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INSTITUTE OF TECHNOLOGY

VOLUME 51

NUMBER 1

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INTERIM CATALOGUE

For a number of years the annual Catalogue Number of the California Institute Bulletin has been published in January. Recently, however, it was decided to change the publication month to July.

To bridge the interval between January and July, 1942, the previous Catalogue Number is here reprinted, with a revised calendar for the sessions of the year 1942.

Entrance and degree requirements for undergraduate and graduate students, schedules of fees and expenses, and descriptions of the general content of courses offered by the California Institute are here revised in accordance with regulations now in effect.

As this Interim Catalogue goes to press, the Faculty of the California Institute is considering the possibility of accelerating the whole program of instruction by adding a summer term and beginning the regular instruction of the academic year in that term, instead of in September, as is now the practice. In case this change is made, all students now enrolled in the Institute and all those applying for admission will be notified immediately by the Registrar.

BULLETIN OF THE CALIFORNIA INSTITUTE OF TECHNOLOGY

VOLUME 51

NUMBER 1

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

INTERIM CATALOGUE

JANUARY-JULY, 1942

PASADENA • CALIFORNIA • JANUARY, 1942

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CALENDAR

1941

1942

JANUARY							JULY							JANUARY							JULY							
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	
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CALENDAR

1942

JANUARY 5	Beginning of Instruction—Second Term
JANUARY 24	Examinations for Removal of Conditions and Incompletes
FEBRUARY 15	Last Day for Applications for Fellowships and Assistantships
MARCH 16-21	Term Examinations
MARCH 16	Registration for Third Term
MARCH 21	Notifications of Awards of Fellowships and Assistantships
MARCH 21	End of Second Term (12 M.)
MARCH 22-29	Recess
MARCH 27	Meeting of Freshman Registration Committee
MARCH 28	Meeting of Registration Committee
MARCH 14 and 21	Examinations for Admission to Freshman Class and for Freshman Scholarships (see page 85)
MARCH 30	Beginning of Instruction—Third Term
APRIL 12	Alumni Seminar
APRIL 18	Examinations for Removal of Conditions and Incompletes
APRIL 18	List of Approved Candidates for Bachelor of Science Degree Posted
MAY 28	Last Day for Examinations and Presenting Theses for the Degree of Doctor of Philosophy
MAY 30	Memorial Day Recess
JUNE 1-6	Examinations for Candidates for the Degrees of Bachelor of Science and Master of Science
JUNE 8-13	Term Examinations for All Undergraduates Except Seniors
JUNE 9	Meetings of Committees on Course in Engineering and Course in Science (10 A. M.)
JUNE 10	Faculty Meeting (10 A. M.)
JUNE 11	Class Day
JUNE 12	Commencement
JUNE 12	Annual Meeting of Alumni Association
JUNE 6, 12, 13	Examinations for Admission to Upper Classes
JUNE 13	Entrance Examinations in Chemistry and English for High School Juniors
JUNE 13	End of College Year (12 M.)
JUNE 22	Meeting of Freshman Registration Committee
JUNE 23	Meeting of Registration Committee
SEPTEMBER 18 and 19	Examinations for Admission to Upper Classes
SEPTEMBER 22	Registration of Freshmen (1:30 P. M.)
SEPTEMBER 24	Registration of Students Transferring from Other Colleges (9 A. M. to 3 P. M.)
SEPTEMBER 25	General Registration (9 A. M. to 3 P. M.)
SEPTEMBER 26	Examinations for Removal of Conditions and Incompletes
SEPTEMBER 28	Beginning of Instruction—First Term
NOVEMBER 21	Last Day for Announcing Candidacy for Bachelor's Degree
NOVEMBER 26-29	Thanksgiving Recess
DECEMBER 14-19	Term Examinations
DECEMBER 14	Registration for Second Term
DECEMBER 19	Last Day for Applications for Candidacy for the Degree of Doctor of Philosophy in June, 1943
DECEMBER 19	End of First Term (12 M.)
DECEMBER 28	Meeting of Freshman Registration Committee
DECEMBER 29	Meeting of Registration Committee
JANUARY 4, 1943	Beginning of Instruction—Second Term

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STUDENT SOCIAL FUNCTIONS: H. Craig, Jr. (*chairman*), D. S. Clark, H. Eagleson, R. D. Gray, G. Laing, H. J. Lucas.

STAFF OF INSTRUCTION AND RESEARCH

ROBERT ANDREWS MILLIKAN, PH.D., LL.D., Sc.D., Nobel Laureate

*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 Società 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, National Academy of Sciences, and Pontificia Accademia delle Scienze; 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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Member of the Executive Council*

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, 1927-1931; Member, Royal Society of London; Finnish Society of Sciences; Associate Member, Société Royale des Sciences Médicales et Naturelles de Bruxelles; Société 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, Accademia Scientiarum Instituti, Bononiensis (Bologna); Member, Pontificia Accademia delle Scienze, 1936; Honorary Foreign Member, Académie Royale de Médecine 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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*Edward S. Harkness Professor of History and Government
Member of the Executive Council*

B.A., Queens University, 1895; M.A., 1896; LL.B., 1898; M.A., Harvard University, 1899; Ph.D., 1900; M.A. (hon.), Williams College, 1904; LL.D., Queens University, 1912; Litt.D., University of Southern California, 1930; LL.D., Mills College, 1931; 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; 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-

268 Bellefontaine Street

RICHARD CHACE TOLMAN, PH.D.*

*Professor of Physical Chemistry and Mathematical Physics
Dean of the Graduate School
Member of the Executive Council*

S.B., in Chemical Engineering, Massachusetts Institute of Technology, 1903; Ph.D., 1910; Student, Berlin and Grefeld, 1903-1904. Dalton Fellow, Instructor in Theoretical Chemistry, and Research Associate in Physical Chemistry, Massachusetts Institute of Technology, 1905-1910; Instructor in Physical Chemistry, University of Michigan, 1910-1911; Assistant Professor of Physical Chemistry, University of Cincinnati, 1911-1912; Assistant Professor of Chemistry, University of California, 1912-1916; Professor of Physical Chemistry, University of Illinois, 1916-1918; Chief, Dispersoid Section, Chemical Warfare Service, 1918; Associate Director and Director, Fixed Nitrogen Research Laboratory, Department of Agriculture, 1919-1921. Member of National Academy of Sciences, American Philosophical Society, and of American Academy of Arts and Sciences; Vice-Chairman, National Defense Research Committee, 1940-. California Institute, 1921-

345 South Michigan Avenue

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

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, 1937-1939; Professor, 1939-

249 South Berkeley Avenue

EDWARD CECIL BARRETT, B.A.

Comptroller

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

942 North Chester Avenue

HARRY BATEMAN, PH.D.

Professor of Mathematics, Theoretical Physics, and Aeronautics

B.A., Cambridge University, 1903; M.A., 1906; Smith's 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, 1928. Member, American Philosophical Society, National Academy of Sciences. California Institute, 1917-

1107 San Pasqual Street

*On leave of absence.

STUART JEFFERY BATES, Ph.D.*Professor of Physical Chemistry*

B.A., McMaster University, Toronto, 1907; M.A., 1909; Ph.D., University of Illinois, 1912. Research Assistant, McMaster University, 1909-1910; Fellow in Chemistry, University of Illinois, 1910-1912; Research Associate in Physical Chemistry, 1912-1913. Instructor in Analytical Chemistry, University of Illinois, 1913-1914; Research Associate in Physical Chemistry, Massachusetts Institute of Technology, 1922-1923 (on leave from California Institute of Technology). California Institute, 1914-

2011 Rose Villa Street

ERIC TEMPLE BELL, Ph.D.*Professor of Mathematics*

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

434 South Michigan Avenue

JAMES EDGAR BELL, Ph.D.*Professor of Chemistry*

S.B., University of Chicago, 1905; Ph.D., University of Illinois, 1913. Instructor in Chemistry, University of Washington, 1910-1911, 1913-1916. Associate Professor, California Institute, 1916-1918; Professor, 1918-

R. D. 1, Box 639, Pasadena

HENRY BORSOOK, Ph.D., M.D.*Professor of Biochemistry*

B.A., University of Toronto, 1921; M.A., 1922; Ph.D., 1924; M.B., 1927; M.D., 1940. Fellow, Research Fellow, and Lecturer in Biochemistry, University of Toronto, 1920-1929. Assistant Professor, California Institute, 1929-1935; Professor, 1935-

1121 Constance Street

IRA SPRAGUE BOWEN, Ph.D.*Professor of Physics*

A.B., Oberlin College, 1919; Ph.D., California Institute of Technology, 1926. Assistant in Physics, University of Chicago, 1920-1921. Member, National Academy of Sciences and American Philosophical Society. Instructor, California Institute, 1921-1926; Assistant Professor, 1926-1928; Associate Professor, 1928-1931; Professor, 1931-

380 Bonita Avenue

JOHN PETER BUWALDA, Ph.D.*Professor of Geology*

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

2103 San Pasqual Street

W. HOWARD CLAPP, E.M.*Professor of Mechanism and Machine Design*

E.M., University of Minnesota, 1901. Instructor in Mathematics, Macalester College, 1897-1898. Superintendent and Designing Engineer, Sherman Engineering Company, Salt Lake City, 1905-1909; Superintendent, Nevada-Goldfield Reduction Company, Goldfield, Nevada, 1909-1910. Chairman, Los Angeles Section, American Society of Mechanical Engineers, 1937-1938; Alternate, American Engineering Council, 1937-1941; member, Executive Committee, Los Angeles Engineering Council, 1938-1939; President, Los Angeles Engineering Council, 1940-1941. Instructor, California Institute, 1911-1913; Assistant Professor, 1913-1914; Associate Professor, 1914-1918; Professor, 1918-

95 South Mentor Avenue

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

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 für Erdbebenforschung, Strassburg, 1914-1919; Privatdozent für Geophysik, Universität Frankfurt a/M, 1924-1926; A. O. Professor, 1926-1930. California Institute, 1930-

399 Ninita Parkway

ARIE JAN HAAGEN-SMIT, Ph.D.*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, 1937-1940; Professor, 1940-

351 South Parkwood 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
Acting Dean of the Graduate School

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; Josiah Willard Gibbs Lecturer of the American Mathematical Society, 1939. 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

*On leave of absence.

