE. 2. Direct Currents. 9 units (3-0-6); second term.
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.
Instructors: Maxstadt, Harrison.

EE. 3. Direct Current Laboratory. 6 units (0-3-3); second term.
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, Havens, Lovoff.

EE. 4. Alternating Currents. 9 units (3-0-6); third term.
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; 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.
Instructors: Maxstadt, Harrison, Oliver.

EE. 5. Alternating Current Laboratory. 6 units (0-3-3); third term.
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 instruments and oscillograph operation of alternators, induction and synchronous motors and transformers; determination of characteristics of these machines.
Text: Laboratory notes.
Instructors: Maxstadt, Havens, Lovoff.

EE. 6 a, b. Electrical Machinery. 6 units (2-0-4) second term; 9 units (3-0-6); third term.
Prerequisites: EE. 2, 3, 4, and 5.
Further study of direct current and alternating current machinery with particular emphasis on application; short transmission lines; short circuit currents; protective devices.
Texts: *Principles of Direct Current Machines,* Langsdorf; *Alternating Currents,* Magnusson; *Problems in Electrical Engineering,* Lyon.
Instructor: Lindvall.

EE. 7. Electrical Laboratory. 9 units (0-3-6); third term.

Prerequisites: EE. 2, 3, 4, 5, 6; Ph. 7.

A continuation of EE. 3 and 5. Efficiency tests of alternating current machinery. Graphic analysis of alternator performance; operation of transformers, alternators and direct current machines in parallel; communication circuit testing; use of electronic devices; writing of engineering reports.

Text: Laboratory notes.

Instructors: Maxstadt, Rideout, Lovoff.

EE. 8. Direct Currents. 7 units (3-0-4); first or second term.

Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d.

An abridged subject in direct currents and direct current machinery designed to acquaint in an objective manner students, not majoring in electrical engineering, with electrical theory through its practical applications to circuits and machines.

Text: *Principles of Electrical Engineering,* Blalock.

Instructors: Maxstadt, Harrison, Jones.

EE. 9. Direct Current Laboratory. 5 units (0-3-2); first or second term.

An abridged subject for other than Electrical Engineering students.

Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d; registration for EE. 8.

Text: Laboratory notes.

Instructors: Maxstadt, Havens, Lovoff, Sherwood.

EE. 10. Alternating Currents. 7 units (3-0-4); second or third term.

Prerequisites: EE. 8 and 9.

An abridged subject in alternating currents and alternating current machinery similar to EE. 8.

Text: *Principles of Electrical Engineering,* Blalock.

Instructors: Maxstadt, Harrison, Jones.

EE. 11. Alternating Current Laboratory. 5 units (0-3-2); second or third term.

Prerequisites: EE. 8 and 9 and registration for EE. 10.

An abridged subject for other than Electrical Engineering students.

Text: Laboratory notes.

Instructors: Maxstadt, Havens, Lovoff, Sherwood.

EE. 12. Electric Circuits. 12 units (3-0-9); first term.

Prerequisites: EE. 2, 3, 4, 5.

A course of study involving the calculation of voltage, current, and power in electrical circuits by the symbolic or complex method.

Texts: *Alternating Current Circuits,* Kerchner and Corcoran; *Problems in Alternating Currents,* Lyon.

Instructor: Sorensen.

EE. 70 a, b, c. Engineering Conference. 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, Lindvall, Mackeown, Maxstadt, Stanton.

FIFTH-YEAR SUBJECTS

EE. 120. Alternating Current Analysis and Machinery. 12 units (4-0-8); 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; symmetrical components; analysis of electromotive force and current, nonsinusoidal wave forms; analysis of oscillograms.

Texts: *Problems in Electrical Engineering*, Lyon; *Applications of the Method of Symmetrical Components*, Lyon.

Instructor: Sorensen.

EE. 121 a, b, c. Alternating Current Laboratory. 6 units (0-3-3); first, second and third terms.

Prerequisites: EE. 7 and preceding courses.

Complete tests of the induction motor; the operation of transformers in parallel; study of polyphase connections; photometric measurements; use of the oscillograph; calibration of watt-hour meters and relays; high voltage tests of insulation. Special emphasis is placed on the report.

Text: Advanced laboratory notes.

Instructors: Maxstadt, Rideout.

EE. 122. Advanced Alternating Current Analysis and Machinery. 12 units (4-0-8); second term.

Prerequisites: EE. 120 and preceding subjects.

An advanced study of the alternator, the induction motor and the stationary transformer, with particular emphasis on problems involving polyphase polarity, together with single and polyphase multiple circuit.

Texts: *Principles of Alternating Current Machinery*, Lawrence; *Problems in Alternating Current Machinery*, Lyon.

Instructor: Sorensen.

EE. 128. Electric Traction. 9 units (3-0-6); second term.

Prerequisites: EE. 2, 4, 6.

Modern electric and oil-electric railways, studies of the motive power, train requirements, frictional and other resistances, schedules, acceleration and braking; the portable power plant vs. substations and contact conductor. Safe speeds and riding qualities are studied.

Text: *Transit Engineering*, Tuthill.

Instructors: Lindvall, Maxstadt.

EE. 130. 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.

Text: *Electrical Distribution Engineering*, Seelye.

Instructor: Maxstadt.

EE. 144. Transmission Lines. 12 units (4-0-8); third term.

Prerequisites: EE. 122 and preceding subjects.

Line performance and protection; elementary transient phenomena; use of hyperbolic functions in line calculations; generalized system constants; the stability problem.

Instructor: Lindvall.

EE. 148. Specifications and Design of Electrical Machinery. 6 units (4-0-2); first term.

Prerequisites: EE. 7 and preceding subjects.

Preparation of specifications and design calculations for alternating and direct current machinery.

Text: *Electrical Machine Design,* Gray.

Instructor: Sorensen.

EE. 152. Dielectrics. 6 units (2-0-4); third term.

Prerequisites: EE. 122 and preceding subjects.

A study of electric fields in insulations, particularly air, and the effects on sparking voltage of the sparking distance, atmospheric pressure and humidity; corona phenomena; high frequency voltages; characteristics of commercial insulations.

Text: *Dielectric Phenomena in High Voltage Engineering,* Peek.

Instructor: Sorensen.

EE. 156. Electrical Communication. 6 units (2-0-4); first term.

Prerequisites: EE. 2, 3, 4, 5.

A study of modern means of communication with special emphasis on recent developments. Includes a study of four terminal networks and filter theory.

Instructor: Mackeown.

EE. 160. Electric Transients. 6 units (2-0-4); second term.

Prerequisites: EE. 120 and preceding subjects.

A detailed study of circuits, including advanced work in wave propagation and transient phenomena in electric conductors; with special emphasis on the use of differential equations for solving circuit problems.

Instructor: Mackeown.

EE. 162. Vacuum Tubes. 12 units (4-0-8); third term.

Prerequisites: EE. 6 and preceding subjects.

Fundamental theory, and uses as detectors, amplifiers, and oscillators. Special uses of vacuum tubes in both radio and line communication.

Instructor: Mackeown.

EE. 163. Radio. 9 units (3-0-6); first term.

Prerequisite: EE. 162.

Elementary subject dealing with fundamentals of Radio Transmission.

Text: *Radio Engineering,* Terman.

Instructor: Mackeown.

ADVANCED SUBJECTS

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 Professors R. W. Sorensen and F. C. Lindvall; 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 Professor F. W. Maxstadt.

EE. 220. Research Seminar in Electrical Engineering. 2 units required; additional units based on work done. First, second and third terms.
Meets once a week for discussion of work appearing in the literature and in progress at the Institute, or for presentation of technical developments in the industry. All advanced students in Electrical Engineering and members of the Electrical Engineering staff are expected to take part.
In charge: Sorensen, Mackeown, Maxstadt, and Lindvall.

EE. 221. 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; second and third terms.
A study of the effect of high potentials applied to dielectrics.
Text: *Theory of Dielectrics,* Schwaiger-Sorensen.
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; first term.
A discussion and calculation course in the analysis of the principles and methods used in the design of electrical machinery.
Instructors: Sorensen, Maxstadt.

EE. 226 a, b, c. Engineering Mathematical Physics. 15 units (3-0-12); first, second and third terms.
Prerequisites: B.S. in Engineering; Differential Equations, Ma. 10 or Ma. 11.
This subject is designed to develop the correlation of mathematics and physics with problems in engineering design and application. The following subjects will be treated in detail: mechanical vibrations, oscillations in electro-mechanical systems,

short circuit forces, power system transients, electric motors applied to variable or pulsating loads, heat transfer and transient heat flow. The principle of constant flux linkage in electrical transient analysis; solution of mechanical problems by electrical methods; application of Heaviside operational calculus to mechanical and thermal problems.

Instructor: Lindvall.

EE. 227. Operational Circuit Analysis. 6 units (2-0-4); third term.

An introduction to the solution of circuit problems by the operational method.

Instructor: Mackeown.

EE. 228. Conduction of Electricity in Gases. Units to be arranged; first, second and third terms.

Selected topics in glow, arcs, and spark discharges.

Instructor: Mackeown.

EE. 229. Advanced Circuit Analysis. 12 units (3-0-9); first, second and third terms in alternate years.

Development of circuit equations from Maxwell's equations; application of Maxwell's equations to circuits at high frequency, filter circuits, symmetrical components, tensor analysis.

Instructor: Mackeown.

HYDRAULICS

PROFESSOR: ROBERT L. DAUGHERTY
ASSOCIATE PROFESSOR: ROBERT T. KNAPP
ASSISTANT PROFESSOR: HUNTER ROUSE

UNDERGRADUATE SUBJECTS

Hy. 1 a, b. Hydraulics. 12 units (3-3-6), first or second term; 9 units (3-0-6), second or third term.

Prerequisite: AM. 1 a, or to be taken at the same time.

Physical properties of water; hydrostatics; flow of water in pipes, nozzles, and channels; hydraulic turbines; centrifugal pumps and other hydraulic equipment.

Text: *Hydraulics,* Daugherty.

Instructors: Daugherty, Knapp, Wagner, Van Driest.

Hy. 2. Hydraulics Laboratory. 6 units (0-3-3); first or second 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.

Instructors: Knapp, Daily.

Hy. 4. Hydraulic Machinery. 9 units (3-0-6); third term.

Prerequisites: Hy. 1 and 2.

Theory, construction, installation, operation, and characteristics of hydraulic turbines and centrifugal pumps.

Instructor: Knapp.

Hy. 5. Hydraulics. 12 units (3-3-6); third term.

Prerequisite: AM 1 a, or to be taken at the same time.

An abridgement of Hy. 1 a, b for electrical engineering students.

Text: *Hydraulics,* Daugherty.

Instructors: Daugherty, Knapp, Wagner.

ADVANCED SUBJECTS

Hy. 100. Fluid Mechanics. 12 units (3-0-9); second term.

Prerequisites: Hy. 1 and 2.

Dimensional analysis; principles of energy, continuity, and momentum; potential flow; use of the flow net; cavitation; equations of viscous motion; laminar flow; turbulence; resistance of immersed bodies; flow in closed conduits; flow in open channels; wave motion.

Text: *Fluid Mechanics for Hydraulic Engineers,* Rouse.

Instructors: Daugherty, Knapp, Rouse.

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.

Instructors: Daugherty, Knapp.

Hy. 102. Hydraulics of Open Channels. 6 units (0-6-0); third term.
Prerequisite: Hy. 1.
Computation of surface profiles for gradually varied flow in open channels; characteristics of the hydraulic jump; delivery of canals in hydroelectric and irrigation projects.
Text: *Hydraulics of Open Channels,* Bakhmeteff.
Instructor: Rouse.

Hy. 103. Hydraulics Problems. 6 units (0-6-0); third term.
Prerequisite: Hy. 1.
Selected advanced problems in hydraulics such as penstock design, water hammer and surge chamber calculations, hydraulic jump determinations, etc.
Instructor: Rouse.

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.

MECHANICAL ENGINEERING

PROFESSORS: ROBERT L. DAUGHERTY, W. HOWARD CLAPP
ASSOCIATE PROFESSOR: ROBERT T. KNAPP
ASSISTANT PROFESSORS: DONALD S. CLARK, ERNEST E. SECHLER
INSTRUCTOR: HOWELL N. TYSON

UNDERGRADUATE SUBJECTS

ME. 1. Mechanism. 9 units (3-3-3); first, second or third term.

Prerequisites: Ma. 1 a, b, c, d; Ph. 1 a, b, c, d; D. 1, 4, 12 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: *Elements of Mechanism,* Schwamb, Merrill and James.

Instructors: Clapp, Tyson, Shapiro.

ME. 3. Materials and Processes. 11 units (3-3-5); second or third term.

A study of the materials of engineering and of the processes by which these materials are made and fabricated. The fields of usefulness and the limitations of alloys and other engineering materials are studied, and also the fields of usefulness and limitations of the various methods of fabrication and of processing machines.

The class work is combined with inspection trips to many industrial plants. The student is not only made acquainted with the technique of processes but of their relative importance industrially and with the competition for survival which these materials and processes continually undergo.

Text: *Materials and Processes,* Clapp and Clark.

Instructor: Clark.

ME. 5 a, b, c. Machine Design. 9 units (3-0-6), first term; 9 units (3-3-3), second and third terms.

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; 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. Also a study of manufacturing processes with especial reference to the economics of design.

Text: *Design of Machine Elements,* Faries.

Instructor: Clapp.

ME. 8. Machine Design. 12 units (3-3-6); first 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: *Design of Machine Elements,* Faries.

Instructor: Sechler.

ME. 10. Metallurgy. 6 units (2-0-4); first term.

Prerequisites: ME. 3; Ch. 6.

A study of the principles underlying the heat treatment, properties, use, and selection of ferrous and non-ferrous alloys as applied to design.

Text: *Physical Metallurgy for Engineers,* Clark.

Instructor: Clark.

ME. 15. Heat Engineering. 12 units (3-3-6); first or second term.

Prerequisites: Ma. 2 a, b, c, d; ME. 1.

Principles of engineering thermodynamics; properties of gases; thermodynamic processes of gases; gas cycles; internal combustion engines; air compressors; and elements of different types of power plants. Inspection of local power plants, laboratory demonstration tests, and computing room exercises.

Text: *Heat Power Engineering,* Vol. I, Barnard, Ellenwood, and Hirshfeld.

Instructors: Tyson, Majors.