HOWARD JOHNSON LUCAS, M.A.*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, 1915-1940; Professor, 1940-.

95 North Holliston Avenue

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-

195 N. Euclid 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

CLARK BLANCHARD MILLIKAN, Ph.D.*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, 1934-1940; Professor, 1940-

1500 Normandy Drive

SEELEY G. MUDD, M.D.*Professor of X-Ray Therapy*

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

1550 Oak Grove Avenue

ALFRED NOYES, C.B.E., LL.D., Litt.D.*Visiting Professor of English Literature*

Litt.D., Yale University, 1913; LL.D., Glasgow University, 1927. Lowell Lectures, 1913. Murray Professor of Modern English Literature, Princeton University, 1914-1923; Visiting Lecturer, California Institute, 1917-1918. California Institute, 1941.

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, 1934. 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-

3500 East Fairpoint Street, Sierra Madre Villa

RALPH BARTON PERRY, PH.D.*Visiting Professor of Philosophy*

A.B., Princeton University, 1896; A.M., Harvard University, 1897; Ph.D., 1899. Instructor in Philosophy, Williams College, 1899-1900; Smith College, 1900-1902. Instructor in Philosophy, 1902-1905; Assistant Professor, 1905-1913; Professor, Harvard, 1913-. Hyde Lecturer in the French universities, 1921-1922.

WILLIAM RALPH SMYTHE, PH.D.*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, 1934-1940; Professor, 1940-

674 Manzanita Avenue, Sierra Madre

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; President, 1940-1941; and member of Board of Directors, 1936-1940. 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. Senior Curator of Vertebrate Paleontology, Los Angeles Museum; Fellow of the John Simon Guggenheim Memorial Foundation, 1939-1940; 1940-1941. 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; Visiting Lecturer, Harvard University, 1940. 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

EDWARD LEE THORNDIKE, PH.D.*Visiting Professor of Psychology*

A.B., Wesleyan University (Connecticut), 1895; A.B., Harvard, 1896, A.M., 1897; Ph.D., Columbia University, 1898. Instructor in Education and Teaching, Western Reserve University, 1898-1899; Instructor in Genetic Psychology, 1899-1901; Adj. Professor Educational Psychology, 1901-1904; Professor, Teachers College, Columbia University, 1904-

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

MORGAN WARD, PH.D.*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, 1935-1940; Professor, 1940-

265 South Holliston Avenue

EARNEST CHARLES WATSON, Ph.B.*Professor of Physics**Chairman of the Faculty Board*

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-

485 South Madison Avenue

LÁSZLÓ ZECHMEISTER, Dr. Ing.*Professor of Organic Chemistry*

Diploma in Chemistry, Zurich, 1911; Dr. Ing., 1913. Assistant and Chief Assistant, Kaiser Wilhelm Institut für Chemie, 1912-1914; Instructor, Danish Royal Veterinary Academy, Copenhagen, 1921-1923; Professor of Chemistry and Director of the Chemical Laboratory, Medical School of the University of Pécs, 1923-; Lecturer, California Institute, 1938. Member of the Hungarian Academy of Science. Laureate of Grand Prize of the Hungarian Academy, 1937; Médaille Pasteur, Paris, 1935. Professor of Organic Chemistry, California Institute, 1939-

Athenæum

GORDON ALBERT ALLES, Ph.D.*Research Associate in Biology*

B.S. in Chemistry and Chemical Engineering, California Institute of Technology, 1922; Du Pont Fellow, 1924; M.S., 1924; Ph.D., 1926. Chemist, Riverside Portland Cement Co., 1922; Research Chemist, The Celite Co., 1922-1923; Research Fellow, Harvard Medical School, 1927-1928; Chemical research with George Pines, M.D., Los Angeles, 1926-1927, 1928-1940. Lecturer in Pharmacology, University of California Medical School, San Francisco, 1932-. California Institute, 1939-

1316 West Haven Road, San Marino

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. Colonel, CA-Res. 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

†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-

2750 Millicent Way

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 and Lecturer 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

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

WILLIAM HALLER, PH.D.*Associate in English Literature*

B.A., Amherst College, 1908; Ph.D., Columbia University, 1916. Instructor in English, Amherst College, 1908-1909; member of the Department of English, Barnard College, 1909-; chairman, 1925-1937. Professor of English, Columbia University. California Institute, 1941.

1539 New York Avenue, Altadena

JOSEPH BLAKE KOEFLI, 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

VLASTIMIL KYBAL, DR. PHIL.*Visiting Lecturer in History and Economics*

Dr. Phil., Czech University of Prague, 1903. Docent of the General History of Western Europe of the Middle and Modern Ages, Czech University, Prague, 1911-1918; Professor Regius, 1919-. Jubilee Prize of the Czech Royal Society of Sciences, 1904; Jubilee Prize of the Czech Academy, 1910, 1915; Prize of the City of Prague, 1914. Member of the Royal Czech Society of Sciences and of the Czech Academy. Plenipotentiary Minister of Czechoslovakia to Italy, 1920-1925; to Brazil and Argentine, 1925-1927; to Spain and Portugal, 1927-1933; to Mexico, Guatemala, El Salvador, Honduras, and Nicaragua, 1935-1939. Member of the Spanish Academy of History, Madrid; Academy of Belles Lettres, Barcelonne; Ibero-American Academy, Cadiz; Colegio de Doctores of the University of Madrid; Mexican Society of Geography and Statistics; Society of History and Geography of Guatemala. Grand Cross of the Crown of Italy, Grand Cross of the Order of Isabelle the Catholic, Aztec Eagle of Mexico. Member of School of Research, University of Southern California. California Institute, 1939-

250 South Holliston Avenue

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; Fellow and member of 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 ALLEN 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, 1920-39; Master of Kirkland House, Harvard University, 1931-1935. Research Fellow, Huntington Library, 1938-1939; member of the Research Staff, 1939-. California Institute, 1939-

1245 Arden Road

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, 1925-

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; Visiting Professor, University of Michigan, summer, 1935. 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., Center College of Central University, 1904; B.L., University of Louisville, 1907. California Institute, 1937-

808 South San Rafael Avenue

ARTHUR HOWLAND YOUNG*Visiting Lecturer on Industrial Relations*

Supervisor of Labor and Safety, Illinois Steel Co., 1912-1917; Director, American Museum of Safety, 1917-1918; Chief Safety Expert, U. S. Arsenals and Navy Yards, World War, also Chief Safety Expert of U. S. Employees Compensation Commission, 1917-1918; Manager of Industrial Relations of International Harvester Company, 1918-1924; Industrial Relations Counsel to Industrial Relations Counselors, Inc., 1924-1934; Secretary Consultant International Labor Organization, Geneva, 1925-1932; Vice-President, U. S. Steel Corporation, 1934-1937; Lecturer on Industrial Relations, Harvard Graduate School of Business Administration, 1929-1931, and Wharton School of Commerce and Industry, 1930-1937; Consulting Professor of Industrial Relations, Leland Stanford University, 1937-. California Institute, 1939-

406 South Chester 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

FREDERICK J. CONVERSE, B.S.*Associate 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, 1933-1939; Associate Professor, 1939-

2167 Lambert Drive

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

*On leave of absence.

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, 1929-1939. Fellow in Physics of the International Education Board, 1927-1928. Visiting Professor, Imperial Universities of Japan and University of Tsinghua, China, 1930. Research Fellow of International Education Board, California Institute, 1927-1928; Research Fellow, 1928-1929; Director of Research, Rare Metals Institute, 1940-. Associate Professor, 1929-

1327 Boston Street, Altadena

ROBERT D. GRAY, B.S.

Associate Professor of Economics and Industrial Relations
Resident Associate in Ricketts House

B.S. in Economics, Wharton School of Finance and Commerce, University of Pennsylvania, 1930. Research Assistant, Industrial Research Department, University of Pennsylvania, 1927-1936; Research Associate, 1936-1939; Instructor in Geography and Industry, Wharton School of Finance and Commerce, 1934-1937. Vice-Chairman, Committee on Prices in the Bituminous Coal Industry, The Conference on Price Research, National Bureau of Economic Research, 1936-1937. Assistant Professor of Economics, University of Connecticut, 1937-1940; Adviser, Division of Business and Commerce, 1939-1940. Special Research Assistant, Life Office Management Association, 1939-1940. California Institute, 1940-

Ricketts House

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, 1936-; Consultant, U. S. Bureau of Reclamation, 1938-1940. Instructor, California Institute, 1922-1930; Assistant Professor, 1930-1936; Associate Professor, 1936-

Kinneloa Ranch, Route 1, Box 680, Pasadena

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 and Mechanical 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

SAMUEL STEWART 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 1923, 1928-1932; Chief of Surveys, 200-inch Telescope, Palomar Mt., Summer, 1933. California Institute, 1918-

388 South Oak Avenue

HENRY VICTOR NEHER, Ph.D.*Associate 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, 1937-1940; Associate Professor, 1940-

1099 South Oakland Avenue

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 Jaroslavl, 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

*On leave of absence.

BRUCE HORN BROOK SAGE, PH.D.*Associate Professor of Chemical Engineering*

B.S., New Mexico State College, 1929; M.S., California Institute of Technology, 1931; Ph.D., 1934. Teaching Fellow, California Institute, 1930-1934; Research Fellow, 1934-1935; Senior Fellow in Chemical Research, 1935-1937; Assistant Professor, 1937-1940; Associate Professor, 1940-

1410 La Solana Drive, Altadena

ERNEST EDWIN SECHLER, PH.D.*Associate Professor of Airplane Structures*

B.S., California Institute, 1928; M.S., 1929; Ph.D., 1933. Assistant in Engineering, California Institute, 1928-1930; Instructor, 1930-1937; Assistant Professor, 1937-1940; Associate Professor, 1940-

2100 Dudley Street

J. E. WALLACE STERLING, PH.D.*Associate 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, 1928-1932; Research Assistant, Hoover War Library, Stanford University, 1930-1937; Research Associate, 1937; Instructor in History, Stanford University, 1935-1937. Assistant Professor, California Institute, 1937-1940; Fellow, Social Science Research Council, 1939-1940; Associate Professor, 1940-

2650 Paloma Street

ERNEST HAYWOOD SWIFT, PH.D.*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

RAY EDWARD UNTEREINER, J.D., PH.D.*Associate Professor of Economics and History
Dean of Freshmen*

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

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

CORNELIS A. G. WIERSMA, PH.D.*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

DON M. YOST, PH.D.*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

FRITZ ZWICKY, PH.D.*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

WILLIAM NOEL BIRCHBY, M.A.*Assistant Professor of Mathematics*

A.B., Hope College, 1899; M.A., Colorado College, 1905. Instructor, Colorado College, 1905 and 1907; Instructor in Physics, University of Southern California, Summer Session, 1916. Instructor, California Institute, 1918-1931; Assistant Professor, 1931-

1500 Sinaloa Avenue

JAMES FREDERICK BONNER, PH.D.*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-

406 South Chester Avenue

A. PERRY BANTA, M.S.*Assistant Professor of Sanitary Engineering*

A.B. in Civil Engineering, Stanford University, 1926; M.S., California Institute of Technology, 1928. Assistant in Surveying and Structural Design, Stanford University, 1924-1926; Teaching Fellow, California Institute, 1926-1927; Designer with Quinton, Code & Hill, 1927; Assistant Engineer, Los Angeles County Sanitation Districts, 1927-. Assistant Professor, California Institute, 1939-

159 Sierra View Road

DONALD SHERMAN CLARK, PH.D.

*Assistant Professor of Mechanical Engineering
Resident Associate in Dabney House
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

HARDIN CRAIG, JR., PH.D.*Assistant Professor of History*

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

124 South Berkeley Avenue

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-

WILLIAM ALFRED FOWLER, Ph. D.**Assistant Professor of Physics*

B.Eng.Physics, Ohio State University, 1933; Ph.D., California Institute of Technology, 1936. Research Fellow, California Institute, 1933-1939; Assistant Professor, 1939-
523 South Los Robles Avenue

HORACE J. FRASER, Ph.D.*Assistant Professor of Metalliferous Geology and Mineralogy*

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-

970 Old Mill Road, San Marino

ANTHONIE VAN HARREVELD, M.D.*Assistant Professor of 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, 1935-1940; Assistant Professor, 1940-

515 South El Molino Avenue

HUGH MARTIN HUFFMAN, Ph.D.*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-

3280 Mount Curve Avenue, Altadena

LOUIS WINCHESTER JONES, A.B.*Assistant Professor of English Language and Literature**Assistant Dean of Upper Classmen**Faculty Associate of the Throop Club*

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

351 California Terrace

ROBERT MINNSEN KLEINPELL, Ph.D.*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-. Senior Petroleum Geologist, National Development Company, Manila, P. I., 1939-. Assistant Professor, California Institute, 1939-

*On leave of absence.

ALBERT EATON LOMBARD, JR., PH.D.**Assistant Professor of Aeronautics and Mechanical Engineering*

B.S., California Institute, 1928; M.S., 1929; Ph.D., 1939. Assistant in Mathematics, California Institute, 1928-1929. Structural, Aerodynamics, Research and Consulting Engineer, Curtiss-Wright Corporation, 1929-1939. Teaching Fellow in Applied Mechanics and Aeronautics, California Institute, 1937-1939; Assistant Professor of Aeronautics and Mechanical Engineering, 1939-

GEORGE EBER MACGINITIE, M.A.*Assistant Professor of Biology**In charge of William G. Kerckhoff Marine Laboratory*

A.B., Fresno State College, 1925; M.A., 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 Enstitüsü, Republic of Turkey, 1936-1937; Research Associate, Carnegie Institution of Washington, 1933-. California Institute, 1928-

1965 Galbreth Road, Altadena

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

CARL GEORGE NIEMANN, PH.D.*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-

JOHANNES VAN OVERBEEK, PH.D.*Assistant Professor of Plant Physiology*

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, 1937-1939; Assistant Professor, 1939-

863 North Sunset Boulevard, Arcadia

WILLIAM HAYWARD PICKERING, PH.D.*Assistant Professor of Electrical Engineering and Instructor in History*

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, 1936-1940; Assistant Professor, 1940-

1773 Oakdale Street

*On leave of absence.

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

ROBERT ROSS, PH.D.*Visiting Lecturer in Psychology*

B.S., California Institute of Technology, 1927; A.M., University of Southern California, 1930; Ph.D., Yale University, 1934. Assistant in English, 1927-1928. Graduate Assistant in Public Address, Pomona College, 1928-1929; Instructor, 1929-1930; Resident Assistant to the Dean, 1930-1931; Instructor in Psychology, 1930-1932; University Fellow in Psychology, Yale University, 1933-1934; Instructor, 1934-1936; Assistant Professor of Psychology, Stanford University, 1936-. Research Associate, Pasadena Playhouse, 1937-. California Institute, 1938-

WILLIAM REES SEARS, PH.D.*Assistant Professor of Aeronautics*

B.Aero.E., University of Minnesota, 1934; Ph.D., California Institute of Technology, 1938. Assistant in Aeronautics, California Institute, 1934-1937; Instructor, 1937-1939; Assistant Professor, 1939-

1320 Fay Place

ROGER STANTON, PH.D.*Assistant Professor of English Language and Literature*

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

JOHN DONOVAN STRONG, PH.D.*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-

852 South Oakland Avenue

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-

Athenzium

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 Biology at Berlin and Naples, 1932-1933; Teaching Fellow, California Institute of Technology, 1928-1929; Instructor, 1929-1938; Assistant Professor, 1938-

773 South Mentor Avenue

HOWELL NEWBOLD TYSON, B.S.*Assistant Professor of Mechanical Engineering and Engineering Drafting*

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, 1936-1939; Assistant Professor, 1939-

505 South Wilson Avenue

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.

2174 Midlothian Drive, Altadena

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-

1080 North Holliston Avenue

WILLIAM L. STANTON, B.A.*Physical Director*

B.A., Dickinson College, 1903. Assistant Director of Physical Education, Pratt Institute, 1903-1904; Director of Athletics and Physical Education, Morristown School, 1905-1906; Professor of English and Director of Athletics, Hamilton Institute, 1906-1908; 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; in charge of field explorations for Vertebrate Paleontology in north-eastern Mexico, 1935-1936; Geologist, Foreign Service, Standard Oil Company of California, in Abyssinia, Eritrea, Somalia, Egypt, Italy, 1937-1939. Instructor in Geology, California Institute, 1936-

2066 Galbreth Road, Altadena

ROBERT B. COREY, PH.D.*Senior Fellow in Structural Chemistry*

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

VERNER SCHOMAKER, Ph.D.

Senior Fellow in Chemical Research

B.S., University of Nebraska, 1934; M.S., 1935; Ph.D., California Institute of Technology, 1938.
California Institute, 1938-

929 East California Street, Apt. 4

JAMES WALLACE DAILY, M.S.

Instructor in Mechanical Engineering

A.B., Stanford University, 1935; M.S., California Institute of Technology, 1937. Graduate
Assistant, California Institute, 1936-1938; Research Assistant, 1938-1939; Research Fellow,
1939-. Manager, Hydraulic Machinery Laboratory, 1937-

161 South Chester Avenue

LOUIS G. DUNN, Ph.D.

Instructor in Aeronautical Engineering

B.S., California Institute, 1936; M.S. in M.E., 1937; M.S. in Ae., 1938; Ph.D., 1940. Stress
Analyst, Lockheed Corporation, 1936-1937. Research Assistant in Airplane Structures, 1937-
1940; Instructor in Aeronautics, 1940-

3360 Yorkshire Road

ROBERT D. ELLIOTT, M.S.

Instructor in Meteorology

B.S. in Physics, California Institute of Technology, 1936; M.S. in Meteorology, 1937. Meteorologist
with Eastern Airlines, Atlanta, Georgia, 1937-1939.

325 Buena Loma Place, Altadena

CHARLES FINK FISCHER, B.S.

Instructor and Coordinator, Civilian Pilot Training Program

B.S., U. S. Naval Academy, 1934; B.S. in Ae., California Institute of Technology, 1940. Designated
naval aviator N.A.S., Pensacola, 1937. U. S. Naval Officer, 1934-1939. First Officer
American Airlines, summer 1940. Instructor and Coordinator Civilian Pilot Training Program,
1940-

1875 Rose Villa Street

RAY H. ODELL, M.S.

Instructor in Meteorology

B.Aero.E., University of Minnesota, 1932; M.S. in Meteorology, California Institute of Technology,
1937. Instructor, California Institute, 1940-

1920 Navarro Avenue

RAYMOND ALFRED PETERSON, Ph.D.

Instructor in Geophysics

B.S., California Institute of Technology, 1931; Ph.D., 1935. Geophysical Engineering Corp.,
1935-1938; United Geophysical Co., 1938-. Assistant and Teaching Fellow, California
Institute, 1931-1935; Research Fellow, 1935-1938; Instructor, 1938-. California Institute,
1931-

1813 Euclid Avenue, San Marino

WILLIAM H. REMPEL, B.A.