ME. 16. Heat Engineering. 12 units (4-0-8); third term.

Prerequisite: ME. 15.

Additional work in thermodynamics; properties of vapors; thermodynamic processes of vapors; vapor cycles; steam engines; steam turbines.

Text: *Heat Power Engineering,* Barnard, Ellenwood, and Hirshfeld.

Instructor: Daugherty.

ME. 17. Heat Engineering. 9 units (3-0-6); first term.

Prerequisite: ME. 16.

Heat transmission; fuels; combustion; flue gas analysis; steam generators; and steam generator accessories.

Text: *Heat Power Engineering,* Vol. II, Barnard, Ellenwood, and Hirshfeld.

Instructor: Daugherty.

ME. 18. Heat Engineering. 10 units (3-0-7); third term.

Prerequisite: ME. 15.

An abridgement of ME. 16 for students in Electrical Engineering.

Instructor: Daugherty.

ME. 19. Heat Engineering. 6 units (2-0-4); second term.

Prerequisite: ME. 17.

Flow of compressible fluids; condensers; feed water heaters; water softening; mixtures of air and water vapor; atmospheric water cooling; heating and ventilating; refrigeration.

Text: *Heat Power Engineering,* Vol. III, Barnard, Ellenwood, and Hirshfeld.

Instructor: Daugherty.

ME. 20. Heat Engineering. 9 units (2-3-4).

An abridgement of ME. 15 for students in Civil Engineering.

Instructors: Tyson, Majors.

ME. 25. Mechanical Laboratory. 6 units (0-3-3); 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.
Instructors: Knapp, Budenholzer, Majors, Van Driest.

ME. 26. Mechanical 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.
Instructors: Knapp, Budenholzer, Majors.

ME. 27. Mechanical Laboratory. 9 units (0-3-6); first term.
Prerequisites: ME. 15 and Hy. 1.
An abridgement of ME. 25 and Hy. 2 for students in Electrical Engineering.
Instructors: Knapp, Budenholzer, Majors, Van Driest.

ME. 50 a, b, c. Engineering Conferences. 2 units (1-0-1); first, second and third terms.
Presentation and discussion of new developments in industry. Review of current literature.
Instructors: Daugherty, Huse.

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 a, b. Advanced Machine Design. 12 units; second and third terms.
Prerequisites: ME. 5, 10.
The student must possess a comprehensive knowledge of mechanics, of materials, and also of the physical properties of the more common materials of construction. Strength of material formulae are studied as to their authority and limitations, and their application is extended to cover such cases as curved bars, thin plates, energy loads, stress concentration around holes, key seats, etc.; dynamic stresses as in rotating disks and flywheels; critical speeds of shafting; bending of bars on elastic foundations. Many examples of evolved designs are studied to determine the considerations which have led to the design. Theory of strengths and their application to the study of designs which have failed in service.
Instructor: Clapp.

ME. 110 a, b, c. Science of Metals. 6 units (3-0-3); each term.
Prerequisite: ME. 10.
A study of modern engineering metals and alloys; their mechanical and physical properties, and the effects upon these properties brought about by the various processes of manufacture and fabrication. A study of the physical principles governing metallic behavior.
Text: *Principles of Physical Metallurgy*, Doan.
Instructors: Clapp, Clark.

ME. 111 a, b, c. Metallography Laboratory. 6 units (0-6-0); first, second and third terms.

Prerequisite: ME. 110 a, b, c, or to be taken at the same time.

Pyrometry, thermal analysis, microscopy, preparation of metallographic specimens, photomicrography, structures of steels and cast irons, heat treatment of steel, structures and treatment of non-ferrous alloys, recrystallization and grain growth, macroscopy, inspection methods, special problems.

Instructor: Clark.

ME. 120. Heat Engineering. 12 units (3-0-9); first term.

Prerequisite: ME. 17.

Advanced work in engineering thermodynamics; thermodynamic processes of actual gases with variable specific heats; complex power plant cycles; heat transmission; combustion; heat balance of boilers; and other applications to practical cases.

Instructor: Daugherty.

ME. 121 and 122. Heat Engineering. 12 units (2-0-10); second and third terms.

Prerequisite: ME. 120.

Advanced study of internal combustion engines of all types, steam turbines, heating and ventilating, refrigeration, air conditioning, and steam power plants. Either term may be taken independently of the other.

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. Advanced Mechanical 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. 132. Engine Laboratory. 15 units; first, second and third terms.

Use of the dynamometer. Experimental work in engine performance, carburetion, ignition, fuel consumption, etc.

ME. 140 a, b. Research or Thesis. 18 units; second and third terms.

This work is arranged with the department to fit the needs and desires of the individual student.

ME. 150 a, b, c. Mechanical Engineering Seminar. 2 units each term.

Attendance required of graduate students in mechanical engineering. Conference on research work and reviews of new developments in engineering.

METEOROLOGY

PROFESSOR: BENO GUTENBERG
ASSOCIATE PROFESSOR: IRVING P. KRICK
INSTRUCTORS: PAUL RUCH, H. J. STEWART

AE. 272 a, b, c. Dynamic Meteorology. 9 units (3-0-6); first, second and third terms.

The application of hydrodynamics and thermodynamics to the study of atmospheric phenomena. Statics and kinematics of the atmosphere; general dynamics of air currents; energy of air movements, gusts, turbulence, etc.

Instructor: Stewart.

AE. 273 a, b, c. Synoptic Meteorology. 12 units (4-0-8); first, second and third terms.

Application of the principles of dynamic meteorology to the study of the phenomena of the weather map. Modern theories on the structure of the extratropical cyclone, general circulation of the atmosphere, air masses, frontogenesis and frontolysis. Upper air soundings and their use in synoptic meteorology, identification of air masses by evaluation of upper air data and by other criteria. Detailed discussion of weather forecasting by means of frontal and air mass analysis, especially in connection with aircraft operations. Forecasting of local weather phenomena such as fogs, thunder storms, etc., effects of topography upon frontal movements and upon properties of air masses.

Instructor: Krick.

AE. 274 a, b, c. Meteorological Laboratory. 15 units; first, second and third terms.

Decoding and plotting of daily weather maps by frontal and air-mass analysis methods. Surface data augmented by all available upper-air information in order to obtain, as far as possible, three-dimensional analyses. The Department of Commerce teletype service is utilized and actual operating conditions simulated in the laboratory, including practice forecasts for selected areas, both of a general nature and of a more detailed nature in connection with forecasts for aviation. The laboratory work is supplemented by observational work carried on at the Institute's Marine Observatory at San Pedro, California.

Instructors: Krick, Ruch.

AE. 275. Structure of the Atmosphere. 3 units; third term.

Constituents of the atmosphere and their distribution. Theories underlying the probable structure and temperature of the stratosphere.

Instructor: Gutenberg.

AE. 276. Meteorological Instruments. 6 units (6-0-0); first term.

Temperature measurements, including a study of mercury and other expansion thermometers, electrical thermometers; hygrometry; barometers; velocity measurements, including dynamic pressure and hot wire instruments, rain and snow gauges, cloud measurements; radiation measurements, including a study of sounding and pilot balloons and their equipment. Practical measurements are made at the Institute's Marine Observatory at San Pedro.

Instructor: Klein.

AE. 280 a, b. Meteorological Research. Units to be determined; second and third terms.

Selected problems in meteorology research assigned to meet the needs of advanced students.

Instructors: Gutenberg, Krick.

AE. 291 a, b, c. Meteorological Seminar. 2 units; first, second and third terms.

Reviews and discussions of current meteorological literature and problems.

In charge: Gutenberg, Krick.

Additional and supplementary subjects are offered as the need arises. Lectures are 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.

SUBJECTS IN THE HUMANITIES

ECONOMICS

PROFESSOR: GRAHAM A. LAING
ASSOCIATE: EDWIN F. GAY
LECTURER: ARCHIBALD B. YOUNG
ASSOCIATE PROFESSORS: PHILIP S. FOGG, HORACE N. GILBERT, RAY E. UNTEREINER
INSTRUCTOR: VICTOR V. VEYSEY

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 and Economic Problems. 10 units (4-0-6); second or third term.

The purpose of this subject is to describe in as great detail as possible the economic life of the community. It includes a study of production, distribution, and exchange of goods, the nature of money and credit, the development of economic institutions, and an analysis of a number of pressing economic problems. The subject is given in the second and again in the third term.

Instructors: Laing, Fogg, Untereiner, with occasional lectures by Gay.

Ec. 17. Accounting. 9 units (3-0-6); first, second or third term. Open only to engineering students in their Junior year.

This is a subject in the interpretation of the financial statements with which engineering students who enter business will come in contact. A description of bookkeeping methods is presented, but not in sufficient detail to enable the average student to keep a set of business books. Emphasis is placed upon the study of actual business problems involving the executive interpretation of accounting reports. A liberal amount of descriptive material regarding business activities accompanies the instruction.

Text: *Accounting*, Porter and Fiske.

Instructor: Fogg.

Ec. 20. Financial Organization. 8 units (3-0-5); first term.

Prerequisite: Ec. 2.

A general study of the financial organization of society. The subject 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); first term.

The principles of law as applied to business affairs; a study of the law governing contracts, negotiable instruments, agency, partnership, corporations, and employer's liability.

Instructor: Young.

Ec. 34. Corporation Finance. 8 units (2-0-6); 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.

Instructor: Laing.

Ec. 45 a, b. Seminar in Social and Economic Organization. 4 units (2-0-2); third term.

This subject 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 expected 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. The seminar meets on Thursday evenings at the home of Professor Laing.

In charge: Laing.

Ec. 50. Industrial Management. *9* units (3-0-6); third term.

Open to senior engineers.

This subject aims to give students planning to enter the general field of manufacturing (1) information regarding special management techniques and (2) an idea as to the relationship of the production function to industrial sales, industrial finance, and general executive policies. The scope of the subject is further indicated by the following partial list of topics studied: plant location, types of factory buildings, plant layout, simplification and standardization of products, time and motion studies, the production budget, production control, cost control, wage systems, and industrial relations.

Several field trips are made to enable students to see industrial management techniques in operation.

Text: *Introduction to Industrial Management,* Folts.

Instructor: Gilbert.

FIFTH-YEAR AND ADVANCED SUBJECTS

Ec. 100 a, b, c. Business Economics. 12 units (4-0-8); first, second and third terms. Open to graduate students.

This subject endeavors to bridge the gap between engineering and business. It is intended for students in applied science and technology who wish to use their technical training as an approach to the administrative side of business and industry.

The subject includes, in brief (a) a description of business and industry, and (b) a consideration of principles of business economics which are relevant to the fields of interest of engineers and applied scientists. The principal subjects treated are (1) business organization, (2) industrial promotion and finance, (3) factory problems, and (4) the marketing of industrial goods. An introduction is given to industrial statistics and accounting. Students are made familiar with the operations of the Federal Reserve system and with various other significant subjects in business economics. Several industries are studied in detail as to the nature of their particular economic problems and as to the actual companies operating in them. The case method of instruction developed by the Harvard Graduate Business School is employed to a considerable extent throughout the subject.

Texts: *Financial Policy of Corporations,* Dewing; *Principles of Industrial Organization,* Kimball; *Fundamentals of Industrial Marketing,* Elder.

Instructor: Gilbert.

Ec. 106 a, b, c. Business Economics Seminar. 3 units; first, second and third terms. Open to graduate students.

Special studies of current economic problems are presented by the instructor, after which an open discussion is held. Emphasis is placed on the materials of economic science, i.e., statistics of production, consumption, prices, banking and finance, etc. These quantitative studies are accompanied, where advisable, by reference to economic doctrine.

In charge: Gilbert.

ENGLISH

PROFESSOR: CLINTON K. JUDY
ASSOCIATES: C. BOWIE MILLICAN, EDWARD A. WHITNEY, LOUIS B. WRIGHT
ASSOCIATE PROFESSORS: HARVEY EAGLESON, WILLIAM HUSE, GEORGE R. MACMINN
ASSISTANT PROFESSORS: L. WINCHESTER JONES, ROGER STANTON
INSTRUCTOR: DAVID L. STEVENSON

English composition is prescribed for all students in the Freshman year, and a 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 those authors, past and present, who are most significant in the development of modern civilization, and to foster the habit of self-cultivation in books.

The regular subjects 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.

All students are required to pass a comprehensive examination in English and History at the end of the Sophomore year. This examination is not confined to specific courses, but covers the general attainments of the students in their humanistic work throughout the first two years.

UNDERGRADUATE SUBJECTS

En. 1 a, b, c. English Composition and Reading. *6* units (3-0-3); first, second and third terms.

This subject 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. The members of the section are held to high standards of excellence in writing and speaking, and are expected to undertake a considerable amount of cultural reading.

Texts: *American Points of View,* Cordell; *Writing and Thinking,* Foerster and Steadman; *College Readings in the Modern Short Story,* MacMinn and Eagleson; *Webster's Collegiate Dictionary.*

Instructors: Eagleson, Huse, Jones, MacMinn, Stanton, Stevenson.

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 16th Century to the 20th, focused on representative works by seven major authors: in the first term, Shakespeare; in the second, Swift, Wordsworth, and the Romantic Movement; in the third, Carlyle, Browning, and Masefield.

Instructors: Eagleson, Huse, Jones, Judy, MacMinn, Stanton, Stevenson.

En. 8. Contemporary English and European Literature. 9 units (3-0-6); first, second or third term.

Prerequisite: En. 7 a, b, c.

A continuation of the survey of English literature to cover the period from 1890 to the present, with some extension into Continental literature. Wide reading is required.

Instructors: Eagleson, Judy.

En. 9. Contemporary American Literature. 9 units (3-0-6); first or second term; second term only in 1937-1938.

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: *American Poetry and Prose,* Part II, Foerster.

Instructor: MacMinn.

En. 10. Modern Drama. 9 units (3-0-6); first, second or third term.

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: *Representative Modern Dramas,* Whitman.

Instructors: Huse, 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.

Texts: *The Bible* (Authorized Version); *Biblical Literature and Its Backgrounds,* Macarthur.

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 and History. 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 subjects in English and History, or independently of any subject, but under the direction of members of the department.

En. 14. Special Composition. 2 units (1-0-1); any term.

This subject 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.

Instructor: MacMinn.

En. 16. Spelling. No credit.

This subject 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. 9 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: Millican, Whitney, Wright.