Instructor in Meteorology

B.A., University of Montana, 1939. Instructor, California Institute of Technology, 1940-

1201 East California Street

KERMIT ROOSEVELT, JR., A.B.*Instructor in History*

A.B., Harvard College, 1937 (as of 1938). Assistant in History, Harvard University, 1937-1939.
California Institute, 1939-; Assistant in Research, Huntington Library, 1940-

717 South Catalina Avenue

PAUL E. RUCH, M.S.*Instructor in Synoptic Meteorology*

B.S., Massachusetts Institute of Technology, 1928; M.S., Meteorology, California Institute of Technology, 1939. Instructor, California Institute, 1938-

2244 North Craig Avenue, Altadena

FRANCES HALSEY SPINING*Librarian*

California Institute, 1914-

1067 North Catalina Avenue

HOMER JOSEPH STEWART, B.Aero.E.*Instructor in Dynamic Meteorology and Aeronautics*

B.Aero.E., University of Minnesota, 1936; Ph.D., California Institute of Technology, 1940. Assistant in Aeronautics, California Institute of Technology, 1936-1938; Instructor, 1938-

746 South Marengo Avenue

NEWTON C. STONE, M.S.*Instructor in Meteorology*

B.E., Southern Illinois Teachers' College, 1934; M.S., University of Illinois, 1935. Assistant in Meteorology, California Institute, 1939-1940; Instructor, 1940-

204 South Wilson Avenue

ARTHUR J. STOSICK, Ph.D.*Instructor in Chemistry*

B.S., University of Wisconsin, 1936; Ph.D., California Institute of Technology, 1939. Research Fellow, California Institute, 1939-1940; Instructor, 1940-

138 South Holliston Avenue

NATHANIEL W. WILCOX, A.B.*Instructor in Engineering Drawing*

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

917 North Granada Avenue, Alhambra

J. NORTON WILSON, Ph.D.*Instructor in Applied Chemistry*

B.A., University of British Columbia, 1934; M.A., 1936; Ph.D., California Institute of Technology, 1939. Research Fellow, California Institute, 1939-1940; Instructor, 1940-

115 North El Molino Avenue

RESEARCH FELLOWS

VERNON LEROY BOLLMAN, PH.D.

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-**

1600 Campus Road, Los Angeles

LEE REED BRANTLEY, PH.D.

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, 1936-1940; Associate Professor of Chemistry and Head of Chemistry Department, 1940-. **Research Fellow, California Institute, 1935-**

412 South Chevy Chase Drive, Glendale

DAN H. CAMPBELL, PH.D.

Rockefeller Foundation Fellow in Chemistry

A.B., Wabash College, 1930; M.S., Washington University, 1932; Ph.D., University of Chicago, 1936. **Research Fellow, University of Chicago, 1936-1938; Instructor in Bacteriology, 1938-1939; Assistant Professor in Immunology, 1939-. California Institute, 1940-**

1129 Dolores Drive

LEVERETT DAVIS, JR., M.S.

Hixon Fund Fellow in Physics

B.S., Oregon State College, 1936; M.S., California Institute, 1938. **Research Fellow, California Institute, 1940-**

ALEXIS A. B. DEMBER, D.Sc.

Research Fellow in Physics¹

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

817 South Oakland Avenue

RICHARD W. DODSON, PH.D.

National Research Fellow in Chemistry

B.S., California Institute of Technology, 1936; Ph.D., Johns Hopkins University, 1939. **Research Assistant, Johns Hopkins University, 1939-1940. California Institute, 1940-**

JOHN T. EDSALL, M.D.

Research Fellow in Chemistry of the John Simon Guggenheim Memorial Foundation

A.B., Harvard University, 1923; M.D., 1928. Tutor Biochemical Sciences, Harvard College, 1928-; Instructor, 1928-1932; Assistant Professor of Biochemistry, 1932-1938; Associate Professor, 1938-. **California Institute, 1940-**

2064 Loma Vista Street

¹Rare Metals Research Fund.

WALTER M. ELSASSER, PH.D.

Research Fellow in Meteorology

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

EUGENE H. EYSTER, PH.D.

George Ellery Hale Fellow in Chemistry

B.Chem., University of Minnesota, 1935; Ph.D., California Institute of Technology, 1938. National Research Fellow, 1938-1940. California Institute of Technology, 1940-

Athenæum

PAUL A. GIGUÈRE, PH.D.

Provincial Government of Quebec Fellow in Chemistry

B.A., Laval University, 1930; B.Sc., 1934; Ph.D., McGill University, 1937. Research Chemist, Canadian Industries, Ltd., Montreal, 1938. Research Fellow, California Institute, 1939-

11 Sierra Bonita Place

NORMAN H. HOROWITZ, PH.D.

Research Fellow in Biology

B.S., University of Pittsburgh, 1936; Ph.D., California Institute of Technology, 1939. National Research Fellow in Biology, Stanford University, 1939-1940. California Institute, 1940-

1100 East Del Mar Street

EDWARD W. HUGHES, PH.D.

Arthur A. Noyes Fellow in Chemistry

B.Chem., Cornell University, 1924; Ph.D., 1935. Resident Doctor, 1935-1938. Research Fellow, California Institute, 1938-

Athenæum

JOSEF JEROME JOHNSON, PH.D.

Charles G. Strater Research Fellow in Astrophysics

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

1030 San Pasqual Street

JUSTUS G. KIRCHNER, PH.D.

Hawaiian Pineapple Producers Cooperative Association Fellow in Bio-organic Chemistry

B.S., Creighton University, 1935; Ph.D., Iowa State University, 1939. Research Assistant, California Institute, 1939-1940; Research Fellow, 1940-

120 North Mentor Avenue

HARRY ALLISTER KIRKPATRICK, PH.D.*Research Fellow in Physics*

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-

1555 North Avenue Forty-Six, Los Angeles

SPIRO KYROPOULOS, PH.D.*Research Fellow in Physics¹*

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-A Mill Road, South Pasadena

RUDOLPH M. LANGER, PH.D.*Research Fellow in Physics*

B.S., College of the City of New York, 1920; M.A., Columbia University, 1921; Ph.D., California Institute of Technology, 1927. Assistant Physicist, Naval Research Laboratory, 1926-1927; National Research Fellow in Physics, Bureau of Standards, 1927-1929; University of Berlin, 1929-1930; Assistant Professor of Physics, Massachusetts Institute of Technology, 1930-1931; Professorial Lecturer in Physics, University of Minnesota, 1931-1932. Research Fellow in Physics, California Institute, 1932-

496 Astabula Street

HENRI A. LÉVY, PH.D.*Research Fellow in Chemistry*

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

Athenæum

HANS WOLFGANG LIEPMANN, D.PHIL.*Research Fellow in Aeronautics*

Dr.Phil., University of Zurich, 1938. Research Fellow, University of Zurich, 1938-1939. Recipient of the prize in physics of the Philosophical Faculty, Zurich, 1939. California Institute, 1939-

294 South Wilson Avenue

PAUL EUGENE LLOYD, PH.D.*Research Fellow in Physics*

B.A., Stanford University, 1929; Ph.D., California Institute of Technology, 1937. Instructor, Oberlin College, 1938. Research Fellow, California Institute, 1938-

620 Burleigh Drive

CHIA-SI LU, PH.D.*Post-Doctorate Scholar in Chemistry*

B.Sc., University of Amoy, 1934; Ph.D., University of London, 1939. Instructor in Chemistry, University of Amoy, 1934-1937. Sino-British Boxer Indemnity Fund Scholar in Chemistry, 1937-1940. California Institute, 1939-

420 South Wilson Avenue

¹Rare Metals Research Fund.

FRANK JOSEPH MALINA, PH.D.

Research Fellow in Aeronautics
Cooperative Agent, Soil Conservation Service

B.S., Texas Agricultural and Mechanical College, 1934; M.S., California Institute of Technology, 1935 and 1936; Ph.D., California Institute of Technology, 1940. Assistant and Teaching Fellow, California Institute, 1936-1939; Research Assistant, 1939-1940; Research Fellow, 1940-

1288 Cordova Street

NICHOLAS MILLER, PH.D.

Commonwealth Fund Fellow in Chemical Engineering

B.Sc., Imperial College of Science and Technology, London, 1937; Ph.D., 1939. Commonwealth Fund Fellow in Chemical Engineering, 1939-. California Institute, 1940-

Athenæum

WALTER J. MOORE, JR., PH.D.

National Research Fellow in Chemistry

B.S., New York University, 1937; Ph.D., Princeton University, 1940. Research Fellow, California Institute, 1940-

Athenæum

SETH HENRY NEDDERMEYER, PH.D.

Research Fellow in Physics

A.B., Stanford University, 1929; Ph.D., California Institute of Technology, 1935. California Institute, 1932-

306 South El Molino Avenue

MILTON SPINOZA PLESSET, PH.D.

Research Fellow in Physics

B.S., University of Pittsburgh, 1929; M.S., 1930; Ph.D., Yale University, 1932; National Research Fellow, California Institute of Technology and University of Copenhagen, 1932-1934; C.R.B. Fellow, 1934-1935; Instructor in Physics, University of Rochester, 1935-1940; California Institute, 1940-

1047 South Rosemead Boulevard, Rosemead

ARTHUR N. PRATER, PH.D.

Hawaiian Pineapple Producers Cooperative Association Fellow in Bio-Organic Chemistry

B.A., University of California at Los Angeles, 1932; M.S., California Institute of Technology, 1933; Ph.D., 1935. Research Assistant, California Institute, 1938-1939; Research Fellow, 1939-

565 South Wilson Avenue

DAVID PRESSMAN, PH.D.

Arthur A. Noyes Fellow in Chemistry

B.S., California Institute of Technology, 1937; M.A., University of California at Los Angeles, 1938; Ph.D., California Institute, 1940. California Institute, 1940-

4743 1/2 Baltimore Avenue, Los Angeles

JOHN R. RAPER, PH.D.

National Research Fellow in Botany

A.B., University of North Carolina, 1933; M.A., University of North Carolina, 1936; M.A., Harvard University, 1939; Ph.D., Harvard University, 1939. California Institute, 1939-

1148 Constance Street

THOR RUBIN, PH.D.*Arthur A. Noyes Fellow in Chemistry*

B.S., Northwestern University, 1933; M.S., 1935; Ph.D., University of California, 1940. California Institute, 1940-

1148 Constance Street

E. L. ROBERT STOKSTAD, PH.D.*Lalor Fellow in Biochemistry*

B.S., University of California, 1934; Ph.D., 1937. Biochemist, Western Condensing Company, 1937-1939; Biochemist, Golden State Company, 1939-1940. California Institute, 1940-

155 South Greenwood Avenue

ARTHUR GEORGE RENE STRICKLAND*Hawaiian Pineapple Producers Cooperative Association
Fellow in Bio-Organic Chemistry*

Bach. Es. Sci., Lausanne, 1904; Dipl. Ing., Eidgen. Politechnikum, Zürich, 1908. Ph.D., Stanford University, 1939. Research Assistant in Biology, Stanford University, 1935-1939; Research Associate, 1939-. California Institute, 1939-

664 South Oak Knoll Avenue

CARL L. THIELE, M.S.*Research Fellow in Aeronautics*

B.S., California Institute of Technology, 1932; M.S., 1933. Research Assistant, California Institute, 1938-

423 South Chester Avenue

RALPH L. TRACY, PH.D.*Research Fellow in Bio-Physics¹*

A.B., Stanford University, 1930; M.A., University of California, 1932; Ph.D., University of Southern California Medical School, 1937. Research Assistant, California Institute, 1938-1939. Research Fellow, Rare Metals Institute, 1939-

258 South Hudson Avenue

HSUE-SHEN TSIEH, PH.D.*Research Fellow in Aeronautics*

B.S., in M.E., Chiao-Tung University, 1934; M.S. in A.E., Massachusetts Institute of Technology, 1936; Ph.D., California Institute of Technology, 1939. California Institute, 1936-

281 South Chester Avenue

VITO AUGUST VANONI, PH.D.*Research Fellow in Hydraulics²*

B.S., California Institute of Technology, 1926; M.S., 1932; Ph.D., 1940. California Institute, 1932-. Project Manager, Cooperative Laboratory, Soil Conservation Service, 1935-

386 South Meridith Avenue

¹Rare Metals Research Fund.

²Soil Conservation Service, Department of Agriculture.

RICHARD ERNEST VOLLRATH, PH.D.*Research Fellow in Astrophysics*

B.A., Johns Hopkins University, 1926; Ph.D., 1929. National Research Fellow in Physics, California Institute of Technology, 1929-1931; Research Professor of Physics, University of Southern California, 1931-. California Institute, 1938-

1818 Mission Street, South Pasadena

HAROLD WAYLAND, PH.D.*Research Fellow in Physics*

B.S., University of Idaho, 1931; M.S., California Institute of Technology, 1935; Ph.D., 1937. Teaching Fellow, California Institute, 1931-1934; Instructor, University of Idaho, 1934-1935; American-Scandinavian Foundation Fellow, University of Copenhagen, 1936-1937; Assistant Professor of Physics, University of Redlands, 1938-. Research Assistant, California Institute, 1938-1939; Research Fellow, 1939-

937 College Avenue, Redlands

SIDNEY WEINBAUM, PH.D.*Research Fellow in Chemistry*

B.S., California Institute of Technology, 1924; Ph.D., 1933. California Institute, 1929-

1136 Steuben Street

J. PAUL YOUTZ, M.S.*Research Fellow in Physics*

B.S., California Institute of Technology, 1917; M.S. in E.E., Union College, 1918; Specialist Course, General Electric Company, 1917-1919. With General Electric Company in Latin America, 1919-1932. California Institute, 1932-

1477 North Holliston Avenue

REUBEN ESSELSTYN WOOD, PH.D.*Research Fellow in Chemistry*

B.S., California Institute of Technology, 1936; M.S., University of Chicago, 1937; Ph.D., California Institute of Technology, 1939. California Institute, 1939-

338 Highland Place, Monrovia

LUKE CHIA-LIU YUAN, PH.D.*Research Fellow in Physics*

B.S., Yenching University, 1932; M.S., 1934; International House Fellow, University of California, 1936-1937; Ph.D., California Institute, 1940.

344 South Catalina Avenue

LLOYD ZUMWALT, PH.D.*Arthur A. Noyes Fellow in Chemistry*

B.S., University of California, 1936; Ph.D., California Institute of Technology, 1939. California Institute, 1939-

115 North El Molino Avenue

RESEARCH ASSISTANTS

NORMAN ABRAHAMSEN

Research Assistant in Chemistry

B.S., North Dakota State College, 1933; M.S., State University of Iowa, 1937; Ph.D., 1939.
California Institute, 1940-

940 East Del Mar Street

HUGH STEVENS BELL, A.B.

Research Assistant in Hydraulics¹

A.B., Western Reserve University, 1922. With U. S. Indian Service, 1932-1935; in charge of Co-operative Field Laboratory, Soil Conservation Service, Mexican Springs, New Mexico, 1935-1937.
California Institute, 1936-

1050 North Holliston Avenue

DAVID MAHLON BONNER, PH.D.

Research Assistant in Biology

B.A., University of Utah, 1936; Ph.D., California Institute of Technology, 1940. California
Institute, 1940-

290 South Michigan Avenue

WILLIAM HAROLD BOWEN, M.S.

Research Assistant in Aeronautics

B.S., University of California, 1928; M.S., California Institute of Technology, 1932; M.S., in
Aero., 1938. California Institute, 1932-

2067 Paloma Street

DAVID S. BRESLOW, PH.D.

Research Assistant in Chemistry

B.S., College of the City of New York, 1937; Ph.D., Duke University, 1940. California Institute,
1940-

404 South Lake Avenue

SAMUEL J. BROADWELL, PH.D.

Research Assistant in Physics

B.S., California Institute of Technology, 1918; M.S., University of Chicago, 1920; Ph.D., Cali-
fornia Institute of Technology, 1935. California Institute, 1937-

322 East Emerson Avenue, Monterey Park

JOHN M. CHERMERDA

Research Assistant in Chemistry

B.S., Pennsylvania State College, 1935; M.S., University of Michigan, 1937; Ph.D., 1939; Anna
Pease Fuller Post-Doctoral Fellow, 1939-1940. California Institute, 1940-

615 South El Molino Avenue

JACOB DUBNOFF, M.A.

Research Assistant in Biology

B.A., University of California at Los Angeles, 1930; M.A., University of California, 1933. Soil
Chemist, Department of Agriculture, 1933; Research Biochemist, University of Kazan,
U.S.S.R., 1934-1936. California Institute, 1936-

1865 Bridgen Road

¹Soil Conservation Service, Department of Agriculture.

EMORY L. ELLIS, PH.D.*Research Assistant in Biology*

B.S., California Institute of Technology, 1930; M.S., 1932. Ph.D., 1934. Research Assistant, California Institute of Technology, 1934-1935; Chemist, Food and Drug Administration, 1935-1936. California Institute, 1936-

432 North San Marino Avenue, San Gabriel

EDWARD SEYMOUR FORMAN*Research Assistant in Aeronautics*

Repair and Maintenance, United Aviation and Parachute Service, 1934-1936; Plant Maintenance Engineer, Halifax Explosives Company, 1936-1937; in charge of Skin Department, Lockheed Aircraft Corporation, 1937-1938. California Institute, 1939-

303 North Hill Avenue

EUSTACE L. FURLONG*Curator in Vertebrate Paleontology*

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

270 South Roosevelt Avenue

FRANKLIN S. HARRIS, JR.*Research Assistant in Physics¹*

B.A., Brigham Young University, 1931; M.A., 1936; Graduate Assistant, California Institute of Technology, 1937-1938; Research Assistant, Rare Metals Institute, 1938-

660 Bellefontaine Street

ERIK HEEGAARD, B.S.*Research Assistant in Chemistry*

B.S., Danmarks Tekniske Hoeskole, Copenhagen, 1936; M.S., California Institute of Technology 1940. Research Chemist, Danmarks Tekniske Hoeskole, 1937. California Institute, 1938-

290 South Michigan Avenue

GEOFFREY KEIGHLEY, M.S.*Research Assistant in Biology*

B.A., University of Toronto, 1926; M.S., California Institute of Technology, 1940. California Institute, 1930-

237 West Las Flores Drive, Altadena

HENRY LANZ, JR., A.B.*Research Assistant in Microanalysis*

A.B., Stanford University, 1936. Research Fellow, Carlsberg Laboratory, Copenhagen, 1936-1938; Medizinische-Chemisches Institut der Universität, Graz, Austria, 1938; Research Assistant, Stanford University, 1938-1939. California Institute, 1939-

1799 Rose Villa Street

ARTHUR L. LE ROSEN, PH.D.*Research Assistant in Chemistry*

B.S., Centenary College, 1934; M.S., State University of Iowa, 1938; Ph.D., 1940. California Institute, 1940-

Dormitory

¹Rare Metals Research Fund.

CHARLES EMERSON MILLER, E.E.*Research Assistant in Physics*

A.B., Stanford University, 1922; E.E., 1923. Engineer, Western Company, 1923-1930. Radio Engineer, Keller-Fuller Mfg. Company, 1930-1934; Western Company, 1935-1937. Geo-Freuenta Company, 1938-1939; California Institute, 1939-

6450 Olympic Boulevard, Los Angeles

BROOKS T. MORRIS, C.E.*Research Assistant in Hydraulics*¹

A.B., Stanford University, 1934; C.E., 1938. Research Assistant, California Institute, 1938-

2059 Navarro Avenue

ROBERT H. OLDS, M.S.*Research Assistant in Chemical Engineering*

B.S., California Institute of Technology, 1938; M.S., 1939. California Institute, 1940-

4073 West Washington Boulevard, Los Angeles

J. PAT O'NEILL, B.S.*Research Assistant in Hydraulics*¹

B.S., New Mexico State College, 1935. California Institute, 1935-

436 North Holliston Avenue

JOHN WHITESIDE PARSONS*Research Assistant in Aeronautics*

Chief Chemist, Halifax Explosives Company, 1935-1938; Explosives Expert, Los Angeles District Attorney's Office, 1938-1939. California Institute, 1939-

168 Terrace Drive

ANDOR POLGÁR, PH.D.*Research Assistant in Chemistry*

Diploma of Junior College Teacher (Chemistry, Physics), University of Budapest and Pécs, Hungary, 1937; Ph.D., University of Pécs, 1939. Teaching and Research Assistant, Chemical Institute, University of Pécs, 1938-1940. California Institute, 1940-

Dormitory

WILLIS PARKISON POPENOE, PH.D.*Curator in Invertebrate Paleontology*

B.S., George Washington University, 1930; M.S., California Institute of Technology, 1933; Ph.D., 1936. Geologist, Far East Oil Development Company, Manila, P. I., 1937; Senior Petroleum Geologist, National Development Company, Manila, 1939-1940. California Institute, 1930-

446 South Hudson Avenue

H. HOLLIS REAMER, M.S.²*Research Assistant in Chemical Engineering*

A.B., University of Redlands, 1937; M.S., California Institute of Technology, 1938.