HISTORY AND GOVERNMENT

PROFESSOR: WILLIAM B. MUNRO
VISITING LECTURER: WALTER LIPPMANN
ASSOCIATES: GODFREY DAVIES, EDWARD MEAD EARLE, EDWIN F. GAY.
ASSOCIATE PROFESSOR: RAY E. UNTEREINER
ASSISTANT PROFESSOR: J. E. WALLACE STERLING
INSTRUCTORS: HARDIN CRAIG, JR., WILLIAM H. PICKERING

All students are required to pass a comprehensive examination in English and History at the end of the Sophomore year. This examination does not cover specific courses, but the general attainments of the students in their systematic work throughout the first two years.

UNDERGRADUATE SUBJECTS

H. 1 a, b, c. Ancient and Medieval History. 5 units (3-0-2); 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. In connection with this course, Freshmen are expected to attend a performance of the classical play presented in the fall term, and to make one visit to the Huntington Collections.

Instructors: Craig, Untereiner.

H. 2 a, b, c. Modern European History. 6 units (2-0-4); first, second and third terms.

Prerequisites: H. 1 a, b, c.

The general political and social history of Europe from 1789 to 1938, presented as the background and development of movements underlying present conditions.

Instructors: Munro, Sterling.

H. 5 a, b. Current Topics. 2 units (1-0-1); first and second terms.

This subject is given collaterally with senior humanities electives, and is articulated with a selected weekly journal of general information and opinion.

Instructors: Sterling and Pickering (with lectures by Walter Lippmann and members of the Division of Humanities).

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.

FIFTH-YEAR AND ADVANCED SUBJECTS

H. 100. Seminar in History and Government. 9 units (1-0-8); first, second and third terms.

Open only to fifth-year students and seniors who have attained honor grades.

First term: The Industrial Revolution.
In charge: Gay.

Second term: Foundations of American Foreign Policy.
In charge: Earle.

Third term: English History in the Nineteenth Century.
In charge: Davies.

LANGUAGES

PROFESSOR: JOHN R. MACARTHUR

The subjects in modern languages are arranged primarily to meet the needs of science students who find it necessary to read books, treatises, and articles in French, German, and Italian. In the study of 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 subject 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 subject in grammer, pronunciation, and reading that will provide the student with a vocabulary 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. Students who have had French in the secondary school should not register for these subjects without consulting the Professor of Languages.

Texts: *Minimum Essentials of French,* Shelton; selected readings, including *Aventures par la Lecture,* Bovée.

Instructor: Macarthur.

L. 11. Elementary Italian. 9 units (3-0-6); one term, as required. A subject 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. Will be offered in the winter term, 1938-1939.

Texts: *Elementary Italian,* Marinoni and Passarelli; *L'Italia nel Passato e nel Presente,* Capocelli.

Instructor: Macarthur.

L. 32 a, b, c. Elementary German. 10 units (4-0-6); first, second and third terms.

This subject is presented in the same manner as the Elementary French. Students who have had German in the secondary school or junior college should not register for these subjects without consulting the Professor of Languages.

Texts: *First German Course for Science Students,* Fiedler and Sandbach; *Einführung in die Chemie,* Curts (for Chemistry sections); *A German Science Reader,* Raschen and Fairfield (for other sections); *Berühmte Forscher und ihre Beiträge,* Sokol and Nye.

Instructors: Macarthur, Dekker.

L. 35 a, b, c. Scientific German. 10 units (4-0-6); first, second and third terms.

Prerequisite: L. 32 a, b, c, or one year of college German.

This is a continuation of L. 32 a, b, c, with special emphasis on the reading of scientific literature.

Text: *Technical and Scientific German,* Greenfield.

Instructors: Macarthur, Dekker.

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); third term.

Prerequisites: L. 32 a, b, c; L. 35 a.

The reading of selected German classics, poetry and drama, accompanied by lectures on the development of German literature. Elective and offered only to students whose work in the prerequisites has been above average. Selected readings from Schiller and other classical authors.

Text: *Historical Survey of German Literature,* S. Liptzin.

Instructor: Macarthur.

L. 51 a, b, c. Greek. 6 units (3-0-3).

This is a subject 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 subject is elective, and will be offered only if six or more persons request it and agree to take it throughout the year.

Texts: *Alpha,* Frost; Xenophon's *Anabasis; The Study of Greek Words in English, Including Scientific Terms,* Hoffman.

Instructor: Macarthur.

PHILOSOPHY, ETHICS AND SOCIOLOGY

PROFESSORS: THEODORE G. SOARES, GRAHAM A. LAING

UNDERGRADUATE SUBJECTS

Pl. 1. Introduction to Philosophy. 9 units (3-0-6); first and second terms.

An endeavor to see how the most fundamental questions have been answered by typical thinkers in the past, and how the modern student may arrive at a philosophy.

Texts: First term, *Types of Philosophy,* Hocking; second term, *First Adventures in Philosophy,* Ferm.

Instructor: Soares.

Pl. 4. Ethics. 9 units (3-0-6); third term.

The fundamental ethical concepts and theories that have emerged in the process of human thought. The major social problems of modern life.

Texts: *Social Ethics,* Ericksen; *Readings in Ethics,* Clark and Smith.

Instructor: Soares.

Pl. 5. Sociology. 9 units (3-0-6); first term.

The genesis and evolution of human society. The influence of economic, religious and social forces. The nature of social control and the analysis of mores, morals and legal codes. The development of social institutions and the nature of change in these institutions.

The class is conducted as a discussion group.

Instructor: Laing.

Psychology. Psychological Foundations of Personality. Second term; no credit.

A series of nine lectures on psychology which contribute to an understanding of personality adjustments and failures. Primarily for seniors, but open to any interested students. 4 to 5:30 p.m. on Mondays beginning Jan. 9, 1939, in 206 Dabney.

Lecturer: Robert Ross, B.S., California Institute, 1927; Ph.D., Yale University, 1934.

FIFTH-YEAR AND ADVANCED SUBJECTS

Pl. 100. A Study of Some Aspects of Philosophical, Ethical or Social Development. 9 units; first, second and third terms.

Instructor: Soares.

PHYSICAL EDUCATION

PHYSICAL DIRECTOR: WILLIAM L. STANTON
ASSISTANT DIRECTOR AND MANAGER OF ATHLETICS: HAROLD Z. MUSSELMAN
CONSULTING PHYSICIAN: DR. E. D. KREMERS
ASSISTANT TO THE CONSULTING PHYSICIAN: DR. M. Y. KREMERS.
PHYSICIAN TO ATHLETES: DR. FLOYD L. HANES

PE. 1, 2, 3, 4. Physical Education. First, second and third terms.

All undergraduate students are required to participate either in the intramural or intercollegiate sports on which the physical education program is based. The intramural sports comprise competition between student houses, classes and clubs, 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. Representative freshmen and varsity teams in the major sports are developed and trained by experienced coaches. Fair-spirited and clean-cut athletic competition is encouraged 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 strength and skill 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 for those who cannot compete in intramural or intercollegiate sports.

DEGREES CONFERRED, JUNE 10, 1938

Doctor of Philosophy

Ralph Doris Baker, B.S., University of Utah; M.S., University of Kansas
Robert DeVore Boche, B.S., California Institute
Eugene Mittell Brunner, B.S., and M.S., California Institute
Alexander Crane Charters, Jr., B.S., and M.S., California Institute
William Cecil Cooper, B.S., University of Maryland; M.S., California Institute
Kamal Djanab, Licencie, University of Teheran; Certificat d'Etudes Superieure, University of Nancy; Licencie es Sciences, University of Paris
Edward Bushnell Doll, B.S., and M.S., California Institute
Norman Elliott, B.A., and M.A., Oberlin College
Eugene Henderson Eyster, B.Ch., University of Minnesota
Clifford Symes Garner, B.S., California Institute
Newman Arnold Hall, A.B., Marietta College
Hsia-Chien Huang, B.S., National Central University; M.S., California Institute
Philip Truman Ives, B.A., and M.A., Amherst College
Edwin Nichols Lassettre, B.S., Montana State College
Henri Arthur Levy, B.S., California Institute
Elburt Franklin Osborn, B.A., De Pauw University; M.S., Northwestern University
Darrell Wayne Osborne, A.B., University of California at Los Angeles
Kenneth James Palmer, B.S., University of California
Louis Telemacus Rader, B.A.Sc., University of British Columbia; M.S., California Institute
Verner Schomaker, B.S., and M.S., University of Nebraska
William Rees Sears, B.Aero.E., University of Minnesota
Howard Stanley Seifert, B.S., and M.S., Carnegie Institute
William Edwards Stephens, A.B., and M.S., Washington University
Donald Stinson Taylor, B.A., Linfield College
Saul Winstein, A.B., and M.A., University of California at Los Angeles

Master of Science in Science

PHYSICS

Leverett Davis, Jr., B.S., Oregon State College
Richard Rohrer Goodell, B.S., California Institute
Stephen Jennings, B.S., Trinity College
Ulrich Jetter, Diploma, Technische Hochschule, Stuttgart
Howard Hollis Reamer, A.B., University of Redlands

Charles Franklin Robinson, B.S., Drury College; A.B., Missouri State Teachers College
Charles Wilcox Sheppard, B.S., California Institute
Meyer Joseph Test, B.S., California Institute
John Shearon Wiggins, A.B., Earlham College

CHEMISTRY

Joseph Axelrod, B.S., California Institute
John Burton Hatcher, B.S., California Institute

CHEMICAL ENGINEERING

Harry Dean Evans, B.S., University of Illinois
Donald Charles Nellis, B.S., California Institute
Cecil Wright Nysewander, B.S., University of Illinois
William Dickinson Yale, B.S., California Institute

GEOLOGICAL SCIENCES

Paul Carrington Henshaw, A.B., Harvard College
Stanley William Lohman, B.S., California Institute
James McPhail Orr, B.S., University of British Columbia
Maurice Sklar, B.S., California Institute
John Cawse Wells, B.S., University of Idaho

BIOLOGY

Willard Lee McRary, B.S., California Institute
Daniel Chapin Pease, B.A., Yale University

Master of Science in Engineering

ELECTRICAL ENGINEERING

Allan Kallan Alsaker, B.S., Northwestern University
Edward Markham Gardner, B.S., University of London
Charles Frederick Gates, B.S., California Institute
Arnulfo Gutierrez y Gomez, B.S., Facultad Nacional de Ingenieria
Charles Franklin Hadley, B.S., California Institute
Jasper Ridgely Leggett, B.S., California Institute
Charles William McLeish, B.A.Sc., University of British Columbia
Robert Charles McMaster, B.S., Carnegie Institute
Bruce Fitzgerald Morgan, B.S., California Institute
James Kneeland Nunan, B.S., University of Southern California

MECHANICAL ENGINEERING

Lee Arnold, B.A., Duke University
Irving Louis Ashkenas, B.S., California Institute
Waldo Milton Claflin, B.S.E., Princeton University
Norman Branson Dewees, B.S., California Institute
Duane Wesley Farnham, B.S., United States Naval Academy
I. Stanley Feuer, B.S., California Institute
Frederic Theodore Fuetsch, B.S., University of Nevada
Willis George Geselbracht, B.S., Washington University
Marvin Henderson Greenwood, B.S., Rice Institute
Edward James Horkey, B.S., California Institute
Albert Hall Hughey, B.S., Purdue University
Sunao Kanemitsu, B.S., University of California
Walter Louis Koch, Diploma, Technische Hochschule, Hannover
Peter Rudolf Kyropoulos, Diploma, Kaiser Wilhelm II, Realgymnasium, Gottingen
Donald Campbell MacPhail, B.A.Sc., University of British Columbia
George Edward Mann, Jr., B.S., California Institute
Robert Alfred McIntyre, B.S., California Institute
Noble Nojima, B.S., California Institute
John Bertrand Parrish, Jr., B.S., Princeton University
Robert Beaton Smith, B.A., Ohio State University
Wilbur Fisher Snelling, B.S., California Institute
Robert Dawson Townsend, Jr., B.S., California Institute
Chi-Cheng Tsao, California Institute
George Yoshio Tsubota, B.S., California Institute
Jay Boreas Van Der Werff, B.S., California Institute
Sylvan Brooks Walton, B.S., University of Southern California
Tsun-Kuei Wang, B.S., National University of Peking
Joseph Fulton Ware, Jr., B.S., Virginia Polytechnic Institute
Edward Earl Wileman, B.S., California Institute

CIVIL ENGINEERING

John Arthur Bonell, B.S., South Dakota State College of Agriculture and Mechanical Arts
LeVan Griffis, B.S., California Institute
Walter Leon Moore, B.S., California Institute
Charles Adelbert Morse, II, B.S., California Institute
Daniel Alexander Okun, B.S., Cooper Union Institute
Hsih-Heng Wang, B.S., Harbin Polytechnic Institute

AERONAUTICAL ENGINEERING

Willard Newton Bell, B.A., University of Texas; M.S. in ME, California Institute
Irving Berler, B.S., New York University; M.S. in ME, California Institute

William Harold Bowen, B.S., University of California; M.S. in ME, California Institute

John Kenneth Bussey, B.S., University of California; M.S. in ME, California Institute

Wesley Theodore Butterworth, B.S., Northwestern University; M.S. in ME, California Institute

Louis Gerhardus Dunn, B.S., and M.S. in ME, California Institute

John Christopher Dykes, B.A., Cambridge University; M.S. in ME, California Institute

Samuel Sloan Jack, Captain U.S. Marine Corps, B.S., United States Naval Academy

Hisayuki Kurihara, B.S., and M.S. in ME, California Institute

Wallace Bristol Mechling, Lieut. U.S.N., B.S., United States Naval Academy

George Rolland Mellinger, B.A., Drake University; M.S. in ME, California Institute

John Lloyd Nollan, B.S., and M.S. in ME, California Institute

Donald Leander Putt, First Lieut. U.S.A., B.S., Carnegie Institute

William Alton Schoech, Lieut. U.S.N., B.S., United States Naval Academy

Albert Buddy Scoles, Lieut. U.S.N., B.S., United States Naval Academy

Apollo Milton Olin Smith, B.S., and M.S. in ME, California Institute

METEOROLOGY

John Bevier Ackerman, First Lieut. U.S.A., B.S., United States Military Academy

Morris Gershzohn, B.S., Brooklyn College

Hyman David Goodman, B.S., University of Illinois

Henry Oscar Kruse, B.A., University of Cincinnati

William Julius Lindstrom, M.E., Rensselaer Polytechnic Institute

Thomas Samuel Moorman, Jr., First Lieut. U.S.A., B.S., United States Military Academy