294 South Wilson Avenue

¹Soil Conservation Service, Department of Agriculture.

²American Petroleum Institute Fellow.

ALF REIMS, CH.E.*Research Assistant in Chemistry*

Ch.E., Abo Akademi, Finland, 1937. Assistant in Chemistry, Abo Akademi, 1937. California Institute, 1938-

1485 East California Street

ROBERT A. RUEHRWEIN, PH.D.*Research Assistant in Biology*

A.B., University of Montana, 1936; Ph.D., University of California, 1939. California Institute, 1939-

1485 East California Street

PETER V. H. SERRELL, M.S.*Research Assistant in Aeronautics*

B.S., California Institute of Technology, 1936; M.S., 1939. California Institute, 1938-

2231 Loma Vista Street

EDWARD E. SIMMONS, JR., M.S.*Research Assistant in Mechanical Engineering¹*

B.S., California Institute of Technology, 1934; M.S., 1936. Research Assistant, California Institute, 1936-

455 South Oakland Avenue

DAVID P. WILLOUGHBY*Scientific Illustrator in Vertebrate Paleontology*

Medical Artist and Illustrator in Vertebrate Paleontology, 1929-1936; Scientific Artist, Federal Art Project, Los Angeles County Museum, 1936-1937. California Institute, 1938-

2155 South Beverly Glen Boulevard, West Los Angeles

FLOYD L. HANES, D.O.*Physical Trainer*

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

2115 Layton Avenue

LEON V. METCALF, M. MUS.*Director of Orchestra and Glee Club; Assistant Director of Institute Band*

Graduate of Music, University of Wisconsin, 1925; B. Mus. Ed., Northwestern University, 1928; M. Mus. (composition), University of Michigan, 1934. Instructor of Music, Grand Rapids Public Schools, 1925-1927; Gary Public Schools, 1928-1930; Director of Instrumental Music, Hartland Area Project (Michigan), 1930-1937; Instructor, Northwestern University, summers of 1928 and 1929; Instructor, National Music Camp, Interlochen, Michigan, summer, 1930; Professor, University of Montana, summers of 1936 and 1937. Director of Orchestra and Glee Club, Assistant Director of Band, California Institute, 1938-

395 South Carmelo Avenue

AUDRE L. STONG, M.S.*Director of Institute Band*

B.S., University of Southern California, 1932; M.S., 1934. California Institute, 1931-

2051 Jefferson Drive

¹Impact Research Fund.

TEACHING FELLOWS AND GRADUATE ASSISTANTS

NORMAN ZINKAN ALCOCK	Electrical Engineering
B.Sc., Queens University, 1940	
SHERWIN PARKER AVANN	Mathematics
B.S., University of Washington, 1938; M.S., California Institute, 1940	
ROBERT ADOLPH BECKER	Physics
B.S., College of Puget Sound, 1935; M.S., California Institute, 1937	
RICHARD W. BELL	Aeronautics
B.A., Oberlin College, 1939	
ANDREW ALM BENSON	Chemistry
B.S., University of California, 1939	
CHARLES LITTLE BLAKE	Aeronautics
B.S., Louisiana State University, 1940	
LEON BLITZER	Physics
B.S., University of Arizona, 1938; M.S., 1939	
DAVID JOSEPH BOHM	Physics
B.S., Pennsylvania State College, 1939	
JAMES HUGH BRADNER	Physics
A.B., Miami University, 1936	
ROBERT CLARENCE BRUMFIELD	Mechanical Engineering
B.S., California Institute, 1940	
DONALD CHARLES BRUNTON	Physics
B.S., Queen's University, 1940	
RICHARD JOHN BURLEIGH	Mechanical Engineering
B.S., University of California, 1940	
CHIEH-CHIEN CHANG	Aeronautics
B.A., National Northeastern University, 1932	
WAYNE GILLESPIE CHRISTIAN	Geology
B.S., West Texas State College, 1939	
ARTHUR STANFORD CHURCH	Aeronautics
B.A.E., University of Minnesota, 1940	
CHARLES LEWIS COBB	Civil Engineering
B.S., University of Notre Dame, 1940	
ROBERT ALONZO COOLEY	Chemistry
B.S., University of California, 1938	
STANLEY CORRSIN	Aeronautics
B.S., University of Pennsylvania, 1940	
JAMES VAILE CRAWFORD	Mechanical Engineering
B.S., California Institute, 1940	
H. DONALD CURRY	Geology
B.A., State University of Iowa, 1929; M.A., 1930	

- JOHN ELDRIDGE CUSHING, JR. Biology
A.B., University of California, 1938
- WALTER BEACH DANDLIKER Biology
B.S., Rollins College, 1940
- PETER DEHLINGER Geology
B.S., University of Michigan, 1940
- BARRY DIBBLE, JR. Physics
B.S., California Institute, 1939
- DARRELL DIETER Meteorology
B.S., State College of Washington, 1939; M.S., 1940
- JOHN ANDREW DILWORTH, III Aeronautics
B.S., Louisiana State University, 1939; B.S. in AE, California Institute, 1940
- ROBERT HENRY DOURSON Chemical Engineering
B.S., California Institute, 1935; B.S. in ChE, 1940; Resident Associate of Fleming House
- ROBERT HOWARD EHRKE Meteorology
B.S., Agriculture and Mechanical College of Texas, 1939
- CHARLES HERBERT ELLIS Biology
A.B., Whittier College, 1934; M.S., 1937
- HERBERT BAILEY ELLIS Mechanical Engineering
B.S., California Institute, 1938
- RICHARD BYRD ESCUE, JR. Chemistry
B.A., North Texas State Teachers College, 1939; M.A., 1940
- JOHN C. EVVARD Physics
B.S., California Institute, 1939; M.S., 1940
- GEORGE EDWARD FEIKER, JR. Electrical Engineering
B.S., Worcester Polytechnic Institute, 1939; M.S., Harvard University, 1940
- ANDREW FEJER Aeronautics
M.E., Technische Hochschule at Prague, 1936; B.S., in AE, California Institute, 1939
- WALTER EDWIN FELLERS Aeronautics
B.A., College of the Pacific, 1940
- LOUIS ALBERT FOURT Biology
A.B., University of Missouri, 1939; M.A., 1940
- JOSEPH LOUIS FREDRICK Aeronautics
B.S., Louisiana State University, 1938; B.S. in AE, California Institute, 1939; M.S. in AE, 1940
- WILLARD PERRIN FULLER, JR. Geology
A.B., Harvard College, 1940
- HUGO GABRIEL German
Ph.D., University of Cologne, 1928
- EDWARD ADOLPH GAUGLER Physics
B.S.E., University of Michigan, 1940
- RAY VAN DEUSEN GERHART Chemical Engineering
B.S., California Institute, 1939; B.S. in ChE, 1940

LLOYD TWEDT GOODMANSON	Aeronautics
B.S., California Institute, 1940	
PAUL RAYMOND GORHAM	Biology
B.A., University of New Brunswick, 1938; M.S., University of Maine, 1940	
SIDNEY GOTTLIEB	Biology
B.S., University of Wisconsin, 1940	
CLARK WEBSTER GOULD, JR.	Chemistry
B.S., College of Puget Sound, 1938; M.S., California Institute, 1940	
CHRIS GREGORY	Physics
B.S., California Institute, 1938; M.S., 1939	
LEVAN GRIFFIS	Mechanical Engineering
B.S., California Institute, 1937; M.S., 1938	
ALAN JOHN GROBECKER	Geology
B.S., California Institute, 1937	
JAMES VERN HALES	Meteorology
A.B., Brigham Young University, 1938	
JOHN BURTON HATCHER	Biology
B.S., California Institute, 1937; M.S., 1938	
BYRON LUTHER HAVENS	Electrical Engineering
B.S., University of Washington, 1938; M.S., California Institute, 1939	
JOHN THOMAS HAYS, JR.	Chemistry
B.S., Montana State College, 1935; B.A., Oxford University, 1937; B.Sc., 1938	
HAROLD HENRY HERD	Chemistry
B.A., University of British Columbia, 1934; M.A., 1940	
GEORGE WILLIAM HOUSNER	Civil Engineering
B.S. in CE, and B.S. in Ma, University of Michigan, 1933; M.S. in CE, California Institute, 1934	
WILLIAM HOVANITZ	Biology
B.S., University of California, 1938	
BENJAMIN FRANKLIN HOWELL, JR.	Geology
A.B., Princeton University, 1939	
CHAO-WANG HSUEH	Physics
B.S., National Peking University, 1931; M.S., California Institute, 1939	
DONALD ELLIS HUDSON	Mechanical Engineering
B.S., California Institute, 1938; M.S., 1939	
STANLEY PARLETT HUGHART	Mathematics
B.S., Whitworth College, 1940	
ROBERT CLARKE JAMES	Mathematics
B.A., University of California at Los Angeles, 1940	
WILSON BURDETTE JONES	Civil Engineering
B.S., California Institute, 1938	
JAMES WILLIAM JONGENEEL	Aeronautics
B.S., California Institute, 1940	