Sidney Andrew Ofsthun, First Lieut. U.S.A., B.S., United States Military Academy

Harold Lester Smith, First Lieut. U.S.A., B.S., United States Military Academy

William Sebastian Stone, First Lieut. U.S.A., B.S., United States Military Academy

Delbert George Van Ornum, B.A., University of Washington

Bachelor of Science

SCIENCE

Carl Wilhelm Ahlroth, Jr.
†Richard Harvey Allen
*†James Robinson Balsley, Jr.
*David Kent Beavon
Theodore Arnold Bertness
William Thomas Cardwell, Jr.
Robert Broadwell Carr
Carroll F. Chatham
Roger Harrison Cowie
Robert Stanley Custer
†Donald Douglas Davidson
Robert Craig Davidson
Paul Arthur Dennis
Blaine Andrew Dixon, Jr.
Jack Francis Dougherty
Arthur Clement Ellings
William John Freede
Chris Gregory
Clyde Winger Harris
Russell Edward Hayward
Carlton Leon Horine
†Lowell Harrison Hulbirt
Benjamin Kazan
Jack William Knight
*†Harrison Morton Lavender, Jr.
*Robert Jules Levit
John Cunningham Lilly
†David Brown Luckenbill
†John Godfrey McLean
Frederic Hollway Moore
Harper Qua North
Robert Horner Olds
*John Eversole Parker
†Richard Rosencranz, Jr.
George Thomas Rudkin
Garn Arthur Rynearson
Maurice J. Schlatter
C. Norman Scully
*David Marx Sherwood
†Paul Charles Siechert
†Clay Taylor Smith
†Roland Cruse Stone
George Wald, Jr.
Albert C. Walker
James Wendell Watson
Samuel Eugene Watson, Jr.
Edward Lee Weinberger
*Richard Norman Wimpress
Emanuel Windsor
William White Woodbury
John Robert Woolson

ENGINEERING

William S. Althouse, Jr.
Michel Ambroff
†John Raymond Baker
†Robert Joseph Barry
Elliott Powell Bennett
*Sidney Bertram
Harry Berthold Boller
Elliott Hinman Bonham
Clark Douglass Bower
*William Carl Brenner
Robert Edgar Carr
Charles William Clarke
Thomas V. Davis
*Munson White Dowd
Arthur Clifford Downing
†Armand Frederick DuFresne
William B. Elconin
†Bruce Cass Elliott
†Herbert Bailey Ellis
†Henry King Evans
John D. Farneman
Richard Wilson Folkins

†Awarded the Honor Key by the Associated Student Body for participation in student activities.
*Graduated with honor in accordance with a vote of the Faculty.

Richard Blair Forward
Carl Frederick Friend
Edward Nathaniel Frisius
Peter Clayton Goff
Boyne Buell Grainger
*Oran Avery Graybeal, Jr.
Arthur George Gross
†George Benjamin Holmes, Jr.
Henry Stuart Hopkins
*Donald Ellis Hudson
Nickolas Giorgievich Ivanoff
†Frank Baldwin Jewett, Jr.
Jack Johannessen
†Evan Albert Johnson, Jr.
†Ralph Wilson Jones, Jr.
*Wilson Burdette Jones
*Albert Earnest Jurs, Jr.
Samuel Harris Keller
Leroy Bruce Kelly
Dalimil Kybal
John J. Lentz
Yuan-Chuen Li
†Frederick Eaton Llewellyn
Clare Frank Lowe
C. Keith Mason
John Thomas McGraw
John L. Merriam
Robert Gerson Metzner
William Edward Milburn
John K. Minasian
Henry Takeshi Nagamatsu
†William Francis Nash, Jr.
†George H. Osborn
Joseph Frank Piro
Edwin Jewett Porter
William Rhett
†Richard Merrill Rowell
Phillip E. Saurenman
August V. Segelhorst
Edmond Francis Shanahan
Harold W. Sharp
Philip Frick Shepherd
Arthur William Sidler
James Farren Stevens
Louis Hernan Tejada
†Robert Coggeshall Thomas
Paul Owen Tilker
Chi-Cheng Tsao
William Edward Twiss, Jr.
†John Richard van Fleet
James Wilkes Van Horn
J. L. Velazquez
Stanley Van Voorhees
Donald Rexford Warren
†Lupton Allemong Wilkinson, Jr.
Gardner Pond Wilson
†Stanley T. Wolfberg
*Homer Jesse Wood

*Graduated with honor in accordance with a vote of the Faculty.
†Awarded the Honor Key by the Associated Student Body for participation in student activities.

UNDERGRADUATE SCHOLARSHIPS, 1938-39

CHARLES L. DENISON SENIOR SCHOLAR:

George O. Crozier

JUNIOR SCHOLARS:

E. Baumgarten
L. Brewer
W. E. Brown
L. Davis
R. W. Grigg
W. D. Hayes
J. Kohl
P. A. Longwell
J. F. Manildi
H. S. Mickley
D. E. Nagle
W. B. Scarborough
R. D. F. Thompson
G. J. Todd
Charles H. Wilts

WALTER HUMPHRY SOPHOMORE SCHOLAR:

Robert Buss

SOPHOMORE SCHOLARS:

J. H. Barber
G. W. Billman
F. W. Billmeyer, Jr.
R. R. Bowles
P. D. Brooks
P. S. Farrington
R. G. Geitz
R. N. Hall
R. H. Harris
M. Ikawa
W. L. Ingersoll
S. G. Stroud
R. W. Wallace
J. R. White
D. S. Wood

BLACKER FRESHMAN SCHOLARS:

Alan Eddy Bell
Donald G. Burkhard
Robert Driscoll
Willard J. Hendrickson
David L. Hill
David Howton
Jack H. Irving
Alexander S. Jerrems

DRAKE FRESHMAN SCHOLARS:

Robert E. MacKenzie
John Wilder Mills
Arthur J. Schneider
Homer Jacobson

AMERICAN CHEMICAL SOCIETY FRESHMAN SCHOLAR:

Rolfe LaForge

LAVERNE NOYES SCHOLARS:

Arthur Mansville Compton
Sheldon Cyr Crane
John Archibald Drake
David Shepard Shisler
Stanley Edward Sohler
Roger William Wallace

GRADUATE STUDENTS

Abbreviations: Eng., Engineering; Sci., Science; A.Ch., Applied Chemistry; AE, Aeronautical Engineering; A.Ph., Applied Physics; Ay, Astronomy; Bi, Biology; CE, Civil Engineering; Ch., Chemistry; Ch.E., Chemical Engineering; EE, Electrical Engineering; Ge, Geology; Ma, Mathematics; ME, Mechanical Engineering; My, Meteorology; Ph, Physics.

(†) following a student's name indicates that he has been admitted to candidacy for the degree of Doctor of Philosophy.

Name	Major Subject	Home Address
Addicott, Fredrick Taylor (†) A.B., Stanford University, 1934	Bi	Palo Alto
Ahlroth, Carl Wilhelm, Jr. B.S., California Institute, 1938	Ge	Hollywood
Aime, Edgar Allan B.S., Tulane University, 1934	My	New Orleans, Louisiana
Albert, Donald Eugene B.A., University of Redlands, 1937	EE	Redlands
Antonenko, Basil Petrovich Petersburg Polytechnic Institute, Petersburg School of Naval Aviation	AE	Pasadena
Armi, Edgar Leo Diploma, Munich Institute of Technology, 1931	Ph	Pasadena
Arnold, Hubert Andrew (†) A.B., University of Nebraska, 1933	Ma	Lincoln, Nebraska
Ashkenas, Irving Louis B.S., California Institute, 1937; M.S., 1938	AE	Los Angeles
Atsumi, John Shoichi (†) B.S., University of Southern California, 1932; M.S.E., University of Michigan, 1935	AE	Stockton
Avann, Sherwin Parker B.S., University of Washington, 1938	Ma	Clinton, Washington
Axelrod, Joseph B.S., California Institute, 1937; M.S., 1938	Ch	Los Angeles
Bailey, Howland Haskell (†) A.B., Haverford College, 1932	Ph	Hyde Park, Massachusetts
Baumgarten, Werner Diploma, University of Munich, 1937	Ch	Pasadena
Beanfield, Byron Fremont B.S., University of Southern California, 1935	ME	Los Angeles
Beardsley, George Francis (Lieutenant) B.S., United States Naval Academy, 1929	AE	Washington, D. C.
Becker, Robert Adolph (†) B.S., College of Puget Sound, 1935; M.S., California Institute, 1937	Ph	Tacoma, Washington
Belsley, Steven Eric B.S., Purdue University, 1938	AE	Peoria, Illinois
Bergren, William Raymond (†) B.S., California Institute, 1932	Bi	Pasadena
Bonell, William Henry B.S., South Dakota State College, 1938	CE	Brookings, South Dakota
Bonner, David Mahlon B.A., University of Utah, 1936	Bi	Salt Lake City, Utah

Name	Major Subject	Home Address
Bradner, Hugh A.B., Miami University, 1936	Ph	Hamilton, Ohio
Brattan, Robert Franklin III B.S., Haverford College, 1938	CE	Norristown, Pennsylvania
Brown, Frank William III B.S., Massachusetts Institute of Technology, 1938	Ph	Rome, New York
Budenholzer, Roland Anthony (†) B.S., New Mexico State College, 1935; M.S., California Institute, 1937	ME	Belen, New Mexico
Burcik, Emil Joseph B.S., Carnegie Institute of Technology, 1937	Ch	Pittsburgh, Pennsylvania
Burns, Martin Charles (Lieutenant) B.S., United States Naval Academy, 1930	My	Spokane, Washington
Byrne, Ralph Edward, Jr. B.S., California Institute, 1933; M.S., 1934	CE	Pasadena
Cabeen, William Ross A.B., University of California at Los Angeles, 1938	Ge	Los Angeles
Cardwell, William Thomas, Jr. B.S., California Institute, 1938	ChE	Pasadena
Carrick, Harry Hall B.S., California Institute, 1937	CE	West Hollywood
Ch'en, Shang-Yi B.S., Yenching University, 1932; M.S., 1934	Ph	Peking, China
Christensen, John Whittaker B.S., University of Utah, 1937	Ph	Cedar City, Utah
Coates, Leonidas Dixon, Jr. (Lieutenant) B.S., United States Naval Academy, 1930	AE	Los Angeles
Cooley, Robert Alonzo B.S., University of California, 1938	Ch	Centerville
Curry, H. Donald (†) B.A., State University of Iowa, 1929; M.S., 1930	Ge	Pasadena
Dahl, Leo Peter (Lieutenant) B.S., United States Military Academy, 1932	My	Ely, Minnesota
Daily, James Wallace A.B., Stanford University, 1935; M.S., California Institute, 1937	ME	Pasadena
Davenport, Horace Willard (†) B.S., California Institute, 1935; B.A., Oxford University, 1937; B.Sc., 1938	Bi	Glendale
Davis, Leverett, Jr. (†) B.S., Oregon State College, 1936; M.S., California Institute, 1938	Ph	Cornucopia, Oregon
Davis, Roderic Charles B.A., Earlham College, 1936; M.S., California Institute, 1937	Ma	Richmond, Indiana
Dekker, Albert Orno (†) B.S., California Institute, 1935	Ch	Glendale
DeLong, James Henry, Jr. A.B., Lafayette College, 1937	Ge	Easton, Pennsylvania
Dery, Robert John B.S., University of Oregon, 1931	Ch	Pasadena
Dickey, Samuel Worth B.A., Pomona College, 1938	ChE	Los Angeles
Dilworth, Robert Palmer (†) B.S., California Institute, 1936	Ma	Hemet

Name	Major Subject	Home Address
Doolittle, Russell Carter A.B., Princeton University, 1935	Ge	Garden City, New York
Dougherty, Jack Francis B.S., California Institute, 1938	Ge	Van Nuys
Drescher, Arthur Bernard B.S., South Dakota School of Mines, 1937	Ge	Elmhurst, Illinois
Dreyer, Robert Marx (†) B.S., Northwestern University, 1934; M.S., California Institute, 1937	Ge	Los Angeles
Dunn, Louis Gerhardus B.S., California Institute, 1936; M.S., 1937 and 1938	AE	Ermelo, Transvaal, South Africa
Easton, Anthony B.S., University of Washington, 1932; M.S., California Institute, 1937	Ph	Pasadena
Easton, Robert Loyal (Captain) B.S., United States Military Academy, 1928	My	Shoreham, Vermont
Eichelberger, Alexis Martin, Jr. A.B., University of California at Los Angeles, 1937	Ge	San Bernardino
Ellis, Herbert Bailey B.S., California Institute, 1938	ME	Los Angeles
Fan, Hsü Tsi Eng. in M.E., Harbin Polytechnic Institute, 1935; M.S., California Institute, 1937	AE	Tientsin, China
Farman, Ivan Lonsdale (Lieutenant) B.S., California Institute, 1926	My	Washington, D. C.
Farquhar, John Percival B.S., Harvard College, 1935	Ch	Pasadena
Fejer, Andrew M.E., Technische Hochschule at Prague, Czechoslovakia, 1936	AE	Bratislava, Czechoslovakia
Felbeck, George Theodore B.S., University of Illinois, 1919; M.S., 1921	Ch	Altadena
Findlay, Willard Alexander (†) B.S., California Institute, 1929; M.S., 1932	Ge	Altadena
Fine, Paul Charles (†) B.A., University of Oklahoma, 1935; M.S., California Institute, 1936	Ph	Idabel, Oklahoma
Fink, Harold Kenneth A.B., Princeton, 1938	Bi	New York
Fischer, Harold B.A., University of California at Los Angeles, 1938	AE	Los Angeles
Fischer, James Rodney B.A., Ohio State University, 1938	Ch	Warsaw, Ohio
Folkins, Richard Wilson B.S., California Institute, 1938	CE	Redlands
Foster, Mark Gardner (†) A.B., Miami University, 1935	Ph	Oxford, Ohio
Fox, Sidney Walter (†) B.A., University of California at Los Angeles, 1933	Bi	Pasadena
Fredrick, Joseph Louis B.S., Louisiana State University, 1938	AE	New Orleans, Louisiana
Friend, Carl Frederick B.S., California Institute, 1938	AE	Los Angeles
Fulton, Robert F. (Lieutenant) B.S., United States Military Academy, 1931	My	Marshall, Minnesota