LEON KATZ	Physics
B.Sc., Queen's University, 1934; M.Sc., 1937	
MARRITT L. KRONBERG	Chemistry
Johns Hopkins University	
JOHN FRANKLIN LANCE	Geology
B.A., Texas College of Mines and Metallurgy	
ELLIS LAPIN	Aeronautics
B.S., Drexel Institute of Technology, 1939; B.S. in AE, California Institute, 1940	
JOSEPH PIERRE LASALLE	Mathematics
B.S., Louisiana State University, 1937	
JOHN JACOB LENTZ	Electrical Engineering
B.S., California Institute, 1938; M.S., 1939	
EDWARD BUTTS LEWIS, JR.	Biology
B.A., University of Minnesota, 1939	
LLOYD ALAN LEWIS	Geology
E.M., University of Minnesota, 1938	
RICHARD NEWTON LEWIS	Chemistry
A.B., University of California, 1937; B.A., Oxford University, 1938	
DAVID ARTHUR LIND	Physics
B.S., University of Washington, 1940	
FRANK PARKER LOCKARD	Mechanical Engineering
B.S., Northwestern University, 1940	
HARLOWE JULIUS LONGFELDER	Aeronautics
B.S., California Institute, 1939; B.S. in AE, 1940	
PAUL ALAN LONGWELL	Chemical Engineering
B.S., California Institute, 1940	
KLAUS JOACHIM MAMPELL	Biology
B.A., University of Southern California, 1939	
ROY EDWARD MARQUARDT	Aeronautics
B.S., California Institute, 1940	
DON STANLEY MARTIN, JR.	Chemistry
B.S., Purdue University, 1939	
SAMUEL THEODORE MARTNER	Geology
A.B., University of California, 1940	
JULES FREDERICK MAYER	Mechanical Engineering
B.S., California Institute, 1940	
GENE WARNER McDANIEL	Physics
B.Sc., University of Nevada, 1940	
ROBERT CHARLES McMASTER	Electrical Engineering
B.S., Carnegie Institute of Technology, 1936; M.S., California Institute, 1938	
WILLIAM HAROLD McNEELY	Chemistry
B.S., University of California, 1940	

JAMES FRANKLYN MEAD	Chemistry
A.B., Princeton University, 1938	
CHARLES BAKER METZ	Biology
A.B., Johns Hopkins University, 1939	
HAROLD SOMERS MICKLEY	German
B.S., California Institute, 1940	
MARK MUIR MILLS	Physics
B.S., California Institute, 1940	
HENRY TAKESHI NAGAMATSU	Aeronautics
B.S., California Institute, 1938; B.S. in AE, 1939; M.S. in AE, 1940	
WILLIAM FRANCIS NASH, JR.	Mechanical Engineering
B.S., California Institute, 1938; M.S., 1939	
CLINTON TOMS NEWBY	Aeronautics
B.S., California Institute, 1940	
PETER L. NICHOLS, JR.	Chemistry
B.A., Texas Christian University, 1938	
EDWARD NOVITSKI	Biology
B.S., Purdue University, 1938	
RICHARD MACY NOYES	Chemistry
A.B., Harvard College, 1939	
GUY CLIFTON OMER, JR.	Physics
B.S., University of Kansas, 1936; M.S., 1937	
JOHN WILLIAM OTVOS	Chemistry
S.B., Harvard College, 1939	
WOLFGANG KURT HERMANN PANOFSKY	Physics
A.B., Princeton University, 1938	
EDMUND JOY PINNEY	Mathematics
B.S., California Institute, 1939	
WILLIAM DUNCAN RANNIE	Aeronautics
B.A., University of Toronto, 1936; M.A., 1937	
ROBERT SEVERIN RASMUSSEN	Chemistry
S.B., University of Chicago, 1938	
LOUIS JOHN REGAN, JR.	Geology
B.S., California Institute, 1939	
KING ARTHUR RICHEY	Geology
B.A., State University of Iowa, 1933; M.A., University of California, 1939	
MAX TOFIELD ROGERS	Chemistry
B.Sc., University of Alberta, 1937; M.Sc., 1938	
BERTRAM VICTOR ROUDEBUSH	Chemical Engineering
B.S., California Institute, 1939; B.S. in ChE, 1940	
SYLVAN RUBIN	Physics
B.S., California Institute, 1939	

GEORGE THOMAS RUDKIN	Biology
B.S., California Institute, 1938; A.M., Stanford University, 1939	
ROBERT EUGENE RUNDLE	Chemistry
B.Sc., University of Nebraska, 1937; M.Sc., 1938	
HORACE RUSSELL, JR.	Chemistry
B.S., Duke University, 1938	
HERBERT SARGENT, JR.	Chemistry
B.S., California Institute, 1940	
PAUL ROME SAUNDERS	Biology
B.S., University of California, 1939	
MAURICE JAY SCHLATTER	Chemistry
B.S., California Institute, 1938	
WALTER ADOLPH SCHROEDER	Chemistry
B.S., University of Nebraska, 1939; M.S., 1940	
CHARLES WILLIAM SEEKINS	Mathematics
A.B., Occidental College, 1938	
PHILIP ANDERSON SHAFFER, JR.	Chemistry
S.B., Harvard College, 1937	
WILLIAM J. SHAND, JR.	Chemistry
A.B., Princeton University, 1940	
EDWARD ELMER SHELTON	Electrical Engineering
B.S., University of Washington, 1939	
RICHARD SHEPHERD SHEVELL	Aeronautics
B.A., Columbia College, 1940	
ALFRED LEON SLATER	Aeronautics
B.S., California Institute, 1935	
ALEXANDER SMITH	Geology
B.A., University of British Columbia, 1932; M.A., 1933	
JOSIAH EDWARD SMITH	Aeronautics
B.S., California Institute, 1939; B.S. in AE, 1940	
STANLEY COOPER SNOWDON	Physics
B.S., Massachusetts Institute of Technology, 1940	
RALPH WILLIAM SPITZER	Chemistry
A.B., Cornell University, 1938	
JOHN SPIZIZEN	Biology
B.A., University of Toronto, 1939	
ROBERT ANTON SPURR	Chemistry
A.B., Rollins College, 1936; B.S., 1937	
WILLIAM BRUCE STEPHENSON	Aeronautics
B.S., Louisiana State University, 1940	
HORTON GUYTORD STEVER	Physics
B.A., Colgate University, 1938	

WILLIAM THOMAS STEWART	Chemistry
B.S., University of Arizona, 1937; M.S., 1938	
HARRISON ALLEN STORMS, JR.	Aeronautics
B.S., Northwestern University, 1938; M.S., 1939; B.S. in AE, California Institute, 1940	
JOHN FREDRICK STREIB	Physics
B.S., California Institute, 1936	
JONATHAN DEAN SWIFT	Mathematics
B.S., University of California, 1939	
STANLEY MORSE SWINGLE	Chemistry
B.S., Montana State College, 1939	
YUJI ALEXIS TAJIMA	Biology
B.S., California Institute, 1940	
JACOB EARL THOMAS, JR.	Physics
A.B., Johns Hopkins University, 1939	
GEORGE JUDSON TODD	Mechanical Engineering
B.S., California Institute, 1940	
EVERETT PARSONS TOMLINSON	Physics
B.S., Yale University, 1936	
WALTER MASSEY TOVELL	Geology
B.A., University of Toronto, 1940	
CHARLES DANIEL WAGNER	Chemistry
A.B., Grinnell College, 1939	
AUSTIN LEVY WAHRHAFTIG	Chemistry
A.B., University of California, 1938	
LEROY GRAM WAIGAND	Civil Engineering
B.C.E., Ohio State University, 1940	
ROBERT EARL WALLACE	Geology
B.S., Northwestern University, 1938; M.S., California Institute, 1940	
DON LOMBARD WALTER	Aeronautics
B.S., California Institute, 1940	
JURG HEINRICH ERNST WASER	Chemistry
Federal Certificate of Maturity, University of Zurich, 1935	
ROBERT H. WEIGHT	Civil Engineering
B.S., Utah State Agricultural College, 1940	
WILLIAM OWEN WETMORE	Mechanical Engineering
B.S., California Institute, 1937; M.S., 1939	
DONALD BINGHAM WHEELER, JR.	Physics
B.S., Lehigh University, 1938	
EDGAR PURELL WILLIAMS	Aeronautics
B.A., Oberlin College, 1940	
HARRY DAVID BRUCE WILSON	Geology
B.Sc., University of Manitoba, 1936; M.S., California Institute, 1939	

- CHARLES HAROLD WILTS Electrical Engineering
B.S., California Institute, 1940
- JOHN ROBERT WOOLSON Mathematics
Ph.B., Gonzaga University, 1936; B.S., California Institute, 1938
- WILLIS GEORGE WORCESTER Electrical Engineering
B.S., University of Colorado, 1939; M.S., California Institute, 1940
- VICTOR WOUK Electrical Engineering
B.A., Columbia University, 1939; M.S., California Institute, 1940
- RUSSELL RAYMOND YOST, JR. Physics
B.S., Haverford College, 1939
- ABE MORDECAI ZAREM Electrical Engineering
B.S., Armour Institute of Technology, 1939; M.S., California Institute, 1940

VISITORS FROM OTHER INSTITUTIONS FOR THE ACADEMIC YEAR 1940-1941

ERNEST BUREAU, E.E., Professor of Electrical Engineering, University of Kentucky
WILLIAM WEST, Ph.D., Assistant Professor of Chemistry, New York University.

STAFF OF INSTRUCTION AND RESEARCH

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ERIC T. BELL	Mathematics
IRA S. BOWEN	Physics
PAUL S. EPSTEIN	Theoretical Physics
WILLIAM V. HOUSTON	Physics
CHARLES C. LAURITSEN *	Physics
ARISTOTLE D. MICHAL	Mathematics
ROBERT A. MILLIKAN	Physics
SEELEY G. MUDD	X-Ray Therapy
J. ROBERT OPPENHEIMER	Theoretical Physics
WILLIAM R. SMYTHE	Physics
ROYAL W. SORESENSEN	Electrical Engineering
RICHARD C. TOLMAN *	Physical Chemistry, Mathematical Physics
HARRY C. VAN BUSKIRK	Mathematics
MORGAN WARD	Mathematics
EARNEST C. WATSON	Physics

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DINSMORE ALTER	Statistics
SAMUEL J. BARNETT	Physics

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ALEXANDER GOETZ	Physics
FREDERICK C. LINDVALL	Electrical and Mechanical Engineering
S. STUART MACKEOWN *	Electrical Engineering
H. VICTOR NEHER	Physics
GENNADY W. POTAPENKO	Physics
LUTHER E. WEAR	Mathematics
FRITZ ZWICKY	Theoretical Physics

ASSISTANT PROFESSORS

WILLIAM N. BIRCHBY	Mathematics
WILLIAM A. FOWLER*	Physics
FRANCIS W. MAXSTADT	Electrical Engineering
WILLIAM H. PICKERING	Electrical Engineering
JOHN STRONG	Physics

*On leave of absence, 1940-41.