Name	Major Subject	Home Address
Glenn, William Holt, Jr. A.B., University of California at Los Angeles, 1935; M.A., 1937	Ma	Glendale
Gongwer, Calvin Andrew B.S., Columbia University, 1937	ME	Guntersville Dam, Alabama
Gould, Clark Webster, Jr. B.S., College of Puget Sound, 1938	Ch	Tacoma, Washington
Gould, Martin James (†) B.A., Rice Institute, 1935; M.A., 1936	Ge	Houston, Texas
Gould, Wendell Oliver B.S., Washington State College, 1930; M.S., 1930	Ph	Pasadena
Green, James Wood, Jr. A.B., Colorado College, 1936; A.M., Dartmouth College, 1938	Ph	Colorado Springs, Colorado
Greenslade, Rush Varley A.B., Princeton University, 1938	Ge	Tulsa, Oklahoma
Gregory, Chris B.S., California Institute, 1938	Ph	Hollywood
Griffis, LeVan B.S., California Institute, 1937; M.S., 1938	ME	Berkeley
Gringorten, Isaac B.A., University of Toronto, 1935; M.A., 1936	My	Toronto, Ontario, Canada
Grobecker, Alan John B.S., California Institute, 1937	Ge	San Diego
Gross, Arthur George B.S., California Institute, 1938	AE	Beverly Hills
Gullekson, Ellsworth Eugene B.S., University of North Dakota, 1937	ChE	Pasadena
Guyton, William Franklin B.S., University of Mississippi, 1938; B.A., 1938	CE	Oxford, Mississippi
Harris, Franklin Stewart, Jr. A.B., Brigham Young University, 1931; M.A., 1936	Ph	Provo, Utah
Harrison, Arthur Elliot B.S., University of California, 1936; M.S., California Institute, 1937	EE	Berkeley
Harrison, Gerald Irving B.A., Arizona State Teachers' College, 1937; M.A., 1938	Ma	Phoenix, Arizona
Hatcher, John Burton B.S., California Institute, 1937; M.S., 1938	Bi	Pasadena
Havens, Byron Luther B.S., University of Washington, 1938	EE	Spokane, Washington
Hays, John Thomas B.S., Montana State College, 1935; B.A., Oxford University, 1937; B.Sc., 1938	Ch	Bozeman, Montana
Helfer, Robert George (†) B.S., Baldwin-Wallace College, 1936	Bi	Cleveland, Ohio
Heller, Aaron B.S., University of Tennessee, 1938	EE	Johnson City, Tennessee
Hendry, Noel Williamson B.S., University of British Columbia, 1937	Ge	Vancouver, British Columbia
Henshaw, Paul Carrington (†) A.B., Harvard College, 1936; M.S., California Institute, 1938	Ge	Rye, New York
Hepner, Franklin Ross B.A., University of Wyoming, 1937	Ch	Laramie, Wyoming

Name	Major Subject	Home Address
Hicks, Bruce Lathan (†) B.S., California Institute, 1936; M.S., 1937	Ph	Pasadena
Hills, John dePeyster Townsend (Lieut.) B.S., United States Military Academy, 1934	My	Albany, New York
Hinds, George Putnam, Jr. B.E.ChE., Tulane University, 1938	ChE	New Orleans, Louisiana
Hlynka, Isydore B.Sc., University of Alberta, 1935; M.Sc., 1937	Bi	Edmonton, Alberta, Canada
Holloway, John Marshall B.S., University of Manitoba, 1937	Ge	Winnipeg, Manitoba, Canada
Horowitz, Norman Harold (†) B.S., University of Pittsburgh, 1936	Bi	Los Angeles
Howell, William Jasper, Jr. B.A., Swarthmore College, 1938	Ch	Toledo, Ohio
Howland, Walter Lavern (†) B.S., California Institute, 1934; M.S., 1935 and 1936	AE	Pasadena
Hoy, Robert Beck B.S., Lafayette College, 1937	Ge	Easton, Pennsylvania
Hsü, Chang-Pen B.S., Chiao-Tung University, 1935; M.E.E., Cornell University, 1938	EE	Changsha, China
Hsueh, Chao-Wang B.S., National University of Peking, 1931	Ph	Shantung, China
Hudson, Donald Ellis B.S., California Institute, 1938	ME	Pasadena
Hughey, Albert Hall B.S., Purdue University, 1934; M.S., California Institute, 1938	AE	Allentown, Pennsylvania
Jackson, Andrew McBurney, Jr. (Lieut.) B.S., United States Naval Academy, 1930	AE	Baton Rouge, Louisiana
Jahns, Richard Henry (†) B.S., California Institute, 1935; M.S., Northwestern University, 1937	Ge	Seattle, Washington
Johnson, Kenneth Delford B.S., Emmanuel Missionary College, 1932	Ch	Los Angeles
Jones, Winthrop Gilman B.S., University of Arizona, 1936	EE	Pasadena
Jordan, Charles Borromeo B.S., California Institute, 1936; M.S., 1937	Ph	Los Angeles
Joseph, Joseph Albert A.B., Washington University, 1935; M.S., 1936	CE	Los Angeles
Kadzielawa, Joseph Leon B.A., University of British Columbia, 1936; M.A., 1938	Ma	Vancouver, British Columbia
Kanemitsu, Sunao B.S., University of California, 1937; M.S., California Institute, 1938	AE	Downey
Karubian, Ruhollah Yahyaw Diploma, Alborz College, Iran, 1934; Petroleum Engineer, Colorado School of Mines, 1938	Ge	Teheran, Iran
Knight, Jack William B.S., California Institute, 1938	Ge	Glendale
Koch, Walter Louis Diploma, Technische Hochschule, Hannover, 1936; M.S., California Institute, 1938	AE	Bremen, Germany
Krantz, Channing Henry B.S., California Institute, 1936	EE	Pasadena

Name	Major Subject	Home Address
Kuo, I. Cheng (†) B.S., National University of Peking, 1928	Ph	Peiping, China
Kybal, Dalimil B.S., California Institute, 1938	AE	Mexico City, Mexico
Larson, Carl Elmer B.S., California Institute, 1937	CE	Arcadia
LaSalle, Joseph Pierre B.S., Louisiana State University, 1937	Ph	Baton Rouge, Louisiana
Lauritsen, Thomas (†) B.S., California Institute, 1936	Ph	Pasadena
Lavender, Harrison Morton, Jr. B.S., California Institute, 1938	ChE	Douglas, Arizona
Leech, William Dale B.A., Union College, 1919; M.A., University of Southern California, 1926	Bi	Cooranbong, N.S.W., Australia
Lentz, John Jacob B.S., California Institute, 1938	EE	Los Angeles
Levit, Robert Jules B.S., California Institute, 1938	Ma	San Francisco
Lewis, Lloyd Alan E.M. in Geology, University of Minnesota, 1938	Ge	Henning, Minnesota
Lewis, Richard Newton A.B., University of California, 1937; B.A., Oxford University, 1938	Ch	Berkeley
Lewis, William Dabney A.B., Denison University, 1938	Ge	Granville, Ohio
Liang, Carr Chia-Chang B.Sc., Catholic University of Peiping, 1937	ME	Peiping, China
Lilleland, Ole B.S., University of California, 1922	Bi	South Pasadena
Lombard, Albert Eaton, Jr. B.S., California Institute, 1928; M.S., 1929	AE	San Marino
Lovoff, Adolph B.S., Lawrence Institute, 1934; B.S.E., University of Michigan, 1936; M.S., 1937	EE	Detroit, Michigan
LuValle, James Ellis B.A., University of California at Los Angeles, 1936; M.A., 1937	Ch	Los Angeles
MacKnight, Robert Harlan (†) A.B., Columbia University, 1936	Bi	Pasadena
Majors, Harry, Jr. B.S., University of California, 1935	ME	Concord
Malina, Frank Joseph (†) B.S., Texas Agricultural and Mechanical College, 1934; M.S., California Institute, 1935 and 1936	AE	Brenham, Texas
Mao, Yu-Yueh Alva B.S., Yenching University, 1937	Ph	Liangtan, Hunan, China
Marmont, George Heinemann (†) B.S., California Institute, 1934	Bi	Hollywood
McLean, William Burdette (†) B.S., California Institute, 1935; M.S., 1937	Ph	Santa Barbara
McRary, Willard Lee B.S., California Institute, 1936; M.S., 1938	Bi	Los Angeles
Mead, James Franklyn A.B., Princeton University, 1938	Ch	Evanston, Illinois

Name	Major Subject	Home Address
Mendoza, Ernesto Tolentino B.S., University of the Philippines, 1924	AE	Gapan, Nueva Ecija, P. I.
Mewborn, Aladuke Boyd B.S., University of Arizona, 1927; M.S., 1933	Ma	Tucson, Arizona
Miller, Dwight Dana A.B., Whittier College, 1937	Bi	Whittier
Miller, Park Hays, Jr. (†) B.S., Haverford College, 1936	Ph	Drexel Hill, Pennsylvania
Mitchell, Fern Wood, Jr. A.B., University of Alabama, 1938	Ch	Pensacola, Florida
Moore, Carl Anderson, Jr. B.S., University of Colorado, 1938	My	Hanover, New Mexico
Moore, Robert Sydney B.A., University of Western Ontario, 1938	Ch	London, Ontario, Canada
Morris, Brooks Theron A.B., Stanford University, 1934; C.E., 1938	CE	Palo Alto
Morris, William Mathews B.A.Sc., University of British Columbia, 1937; M.A.Sc., 1938	Ch	Vancouver, British Columbia
Mouat, Thomas William B.A.Sc., University of British Columbia, 1934	EE	Vancouver, British Columbia
Müller, Conrad Roeben B.S., California Institute, 1936; M.S., 1937	EE	Portland, Oregon
Nagamatsu, Henry Takeshi B.S., California Institute, 1938	AE	Santa Ana
Nash, William Francis, Jr. B.S., California Institute, 1938	AE	San Diego
Neal, Wilson Hawkes (Lieutenant) B.S., United States Military Academy, 1934	My	Washington, D. C.
Nichols, P. L., Jr. B.A., Texas Christian University, 1938	Ch	Pasadena
Nojima, Noble B.S., California Institute, 1937; M.S., 1938	AE	Long Beach
Norquest, Kenneth Smith B.S., College of Idaho, 1930	My	Portland, Oregon
Novitski, Edward B.S., Purdue University, 1938	Bi	New York, New York
Olds, Robert Horner B.S., California Institute, 1938	Ph	Los Angeles
Oliver, Bernard More (†) B.A., Stanford University, 1935; M.S., California Institute, 1936	EE	Santa Cruz
Omer, Guy Clifton, Jr. B.S., University of Kansas, 1936; M.S., 1937	Ph	Lawrence, Kansas
Oppenheimer, Frank (†) B.A., Johns Hopkins University, 1933	Ph	New York, New York
Ortigas, Crisostomo A. B.S., University of the Philippines, 1924	ME	Manila, P. I.
Pai, Shih-I. (†) B.S., National Central University, 1935; M.S., Massachusetts Institute, 1938	AE	Chungking, China
Panofsky, Wolfgang Kurt Hermann A.B., Princeton University, 1938	Ph	Princeton, New Jersey

Name	Major Subject	Home Address
Parish, Elliott Walter, Jr. (Lieutenant) B.S., United States Naval Academy, 1929	AE	Savannah, Georgia
Pasternack, Simon (†) B.Sc., University of Alberta, 1935	Ph	Calgary, Alberta, Canada
Piper, Clark Neil (Lieutenant) B.S., United States Military Academy, 1930	AE	Paris, Illinois
Poon, Yuk Pui B.S., Massachusetts Institute, 1938	AE	Hong Kong, China
Powell, Walter Brown B.A., Stanford University, 1937	AE	Burlingame
Pressman, David B.S., California Institute, 1937; M.S., University of California, 1938	Ch	Los Angeles
Rannie, William Duncan B.A., University of Toronto, 1936; M.A., 1937	AE	Chesley, Ontario, Canada
Rasmussen, Robert Severin S.B., University of Chicago, 1938.	Ch	Chicago, Illinois
Reamer, H. Hollis A.B., University of Redlands, 1937; M.S., California Institute, 1938	Ph	Beaumont
Redemann, C. Ernst (†) A.B., University of California at Los Angeles, 1931	Ch	Los Angeles
Rideout, Vincent Charles B.Sc., University of Alberta, 1938	EE	Sardis, British Columbia
Roberts, Ellis Earl B.S., Michigan College of Mining and Technology, 1937	Ge	Houghton, Michigan
Robinson, Charles Franklin A.B., Missouri State Teachers College, 1935; B.S., Drury College, 1936 M.S., California Institute, 1938	Ph	Springfield, Missouri
Rogers, Max Tofield B.Sc., University of Alberta, 1937; M.Sc., 1938	Ch	Tofield, Alberta, Canada
Rosenthall, Edward B.Sc., McGill University, 1937; M.Sc., 1938	Ma	Montreal, Quebec, Canada
Ruch, Paul Elmer B.S., Massachusetts Institute, 1928	My	Akron, Ohio
Rumph, Lewis Benning, Jr. B.S., Georgia School of Technology, 1933; M.S., 1936	AE	Marshallville, Georgia
Rundle, Robert Eugene B.S., University of Nebraska, 1937; M.S., 1938	Ch	Lincoln, Nebraska
Russell, Charles Daniel, Jr. B.S., Niagara University, 1938	Ch	Niagara Falls, New York
Russell, Horace, Jr. B.S., Duke University, 1938	Ch	Glencoe, Illinois
Sanders, Robert Alexander B.S., Cumberland University, 1937	My	Shelbyville, Tennessee
Schairer, Robert Sorg (†) B.S., Swarthmore College, 1936; M.S., California Institute, 1937	AE	Bronxville, New York
Schlatter, Maurice Jay B.S., California Institute, 1938	Ch	Pasadena
Schmidt, Milton Elmer B.C.E., University of Minnesota, 1932	My	Perham, Minnesota
Sears, David Hume B.S., Harvard University, 1936; M.S., University of Arizona, 1938	Ge	Springfield, Massachusetts

Name	Major Subject	Home Address
Seekins, Charles William A.B., Occidental College, 1938	Ma	Van Nuys
Segelhorst, August Van Ness B.S., California Institute, 1938	ME	Taft
Serrell, Peter Van Horne B.S., California Institute, 1936	ME	Redlands
Shaffer, Philip Anderson, Jr. B.S., Harvard University, 1937	Ch	St. Louis, Missouri
Shapiro, Herbert Barnett B.S., California Institute, 1936; M.S., 1937	ME	Los Angeles
Sharp, Harold Wilson B.S., California Institute, 1938	ME	Santa Paula
Sheppard, Charles Wilcox B.S., California Institute, 1937; M.S., 1938	Ph	Coldwater, Ontario, Canada
Sheppard, Herbert Ramsey B.S., California Institute, 1937	CE	Los Angeles
Sherwood, David Marx B.S., California Institute, 1938	EE	Palo Alto
Sidler, Arthur William B.S., California Institute, 1938	CE	San Bernardino
Sloane, Richard Lewis B.C.E., Ohio State University, 1938	AE	Columbus, Ohio
Smith, Alexander B.A., University of British Columbia, 1932; M.A., 1933	Ge	Victoria, British Columbia
Smith, Clay Taylor B.S., California Institute, 1938	Ge	Glendale
Smith, Jack Carlton B.E., Ohio State University, 1935; M.Sc., 1936	Ph	Akron, Ohio
Smith, Max F. B.S., University of California, 1938	ChE	Berkeley
Smith, Robert Beaton B.A., Ohio State University, 1936; M.S., California Institute, 1938	AE	Columbus, Ohio
Smith, Theodore Beaton A.B., Ohio State University, 1938	Ph	Columbus, Ohio
Snow, William Eugene (†) B.A.Sc., University of British Columbia, 1935; M.A.Sc., 1936	Ge	North Vancouver, B.C., Canada
Sparks, Brian Orville B.S., California Institute, 1932; M.S., 1933	AE	Los Angeles
Spitzer, Ralph William A.B., Cornell University, 1938	Ch	Erie, Pennsylvania
Spurr, Robert Anton A.B., Rollins College, 1936; B.S., 1937; M.S., Harvard University, 1938	Ch	Winter Park, Florida
Stephens, Frank Briscoe (Lieutenant) B.S., United States Naval Academy, 1929	My	Westfield, Illinois
Stevens, James Farren B.S., California Institute, 1938	EE	Phoenix, Arizona
Stever, Horton Guyford B.A., Colgate University, 1938	Ph	Corning, New York
Stewart, Homer Joseph B.Aero.E., University of Minnesota, 1936	AE	Minneapolis, Minnesota

Name	Major Subject	Home Address
Stewart, William Sheldon (†) B.A., University of California at Los Angeles, 1936; M.A., 1938	Bi	Pasadena
Stewart, William Thomas B.S., University of Arizona, 1937; M.S., 1938	Ch	Phoenix, Arizona
Stosick, Arthur James (†) B.S., University of Wisconsin, 1936	Ch	Milwaukee, Wisconsin
Streckewald, Paul Beals B.S., University of Wisconsin, 1936	My	Wauwatosa, Wisconsin
Streib, John Fredrick B.S., California Institute, 1936	Ph	Pasadena
Summerfield, Martin (†) B.S., Brooklyn College, 1936; M.S., California Institute, 1937	Ph	Brooklyn, New York
Tao, Shih Chen B.A., College of Yale-in-China, 1926; M.S., Yenching University, 1932	EE	Shanghai, China
Tatom, John Fletcher (Lieutenant) B.S., United States Naval Academy, 1930	My	Washington, D.C.
Tsien, Hsue-Shen B.S., Chiao-tung University, 1934; M.S., Massachusetts Institute of Technology, 1936	AE	Shanghai, China
Tomlinson, Everett Parsons B.S., Yale University, 1936	Ph	Montclair, New Jersey
Townes, Charles Hard (†) B.A., and B.S., Furman University, 1935; M.A., Duke University, 1937	Ph	Greenville, South Carolina
Tregidga, Angus Campbell (†) B.A., University of British Columbia, 1932; B.App.Sci., 1933; M.A., 1935	Ph	Vancouver, British Columbia
Tsubota, George Yoshio B.S., California Institute, 1937; M.S., 1938	AE	Arlington
Unholtz, Karl B.S., California Institute, 1936	EE	Los Angeles
Urick, Robert Joseph B.S., Brooklyn College, 1935	Ge	Brooklyn, New York
Van Driest, Edward Reginald B.S., Case School of Applied Science, 1936; M.S., State University of Iowa, 1937	CE	Cleveland Heights, Ohio
Vargus, Joseph Anthony, Jr. A.B., Amherst College, 1934; B.A., Cambridge University, 1936	Ph	Elmhurst, New York
Velazquez, Jose Luis B.S., California Institute, 1938	AE	Mexico City, Mexico
Wagner, Warren Orval (†) B.S., State College of Washington, 1934; M.S., University of Michigan, 1936	CE	Spokane, Washington
Wahrhaftig, Austin Levy A.B., University of California, 1938	Ch	Sacramento
Wald, George B.S., California Institute, 1938	ChE	Alhambra
Wallace, Lewis Chauncey B.S., Rollins College, 1938	Ch	Okeechobee, Florida
Wallace, Robert Earl B.S., Northwestern University, 1938	Ge	Demarest, New Jersey
Wang, Hsih Heng B.S., Harbin Polytechnic Institute, 1935; M.S., California Institute, 1938	CE	Tientsin, China
Wang, Tsun Kuei B.S., National University of Peking, 1933; M.S., California Institute, 1938	AE	Kwangling, Shansi, China

Watanabe, Kenichi — Ph — Honolulu, T. H.
B.S., California Institute, 1936

Weinstein, Joseph — EE — Los Angeles
B.S., University of California, 1938

Weir, Charles Edward — Ph — Washington, D. C.
B.S., University of Chicago, 1932; M.S., Howard University, 1934

Wetmore, William Owen — ME — Taft
B.S., California Institute, 1937

Wheeler, Donald Bingham, Jr. — Ph — Buffalo, New York
B.S., Lehigh University, 1938

Widmer, Robert Henry — AE — Hawthorne, New Jersey
B.S., Rensselaer Polytechnic Institute, 1938

Wiggins, John Shearon — Ph — Richmond, Indiana
A.B., Earlham College, 1936; M.S., California Institute, 1938

Wilson, Harry David Bruce — Ge — Winnipeg, Manitoba, Canada
B.Sc., University of Manitoba, 1936

Wilson, John Norton (†) — Ch — Vancouver, British Columbia
B.A., University of British Columbia, 1934; M.A., 1936

Wood, Reuben Esselstyn (†) — Ch — Monrovia
B.S., California Institute, 1936; M.S., University of Chicago, 1937

Woolson, John Robert — Ma — Spokane, Washington
Ph.B., Gonzaga University, 1936; B.S., California Institute, 1938

Wright, Frederick Hamilton (†) — Ph — Washington, D. C.
B.A., Haverford College, 1934

Wyman, Max — Ma — Edmonton, Alberta, Canada
B.Sc., University of Alberta, 1937

Yates, Donald Norton (Lieutenant) — My — Bangor, Maine
B.S., United States Military Academy, 1931

Yood, Bertram — Ma — Bayonne, New Jersey
B.S., Yale University, 1938

Yuan, Luke Chia-Liu — Ph — Tientsin, China
B.S., Yenching University, 1932; M.S., 1934

Zumwalt, Lloyd Robert (†) — Ch — Oakland
B.S., University of California, 1936

UNDERGRADUATE STUDENTS

Students whose names are starred attained honor standing during the preceding year.

SENIOR CLASS

Name	Option	Home Address
Anderson, Clarence Russell	ME	Los Angeles
Anderson, Noah Herbert, Jr.	ME	Texarkana, Texas
Arvin, George Howard	A.Ch	Long Beach
Asakawa, George	A.Ch	San Diego
Axtman, Grice	A.Ch	San Marino
Battle, John Allen	Ge	Los Angeles
Bauer, Charles Henry, Jr.	ME	Carmel
Beard, Leo Roy	CE	San Gabriel
Beck, Duane Wesley	ME	Los Angeles
Berg, William Eugene	Bi	Round Mountain, Nevada
Bishop, Richard Hawley	Ph	Milwaukee, Wisconsin
Black, John William	ME	Hollywood
Blackinton, Roswell Jones	A.Ch	Bell
Borgeson, Lawrence Glenn	EE	Pasadena
Bradshaw, Richard Rotherwood	CE	Walnut Park
Bragg, Kenneth Rankin	ME	San Marino
Braithwaite, James William	AE	Arcadia
Brown, Claude H., Jr.	ME	Los Angeles
Brown, Perry H.	ME	Los Angeles
Brown, William Lowe	EE	Tulsa, Oklahoma
Browne, John Jake	ME	Clovis
Carlisle, Francis Lacey	ME	Pasadena
Carstarphen, Charles Fredrick	ME	Denver, Colorado
Carter, Robert Trissel	A.Ch	Glendale
Chung, David	ME	Los Angeles
Collins, R. Kenneth	EE	Pasadena
Connelly, Ronald Boerner	EE	Huntington Park
Craft, Claude Howard	Ch	Elsinore
Crawford, Virgil Kenmore	A.Ch	Burbank
Crozier, George Olds	ME	Monrovia
Davis, Harry Owens, Jr.	ME	Los Angeles
Degnan, Thomas J. J.	ME	Pasadena
Devirian, Philip Sarkis, Jr.	ME	Altadena
Dibble, Barry	Ph	Pasadena
Diehm, Walter A.	EE	Pasadena
Engelder, Paul Oscar	EE	Douglas, Arizona
Englander, Herman Sigmund	Ma	Sierra Madre
Evvard, John C.	Ph	Phoenix, Arizona
Flint, Delos Edward	Ge	Pasadena
Frampton, William Rex, Jr.	A.Ch	Glendale
Fraser, Stuart MacMillan	ME	San Diego
Gassaway, James Scott	ME	Los Angeles
Gerhart, Ray Van Deusen	A.Ch	Pasadena
Gombotz, Joseph John	Ge	San Marino
Goodell, Jack H.	ME	Pasadena
Goodin, Harry Allen	ME	South Pasadena

NAME	OPTION	HOME ADDRESS
Green, Albert Pennington	EE	Los Angeles
Green, William Manning	EE	Ogden, Utah
Griffiths, John Robert	Ge	Santa Barbara
Griswold, Edgar Allen	CE	Los Angeles
Guillou, Alfred Victor	EE	Van Nuys
Hagen, Robert Christian	Ge	Riverside
Hall, Marcus A.	ME	Pasadena
Hance, Harold Vivian	EE	Los Angeles
Hannon, Andrew Lucien	EE	Los Angeles
Haussler, Robert Walter	CE	Los Angeles
Hiehle, Ernest Michael	EE	Walnut Park
Hoff, Frederick Carl	ME	Bell
Hotz, George Marion	ME	Los Angeles
Ingalls, Francis Chandler	A.Ch	Alhambra
Israel, Richard Alfred	EE	Glendale
James, Raymond Allen	Ph	Salt Lake City, Utah
Kimball, Robert Barry	EE	Glendale
Kolb, Louis Lawrence	A.Ph	Los Angeles
Konecnik, John	ME	Los Angeles
Kyte, Robert McClung	A.Ch	Huntington Park
Lavatelli, Leo Silvio	Ph	Los Angeles
Lawrie, Donald Gibb	ME	Milwaukee, Wisconsin
Lawson, William George	ME	Pasadena
Lee, Curtis Munn	ME	San Diego
Levet, Melvin Newton	Ge	Monterey Park
Longfelder, Harlowe Julius	AE	Los Angeles
Macleish, Kenneth Gordon	Ph	Santa Barbara
Matthew, Tyler	EE	Hollywood
McClung, Roderick	ME	Winslow, Arizona
McCreery, Frank Ewing	ME	Coronado
McKinlay, James Robb	EE	Glendale
McLaughlin, Stuart Watson	A.Ch	Pasadena
Merrick, William Deming	EE	Glendale
Meyer, David Elmore	EE	San Marino
Morikawa, George Kiyoshi	ME	North San Diego
Norton, William Mear	ME	Beverly Hills
Oakley, Spencer Whittemore	ME	Pasadena
Ogg, James Truman	EE	Eagle Rock
Osborn, John E.	CE	Pasadena
Parker, Edward Haig	A.Ch	Pasadena
Paul, Carl Hutton	ME	Hollywood
Peat, John McCowan	Ge	South Pasadena
Pettingall, Charles Edward	ME	Burbank
Phillips, Robert Austin	EE	Rivera
Pinney, Edmund	Ma	Seattle, Washington
Pond, Richard Kelley	ME	Pasadena
Pullen, Keats A.	Ph	Los Gatos
Rainwater, Leo James	A.Ph	Hanford
Rasmussen, Volney Kinne	Ph	Hamburg, New York
Regan, Louis John	Ge	Los Angeles
Richards, Raymond Gardner	ME	Exeter
Ritchey, James Clifton	CE	Lynwood

Name	Option	Home Address
Robertson, Francis Allen	A.Ch	South Pasadena
Root, William Arthur	EE	Huntington Park
Ropp, William Franklin	CE	Glendale
Roudebush, Bert Victor	A.Ph	Glendale
Rubin, Sylvan	Ph	Pasadena
Ruggiero, Ralph John	Ph	Los Angeles
Rush, Hugh M.	AE	Tulsa, Oklahoma
Schneider, Selmer Guerton	EE	Beverly Hills
Scott, David Holcomb	Ge	Pasadena
Shultise, Quido Miles	EE	Pasadena
Silvertooth, E. Wilbur	Ph	Long Beach
Sinclair, George William	EE	Huntington Park
Skei, Thurston	Ch	Portland, Oregon
Smith, Josiah Edward	AE	Corona
Smith, Paul Louis	ME	Pasadena
Smith, Philip Ernest	A.Ch	Santa Ana
Smith, Robert Louis	CE	Los Angeles
Snyder, Willard M.	CE	Hermosa Beach
Steel, Collis Kachler	EE	Butte City
Streightoff, Frank Doan	Bi	Indianapolis, Indiana
Strong, Herbert Davis	ME	Glendale
Sullivan, Edwin Franklin	CE	San Bernardino
Svimonoff, Constantine	CE	Bakersfield
Tangren, Robert Fulton	AE	Grass Valley
White, Robert William	A.Ch	Chelsea, Massachusetts
Winchell, Robert Winslow	EE	Beverly Hills
Younger, Udene Earl	Ph	Los Angeles
Zukerman, Lester Goffin	EE	Hollywood

JUNIOR CLASS

Name	Option	Home Address
Acker, Roy Mitchell	ME	Riverdale
Adams, Robert Powell	ME	Arcadia
Alcock, Robert Ward	ME	Iowa City, Iowa
Alonso, Frank Anthony	EE	Los Angeles
Anderson, Keith Elliott	Ge	South Pasadena
Baller, Howard Samuel	EE	Newark, New Jersey
Ballreich, Newell	A.Ch	Los Angeles
Barber, George Claire	AE	Pasadena
*Baumgarten, Erwin	A.Ch	Pasadena
Beller, Gordon Melvin	CE	Los Angeles
Bennett, Dwight Henry	AE	Tulsa, Oklahoma
Berlot, Robert Raymond	A.Ph	Los Angeles
Biddison, Cydnor Mark	CE	San Gabriel
Billheimer, John	Ch	Altadena
Bowers, Orrin C.	EE	Walnut Park
Brewer, Alexander Frederick	EE	Hollywood
*Brewer, Leo	Ch	Los Angeles
Brose, Frederic Morgner	ME	Hollywood
Brown, George Reynolds	A.Ch	Colorado, Texas

NAME	OPTION	HOME ADDRESS
*Brown, William Emil	Ch	Huntington Park
Brumfield, Robert Clarence	ME	Los Angeles
Brunner, Frederick Calvert	A.Ch	Alhambra
Burton, Clifford Chickering	A.Ch	Coffeyville, Kansas
Campbell, Donald Cameron	ME	Pasadena
Carey, John Crawford	EE	Hollywood
Carson, Donald Bell	EE	Pasadena
Cleveland, William Roy, Jr.	Ge	Whittier
Clinton, Raymond Otto	Ch	Glendale
Compton, Arthur Mandeville	AE	Davenport, Iowa
Cooper, Robert William	Ge	Los Angeles
Crane, Sheldon Cyr	Bi	Los Angeles
Crawford, James Vaile	ME	Burbank
Daams, Gerrit	A.Ph	Alhambra
*Davis, Leo	Ph	Los Angeles
Day, John Paul	Ph	Arcadia
Dessel, Frank William, Jr.	Bi	San Francisco
Dickerson, Edward Oakes	ME	Redlands
Elms, James Cornelius	AE	Phoenix, Arizona
Epstein, Ludwig	Ch	Santa Monica
Fleming, Robert Ernest	A.Ph	Glendale
Foster, Gerald Pentland	ME	Los Angeles
France, Albert Finley	ME	Long Beach
Freehafer, Paul Robinson	A.Ch	Payette, Idaho
German, Irvine F., Jr.	A.Ch	Garden Grove
Gewe, Robert Alexander	CE	Los Alamos
Glassco, James Brinton	ME	San Gabriel
Glassco, Robert Bond	ME	San Gabriel
Goodmanson, Lloyd Twedt	AE	Eagle Rock
Green, Elliott Aaron	ME	Los Angeles
*Grigg, Robert Webb	EE	Pasadena
Haffner, Bernhard	Ge	Kimberly, Nevada
Hankey, Eugene Daniel	EE	Los Angeles
Hardenbergh, George Adams	A.Ph	St. Paul, Minnesota
Harper, John Cline	A.Ch	Denver, Colorado
*Hayes, Wallace Dean	A.Ch	Palo Alto
Hiatt, John Brodby	ME	Alhambra
Hines, Marion Earnest	A.Ph	Long Beach
Hofeller, Gilbert Walter	ME	Pasadena
Hofmann, Walter	CE	Bell
Hohwiesner, Henry George, Jr.	ME	Sacramento
House, William Carl	AE	Eau Claire, Wisconsin
Jacobs, Millard W.	CE	Los Angeles
Janssen, Robert Ramsay	EE	Whittier
Jongeneel, James William	CE	Honolulu, Hawaii
Kemp, Leroy James	ME	Bell
Keyser, John Harold, Jr.	EE	Hayward
Kluge, William Thomas	A.Ch	Portland, Oregon
*Kohl, Jerome	A.Ch	Los Angeles
Kupfer, Donald Harry	Ge	Los Angeles
Kuttler, Luther P.	CE	Los Angeles
Langerud, Ralph Owes	AE	Aamot-Modum, Norway

Name	Option	Home Address
Larson, Walter Ramey	EE	Los Angeles
Laue, Eric G.	EE	Los Angeles
LeGrand, Charles Croxall	EE	South Pasadena
Lemm, Willys	ME	Pasadena
Loeffler, Donald Edward	Ch	Inglewood
Lolmaugh, Orson Bernard	EE	Hemet
*Longwell, Paul Alan	A.Ch	Santa Maria
Love, Bernard	Ch	Los Angeles
MacKay, Wallace Matthew	ME	Los Angeles
Main, John Hamilton	A.Ch	Evanston, Illinois
Maleev, Leonid Vladimir	ME	Hollywood
*Manildi, Joe Frank	EE	Soquel
Marriott, William Robert Victor	Ch	Los Angeles
Mayer, Jules Frederick	ME	Los Angeles
Merryfield, Lloyd William	Ch	Los Angeles
Meyer, Robert B.	ME	Alhambra
*Mickley, Harold Somers	A.Ch	Long Beach
Mills, Mark Muir	Ph	Estes Park, Colorado
Mohammad, Ali Haj	EE	Shatrah, Iraq
Moran, Stephen Faulkner	AE	Alhambra
Munk, Walter Heinrich	A.Ph	Vienna, Austria
*Nagle, Darragh	Ph	Hartsdale, New York
Nakada, Yoshinao	Ph	Azusa
Neiswander, Robert South	EE	Phoenix, Arizona
Newby, Clinton Toms	AE	Long Beach
Nickerson, Douglas Blain	ME	Redlands
Oder, Frederic Emil	Ge	Alhambra
Oldson, Norman P.	ME	Pasadena
Olney, Frank Denman	EE	Moneta
Palmer, Charles Sumner	ME	Pasadena
Palmer, John Gordon	ME	Brawley
Partch, Newell	ME	Pasadena
Paul, Ralph Graham	Ch	Laguna Beach
Payne, Charles Melvin	ME	Denver, Colorado
Powell, Richard Wells	EE	Twin Falls, Idaho
Quarles, Miller Winthrop, Jr.	Ge	Los Angeles
Ray, Robert Stanley	A.Ch	Pasadena
Reppert, Allen Burrows	A.Ph	Amarillo, Texas
Reynolds, Howard William	Ge	Beverly Hills
Rogers, Lawrence Arnold	Ge	Los Angeles
Samuel, Hubert David, Jr.	ME	Los Angeles
Sandiford, Perry Lathrop	EE	Huntington Park
Sargent, Herbert, Jr.	Ch	Pasadena
*Scarborough, William Bertram	A.Ch	Denver, Colorado
Schrader, Carl George	ME	Mill Valley
Shisler, David Shepard	ME	San Anselmo
Skaling, Percy Eaton	Ph	Syracuse, New York
Smith, Randlow	A.Ch	Los Angeles
Spalding, Delman Seward	CE	Guilford, Connecticut
Spielberger, Robert Elmer	ME	Manila, Philippine Islands
Spooner, William Austin	A.Ch	Long Beach
Staatz, Dumont Sutherland	Bi	Olive View

Name	Option	Home Address
Staatz, Mortimer Hay	Ge	Olive View
Steinmetz, David Henry, III	ME	Eagle Rock
Stevens, Jean Barrieu	EE	Long Beach
Stone, William Welch	Ph	West Los Angeles
Stoner, Willis Allen	ME	Altadena
Stowell, Ellery Cory, Jr.	Bi	Santa Barbara
Strickler, Robert F.	AE	Pasadena
Sullivan, Richard Louis	EE	Glendale
Tajima, Yuji	Bi	Pasadena
*Thompson, Ross D. F.	Ph	Los Angeles
Tielrooy, Jack	A.Ch	North Hollywood
Tobin, Bernard Milton	EE	Brooklyn, New York
*Todd, George Judson	ME	Altadena
Tomiyasu, Kiyo	EE	Las Vegas, Nevada
Van Dusen, Lawrence William	ME	San Diego
Van Dyke, Gilbert Rush	Ge	Fallbrook
Varnes, David Joseph	Ge	Los Angeles
Veenhuyzen, Paul N. A.	EE	Monterey Park
Vetter, Warren Herman	CE	Los Angeles
Wald, Edwin Prescott	CE	Alhambra
Walker, Richard Langan	ME	Alhambra
Walter, Don Lombard	AE	Glendale
Wasem, Richard	Ge	Long Beach
Watkins, James M.	A.Ch	San Marino
Watson, James Arthur	Ch	San Antoino, Texas
Wayman, Robert William	ME	Los Angeles
Weaver, Theodore Sol	A.Ch	Hollywood
Weir, Gordon Bruce	Ge	Los Angeles
White, Howard Jack	ME	Los Angeles
Whittlesey, David Walter	ME	Portland, Oregon
Whittlesey, James Wright	ME	Portland, Oregon
Widenmann, John Adolph	A.Ph	Burlingame
Williams, Charles	EE	San Juan Capistrano
Williamson, John Bridgers	EE	Fontana
Wilson, Lindley Sothern	EE	Long Beach
Wilts, Charles Harold	EE	Los Angeles
Worcester, Herbert Moore, Jr.	AE	Pasadena
Young, David Arthur	ME	Utica, Missouri
Young, Robert Busbey	ME	Los Angeles

SOPHOMORE CLASS

Name	Course	Home Address
Abraham, Wayne Gordon	Sci.	Boston, Massachusetts
Anderson, Robert Edwin	Sci.	Los Angeles
Andrews, Richard Allworth	Eng.	Glendale
*Barber, John Howland	Sci.	Mexico City, Mexico
Beers, Kenneth Hurst	Eng.	Los Angeles
Benson, Arthur S.	Eng.	Hollywood
Berman, Dave	Sci.	Phoenix, Arizona
Bezdecheck, William Dionecious	Eng.	Long Beach
*Billman, Glenn Wagner	Sci.	Long Beach

NAME	COURSE	HOME ADDRESS
*Billmeyer, Fred Wallace, Jr.	Sci.	Pasadena
Boardman, Warren	Sci.	Glendale
Bolles, Arthur Stanard	Sci.	Whittier
Bosworth, George Hobart	Sci.	Montrose
*Bowles, Robert Ryland	Sci.	Denver, Colorado
Bowlus, Robert Glenhart	Sci.	San Marino
Bramhall, George Hardy	Eng.	Webster Groves, Missouri
Brandt, Roger	Eng.	San Marino
*Brooks, Philip Daniel	Eng.	Alhambra
Buchzik, Charles Mallory	Sci.	North Hollywood
Buss, Robert	Sci.	Centerville, Iowa
Callaway, William Franklin	Eng.	Coronado
Capron, Sanford Donley	Eng.	Santa Monica
Carlson, Carl Arthur	Eng.	Fontana
Casserly, Frank Gordon	Eng.	Pasadena
Chapin, William F.	Sci.	Long Beach
Chastain, J. Alexander	Eng.	Sacramento
Clark, Joseph Ernest	Sci.	San Diego
Clarke, Frederick Weaver, III	Eng.	Omaha, Nebraska
Collison, William Fraser	Sci.	Niagara Falls, New York
Cooper, Robert George	Sci.	Pasadena
Corcoran, William H.	Sci.	Los Angeles
Davis, Walter Z.	Eng.	Spokane, Washington
Dawson, Donald Edwin	Eng.	Pasadena
Deniston, John Joseph	Sci.	Hollywood
Dobbins, Willis E.	Eng.	Lakewood, New York
Doheny, William Henry	Eng.	Beverly Hills
Edmund, William J.	Sci.	Santa Cruz
Edwards, Gene Lloyd	Sci.	Crockett
Elliott, Quentin	Sci.	Aurora, Nebraska
Elmer, David Arthur	Sci.	South Pasadena
Eusey, Merritt V.	Eng.	Pasadena
Fahs, James Roger	Sci.	Fullerton
*Farrington, Paul Stephen	Sci.	Indianapolis, Indiana
Faust, Paul Harry	Sci.	Pasadena
Fisher, Bob Edwin	Eng.	West Los Angeles
Frank-Jones, Glyn	Eng.	Los Angeles
Galeski, Robert Benjamin	Sci.	Los Angeles
Geib, Elden Ray	Sci.	Redlands
*Geitz, Robert Charles	Sci.	McKeesport, Pennsylvania
Gillings, John William	Eng.	Los Angeles
Given, Frank I.	Eng.	San Diego
Gold, Sydney Kendall	Eng.	Los Angeles
Green, Jerome	Sci.	Los Angeles
Greenhalgh, Francis	Eng.	Los Angeles
Hall, Robert Franklin	Eng.	Long Beach
*Hall, Robert Noel	Sci.	Berkeley
Hardin, Paul Verle	Sci.	Colton
Harr, George Bowman	Sci.	Long Beach
*Harris, Robert H.	Sci.	Dayton, Ohio
Hassard, Thomas Jason	Sci.	Chula Vista
Head, Richard Moore	Eng.	Altadena

Name	Course	Home Address
Hicks, Frank Randall	Sci.	Honolulu, Hawaii
Hill, Harold Eugene	Sci.	Los Angeles
Hill, Kim, Jr.	Sci.	Glendale
Hirons, Robyn	Eng.	Portland, Oregon
Horne, Othniel	Eng.	El Centro
Howenstein, John Barrett	Eng.	Westmorland
Hudspeth, Tom	Eng.	Santa Ana
*Ikawa, Miyoshi	Sci.	Venice
*Ingersoll, William Lee	Eng.	West Linn, Oregon
Jones, Gilbert Allan	Eng.	Scottsdale, Arizona
Jones, Jeremy Aldan	Sci.	San Marino
Jones, John Willard	Sci.	Pasadena
Kaiser, Harold Robert	Sci.	Tracy
Kashiwabara, Naomi	Eng.	Los Angeles
Kennedy, Maurice Paul	Sci.	Los Angeles
Kingsmill, Robert E.	Eng.	Long Beach
LaBombard, Emerson Hogue	Eng.	Santa Monica
Lakos, Eugene Alexander	Eng.	Santa Barbara
Lawrence, Bruce	Sci.	Pasadena
Levenson, Berl D.	Eng.	Los Angeles
Levitt, Leo Charles	Sci.	Sierra Madre
Lewis, Joseph Walters	Eng.	South Pasadena
Long, Calvin Washburn	Eng.	Santa Monica
Lyle, Francis Vivian	Sci.	Los Angeles
Makepeace, Gershom Reynolds	Sci.	Pasadena
Maker, Robert Roy	Eng.	Santa Barbara
Maninger, Ralph Carroll	Sci.	Pasadena
Marquardt, Roy Edward	Eng.	Burlington, Iowa
McClain, John Franklin, Jr.	Eng.	Coronado
McIntosh, James	Eng.	Victoria, British Columbia
Meyer, George Frederick	Sci.	Trona
Mitchell, Stanley John	Sci.	San Gabriel
Moore, Charles Leroy	Sci.	Mojave
Murr, William Carl	Sci.	Chicago, Illinois
Myers, Robert Francis	Eng.	Redondo Beach
Neufeld, Lester N.	Sci.	Shafter
Noble, Edward D.	Sci.	Yuma, Arizona
Noland, Robert LeRoy	Eng.	San Diego
Nyborg, Meredith McRae	Eng.	San Anselmo
Oakes, Gibson	Eng.	Seattle, Washington
Olson, Norman Eric	Sci.	Fallbrook
Partlow, John Graydon	Eng.	Los Angeles
Peters, Ralph	Eng.	Los Angeles
Pickles, Arthur Montgomery	Eng.	Victoria, British Columbia
Pollycove, Myron	Sci.	Los Angeles
Porter, Livingstone, Jr.	Sci.	Clarkdale, Arizona
Priest, James Virginius	Sci.	Hollywood
Reimers, George I.	Eng.	New York, New York
Rinker, Robert Jay	Eng.	Lindsay
Robinson, Theodore Bliss	Sci.	Coronado
Rockdale, Lloyd Harold	Sci.	Pasadena
Roen, Charles Brandt	Sci.	Alhambra

Name	Course	Home Address
Rominger, Joseph Franklin	Sci.	Long Beach
Routt, Robert Patterson	Sci.	Pasadena
Rupert, Claud Stanley	Sci.	Exeter
Russell, Edward Lockard	Sci.	Los Angeles
Rutherford, Charles Ettinger	Sci.	Beverly Hills
Sakai, George Chitsugi	Eng.	Pasadena
Sattler, Leroy Edward	Sci.	Maywood
Schaff, Alfred	Eng.	Panama City, Panama
Schubert, William	Eng.	Huntington Park
Silberstein, Richard Frederick	Eng.	Sacramento
Small, John Gilbert	Sci.	San Rafael
Smallberg, Merle Leroy	Sci.	Los Angeles
Snodgrass, Reuben	Eng.	Tulsa, Oklahoma
Sohler, Stanley Edward	Eng.	Portland, Oregon
Spikes, John Daniel	Sci.	Redondo Beach
Spraker, Jack David	Eng.	Los Angeles
Stadum, Clarence Bernhard	Eng.	Sioux Falls, South Dakota
Stewart, Wilton Alexander	Eng.	San Diego
*Stroud, Stanley Grover	Eng.	Fillmore
Sturdevant, C. Victor, III	Eng.	Pasadena
Svendsen, Norman F.	Eng.	Chicago, Illinois
Taylor, Thayle Flandars	Eng.	Los Angeles
Thayer, Charles Louis	Sci.	Ogden, Utah
Thiele, Frederick W.	Eng.	Hollywood
Thomas, Delbert David	Sci.	Pasadena
Trauerman, Joe Klee, Jr.	Sci.	Fort Dodge, Iowa
Trindle, Joseph Warren	Eng.	Seattle, Washington
Turner, Dale Edward	Sci.	Kingsburg
Tyler, Edmund Forrest	Sci.	Hollywood
Van Camp, Lincoln	Sci.	Denver, Colorado
Vartikian, Onick	Eng.	Fresno
Vaughan, Richard McKown	Eng.	Burbank
Vey, Ebenezer	Eng.	Grates Cove, Newfoundland
Wagner, William J.	Eng.	Los Angeles
Wahrhaftig, Clyde Adolph	Sci.	Fresno
*Wallace, Roger	Sci.	Hermosa Beach
Weiss, Joseph	Eng.	San Bernardino
*White, John Robertson	Eng.	Los Angeles
White, Thomas Leeming	Eng.	Los Angeles
Widdoes, Laurence Curtis	Sci.	Sebastopol
Williamson, Herbert Edward	Eng.	Newport
Wilmoth, Robert Carlyle	Sci.	North Hollywood
*Wood, David Shotwell	Eng.	Sierra Madre
Wood, Harry Alfred, Jr.	Sci.	Los Angeles
Young, Cecil Gilbert	Eng.	Palmyra, Missouri
Zebb, Keirn	Eng.	Denver, Colorado

FRESHMAN CLASS

Name	Home Address
Acord, James Donovan	Burbank
Albrecht, Albert Pearson	Riverside
Allan, John Reppy	Pasadena

Name	Home Address
Allen, John Dwight	San Diego
Allen, Paul Hodges	Fresno
Ayers, Alden Whittemore	Alhambra
Ban, Edward Richard	Tucson, Arizona
Bangs, William John	Beverly Hills
Becker, Paul Henry	Los Angeles
Bell, Alan Eddy	Seattle, Washington
Benelisha, James Joseph	Brockton, Massachusetts
Berdahl, Carroll Martin	Sioux Falls, South Dakota
Bevan, James W.	Ogden, Utah
Bishop, Robert Carskaddan	Muscatine, Iowa
Blight, Arthur Frederick, Jr.	South Pasadena
Bluemle, Theodore Rudolph	Beverly Hills
Blumenthal, William D.	Los Angeles
Bowen, Dwain Burns	Los Angeles
Bowen, John Thomas	Los Angeles
Boyer, William Lee	Martinez
Brockman, John A.	Reno, Nevada
Brown, Charles M., Jr.	Hollywood
Browne, Davenport, Jr.	Pasadena
Bruce, Victor Gardiner	Los Angeles
Burkhard, Donald George	Los Angeles
Carr, Earle Albert	Lone Pine
Carter, Claude LeVerne	Santa Monica
Cleary, William Boswell	Ponca City, Oklahoma
Cobb, Alfred Burl, Jr.	Cut Bank, Montana
Cohn, George Irving	Lake Forest, Illinois
Conner, William Michael	Glendale
Cox, Richard Horton	Eleele, Kauai, Hawaii
Cunningham, Robert Ernest	Beverly Hills
Curtis, Thomas Grey	Los Angeles
Cyr, Rob Roy	San Francisco
Davis, Stewart	Kingston, Pennsylvania
Densmore, Robert Earl, Jr.	Monrovia
DeVault, Robert Tenney	South Pasadena
Dixon, John Kerner	Chicago, Illinois
Drake, John Archibald	Pasadena
Driscoll, Robert Bruce	Hood River, Oregon
Elliott, Thomas Davidson	Eagle Rock
Ellis, Albert Tromly	Pasadena
Ellis, Joe Walter	Pasadena
Ersoz, Ali Muzaffer	Istanbul, Turkey
Fiul, Abraham	Hoboken, New Jersey
Foster, William Wright	Beverly Hills
Fox, Thomas Warren	Palo Alto
Franzini, Joe B.	Pasadena
Gayer, Martin Roger	Santa Monica
Gillette, Warren	Los Angeles
Glover, Norman Patrick	Los Angeles
Goddard, William Herbert	Los Angeles
Green, Howard Lewis	London, England
Greenwood, Robert	Pacific Palisades

Name	Home Address
Grossberg, Allan Louis	Helena, Montana
Grossberg, Arnold Lewis	Los Angeles
Guttersen, Leonard Harbert	Los Angeles
Hanson, Lawrence Adolph	Long Beach
Harris, John S.	Oklahoma City, Oklahoma
Hart, Wilson Ritter	Chicago, Illinois
Hatcher, David Sheridan	South Pasadena
Haupt, Laurence Oliver, Jr.	Hanford
Head, Alfred Benjamin	Waddell, Arizona
Hedrick, Langdon Clyde	Seattle, Washington
Hendrickson, Willard James	Battle Creek, Michigan
Hicks, William Berkeley	Berkeley
Hill, David L.	Corinth, Mississippi
Hobbs, Robert	Fort Worth, Texas
Hogan, Gerald Francis	Durango, Colorado
Holser, Bill Thomas	Moorpark
Hovey, Serge	Beverly Hills
Howton, David Ronald	Glendale
Hudson, Thomas Ernest	Monterey Park
Huggins, Thomas Jackson, Jr.	Baltimore, Maryland
Hunt, Carter	West Los Angeles
Irving, Jack Howard	Los Angeles
Jacobson, Homer	Los Angeles
Jerrems, Alexander Stapler	Kansas City, Missouri
Johnsen, Edwin George	Reedley
Johnson, Philip Ord	Los Angeles
Jones, John Alastair	San Francisco
Kafitz, Peter Henry	Glendale
Kendall, George Alden	San Gabriel
Kennedy, William Grady	Decatur, Illinois
Kepler, Paul	South Pasadena
Kyllonen, Erland Ralph	Monessen, Pennsylvania
LaForge, Gene Rolfe	Pasadena
Larson, Erwin Raymond	South Pasadena
Lawrence, Harvey John, Jr.	Los Angeles
LeFever, Ralph Raymond	Hollywood
Lessing, John Dodd	Glendale
Lind, George William, Jr.	Portland, Oregon
Locanthi, Bartholomew	White Plains, New York
Lutz, Philip Brooks	Aberdeen, Washington
MacCarter, Douglas LaRue	Cut Bank, Montana
MacKenzie, Robert Earl	Los Angeles
MacRostie, Wayne	Santa Barbara
Mader, Paul Miller	Los Angeles
Maguire, George Herbert	Hollywood
Mahoney, James William	Los Angeles
Mairata, Luis Alberto	Iquitos, Peru
Marshall, Boyd Thomas	Rock Springs, Wyoming
Maxwell, Charles Thomas	Sioux City, Iowa
Mayer, Adrian S.	Pasadena
McClure, Harold B.	Paducah, Kentucky
McConnell, Walter Wilson Sanderson	South Gate

Name	Home Address
McCornack, Richard William	Elgin, Illinois
McElfresh, Robert E.	Osage City, Kansas
McKibben, Paul Stilwell	Los Angeles
McLain, Earl Anderson	Sacramento
Menard, Henry William	Los Angeles
Merrick, Robert Tresilian	Huntington Park
Miles, John Wilder	Oakland
Miller, Herman	Long Beach
Moore, Robert Layton	Los Angeles
Nichols, Ralph	Salmon, Idaho
Oechsli, Frank William	Olive View
Paul, Albert D.	Cedar Falls, Iowa
Pearson, Charles William	San Marino
Penhallegon, Glenn Herbert	Rapid City, South Dakota
Piatt, Alvin Ray	Long Beach
Pichel, Pichel Wilson	La Cañada
Porter, John Henry	Shawnee, Colorado
Price, Harrison Alan	San Bernardino
Rhyne, Russell Foote	Valley Center
Richards, Louis James	Pasadena
Ridland, Alexander Charles	Pasadena
Roese, Henry Valentine	Los Angeles
Rubel, John H. W.	Los Angeles
Savit, Carl Hertz	Burbank
Saye, Roland Stanley	Los Angeles
Schneider, Arthur J. R.	Alameda
Schureman, Kenneth Danforth	Santa Monica
Seegman, Irvin Phillip	Los Angeles
Seibel, Charles M.	Wichita, Kansas
Shapiro, Haskell	Los Angeles
Smith, Lawrence Wesley	Altadena
Smith, Marcius Curtis	Los Angeles
Staley, Robert Ross	Tulsa, Oklahoma
Steele, Harry Max	Glendale
Stevens, Kenneth Eldon	Western Springs, Illinois
Stone, Jack Dell	Los Angeles
True, Leighton J., Jr.	Van Nuys
Truesdell, Clifford Ambrose	South Pasadena
Turner, William Russell	Salt Lake City, Utah
Urbach, Kenneth	Seward, Alaska
Vail, Thomas Edward	Los Angeles
Van Ness, Everett Willard	Los Angeles
Veronda, Carol McCauley	San Marino
Webster, Paul Winston	Santa Monica
Weiler, Harry Burkhart	North Hollywood
Weller, LeRoy Ashton	Upland
Willits, Ralph Milton	Wrightwood
Wilson, Webster deLong	Oakland
Wolfe, Fred R.	Honolulu, Hawaii
Wood, Frank William	Huntington Park
Woods, Gordon Keaton	Spokane, Washington
Wyckoff, Donald Mackenzie	Canoga Park

SUMMARY

GRADUATE SCHOOL

RESEARCH FELLOWS

American Can Company Fellow	1	
Carlsberg Fond, Rask Oersted Fond, and Danmarks Amerikanske Selskab Fellow	1	
Hale Fellow	1	
International Research Fellow of the Rockefeller Foundation	1	
International Exchange Fellow	1	
Leverhulme Research Fellows	2	
National Research Fellows	2	
Noyes Fellows	2	
H. H. Rackham Postdoctoral Fellow	1	
Research Fellows of the Institute	25	
Standard Oil Company of California Technical Fellow	1	
		38
Research Assistants of the Institute		27
		65

GRADUATE STUDENTS

Aeronautics	40	
Biology	17	
Chemistry	40	
Chemical Engineering	7	
Civil Engineering	13	
Geology	28	
Electrical Engineering	17	
Mechanical Engineering	15	
Meteorology	18	
Mathematics	13	
Physics	48	
		256

UNDERGRADUATE SCHOOL

Seniors	126	
Juniors	162	
Sophomores	159	
Freshmen	159	
		606
Total Number of Students		862

COURSES AND OPTIONS OF UNDERGRADUATE STUDENTS

SCIENCE COURSE	Seniors	Juniors
Biology	2	5
Chemistry	2	14
Applied Chemistry	15	19
Geology	9	14
Mathematics	2	0
Physics	12	8
Applied Physics	3	8
Total	45	68

ENGINEERING COURSE		
Aeronautics	5	12
Civil	11	10
Electrical	27	29
Mechanical	38	43
Total	81	94

INDEX

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PASADENA, CALIFORNIA