RESEARCH FELLOWS IN PHYSICS

VERNE L. BOLLMAN	PAUL EUGENE LLOYD
L. REED BRANTLEY	SETH H. NEDDERMEYER
LEVERETT DAVIS, JR. ⁴	MILTON S. PLESSET
ALEXIS A. B. DEMBER ¹	RALPH L. TRACY ¹
HARRY A. KIRKPATRICK	HAROLD WAYLAND
SPIRO KYROPOULOS ¹	J. PAUL YOUTZ
RUDOLPH M. LANGER	LUKE C. L. YUAN

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SHERWIN P. AVANN	MARK M. MILLS
ROBERT A. BECKER	GUY C. OMER
LEON BLITZER	WOLFGANG K. PANOFSKY ³
DAVID J. BOHM ²	EDMUND J. PINNEY
J. HUGH BRADNER ²	SYLVAN RUBIN
DONALD C. BRUNTON ²	CHARLES W. SEEKINS
BARRY DIBBLE, JR. ²	EDWARD E. SHELTON ²
JOHN EVVARD	STANLEY C. SNOWDON
GEORGE E. FEIKER, JR. ²	HORTON G. STEVER
EDWARD A. GAUGLER	JOHN F. STREIB ²
CHRIS GREGORY	J. DEAN SWIFT ³
BYRON L. HAVENS ²	J. EARL THOMAS, JR.
CHAO-WANG HSUEH	EVERETT P. TOMLINSON ²
STANLEY P. HUGHART	DONALD B. WHEELER ³
ROBERT C. JAMES	CHARLES H. WILTS
LEON KATZ	JOHN R. WOOLSON
JOSEPH P. LASALLE ³	WILLIS G. WORCESTER
JOHN J. LENTZ	VICTOR WOUK
DAVID A. LIND ³	RUSSELL R. YOST
GENE W. McDANIEL	ABE M. ZAREM

RESEARCH ASSISTANTS IN PHYSICS

SAMUEL J. BROADWELL
FRANKLIN S. HARRIS, JR.¹
CHARLES E. MILLER

¹Rare Metals Research Fund.

²Caroline W. Dobbins Fellow.

³Henry Laws Fellow.

⁴Hixon Fund Fellow.

DIVISION OF CHEMISTRY AND CHEMICAL ENGINEERING

LINUS PAULING, *Chairman*

PROFESSORS

STUART J. BATES	Physical Chemistry
JAMES E. BELL	Chemistry
ROSCOE G. DICKINSON	Physical Chemistry
WILLIAM N. LACEY	Chemical Engineering
HOWARD J. LUCAS	Organic Chemistry
LINUS PAULING	Chemistry
RICHARD C. TOLMAN *	Physical Chemistry, Mathematical Physics
LÁSZLÓ ZECHMEISTER	Organic Chemistry

ASSOCIATE PROFESSORS

RICHARD M. BADGER	Chemistry
BRUCE H. SAGE	Chemical Engineering
ERNEST H. SWIFT	Analytical Chemistry
DON M. YOST	Inorganic Chemistry

RESEARCH ASSOCIATES

EDWIN R. BUCHMAN	Organic Chemistry
JOSEPH B. KOEPFLI	Chemistry

ASSISTANT PROFESSORS

CARL G. NIEMANN	Organic Chemistry
JAMES H. STURDIVANT	Chemistry

SENIOR FELLOWS IN RESEARCH

ROBERT B. COREY	Structural Chemistry
VERNER SCHOMAKER	Chemistry

INSTRUCTORS

ARTHUR J. STOSICK	Chemistry
J. NORTON WILSON	Applied Chemistry

NATIONAL RESEARCH FELLOWS

RICHARD W. DODSON	Chemistry
WALTER J. MOORE, JR.	Chemistry

GEORGE ELLERY HALE FELLOW

EUGENE H. EYSTER

ARTHUR A. NOYES FELLOWS

EDWARD W. HUGHES
CHIA-SI LUDAVID PRESSMAN
THOR RUBIN

LLOYD ZUMWALT

*On leave of absence, 1940-41.

DIVISION OF CIVIL AND MECHANICAL ENGINEERING, AERONAUTICS, AND METEOROLOGY

FRANKLIN THOMAS, *Chairman*

PROFESSORS

HARRY BATEMAN	Mathematics, Theoretical Physics, Aeronautics
W. HOWARD CLAPP	Mechanism and Machine Design
ROBERT L. DAUGHERTY	Mechanical and Hydraulic Engineering
FREDERIC W. HINRICH, JR.	Mechanics
THEODORE VON KÁRMÁN	Aeronautics
R. R. MARTEL	Structural Engineering
CLARK B. MILLIKAN	Aeronautics
FRANKLIN THOMAS	Civil Engineering

ASSOCIATE PROFESSORS

FRED J. CONVERSE	Civil Engineering
ARTHUR L. KLEIN	Aeronautics
ROBERT T. KNAPP	Hydraulic Engineering
IRVING P. KRICK	Meteorology
FREDERICK C. LINDVALL	Electrical and Mechanical Engineering
WILLIAM W. MICHAEL	Civil Engineering
ERNEST E. SECHLER	Airplane Structures

RESEARCH ASSOCIATE

MAURICE A. BIOT	Aeronautics
---------------------------	-------------

ASSISTANT PROFESSORS

A. PERRY BANTA	Sanitary Engineering
DONALD S. CLARK	Mechanical Engineering
ALBERT E. LOMBARD, JR. *	Aeronautics and Mechanical Engineering
WILLIAM R. SEARS	Aeronautics
HOWELL N. TYSON	Mechanical Engineering and Engineering Drawing

INSTRUCTORS

JAMES W. DAILY	Mechanical Engineering
LOUIS G. DUNN	Aeronautical Engineering
ROBERT D. ELLIOTT	Meteorology
CHARLES F. FISCHER	Aeronautics
RAY H. ODELL	Meteorology
WILLIAM H. REMPEL	Meteorology
PAUL E. RUCH	Synoptic Meteorology
HOMER J. STEWART	Dynamic Meteorology and Aeronautics
NEWTON C. STONE	Meteorology
NATHANIEL W. WILCOX	Engineering Drawing

*On leave of absence, 1940-41.

RESEARCH FELLOWS

WALTER M. ELSASSER ¹	Meteorology
HANS W. LIEPMANN	Aeronautics
FRANK J. MALINA	Aeronautics and Soil Conservation
MARTIN SUMMERFIELD	Aeronautics and Soil Conservation
CARL THIELE	Aeronautics
HSUE-SHEN TSIEH ²	Aeronautics
VITO A. VANONI ³	Hydraulics

RESEARCH ASSISTANTS

HUGH S. BELL ³	Hydraulics
WILLIAM H. BOWEN	Aeronautics
EDWARD S. FORMAN	Aeronautics
BROOKS T. MORRIS ³	Hydraulics
J. PAT O'NEILL ³	Hydraulics
JOHN W. PARSONS	Aeronautics
PETER V. H. SERRELL	Aeronautics
EDWARD E. SIMMONS, JR. ⁴	Mechanical Engineering

TEACHING FELLOWS AND ASSISTANTS

RICHARD W. BELL	JAMES W. JONGENEEL
CHARLES L. BLAKE	ELLIS LAPIN
ROBERT C. BRUMFIELD	FRANK P. LOCKARD
RICHARD J. BURLEIGH	HARLOWE J. LONGFELDER
CHIEH CHIEN CHANG	ROY E. MARQUARDT
A. STANFORD CHURCH	JULES F. MAYER
CHARLES L. COBB	CHARLES E. MILLER
STANLEY CORRSIN	HENRY T. NAGAMATSU
JAMES V. CRAWFORD	WILLIAM F. NASH, JR. ⁵
DARRELL DIETER	CLINTON T. NEWBY
JOHN A. DILWORTH	WILLIAM D. RANNIE
ROBERT H. EHRKE	RICHARD S. SHEVELL
HERBERT B. ELLIS	ALFRED L. SLATER
ANDREW FEJER	JOSIAH E. SMITH
WALTER E. FELLERS	WILLIAM B. STEPHENSON
JOSEPH L. FREDRICK	HARRISON A. STORMS
LLOYD GOODMANSON	GEORGE J. TODD ⁵
LEVAN GRIFFIS	LEROY G. WAIGAND
J. VERN HALES	DON L. WALTER
GEORGE W. HOUSNER	ROBERT H. WEIGHT
DONALD E. HUDSON	WILLIAM O. WETMORE
WILSON B. JONES	EDGAR P. WILLIAMS

¹Cooperative Agent, U. S. Weather Bureau.²Civil Aeronautics Authority, Research Fund Fellow.³Soil Conservation Service, Department of Agriculture.⁴Impact Research Fund Fellow.⁵Rare Metals Research Fellow.

DIVISION OF THE GEOLOGICAL SCIENCES

J. P. BUWALDA, *Chairman*

PROFESSORS

JOHN P. BUWALDA	Geology
BENO GUTENBERG	Geophysics
CHESTER STOCK	Paleontology

RESEARCH ASSOCIATES

ROBERT T. MOORE	Vertebrate Zoology
HARRY O. WOOD	Seismology

ASSOCIATE PROFESSORS

HUGO BENIOFF	Seismology
IAN CAMPBELL	Petrology
GENNADY W. POTAPENKO	Geophysics

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HORACE J. FRASER	Metalliferous Geology and Mineralogy
ROBERT M. KLEINPELL	Micropaleontology
JOHN H. MAXSON	Geology
CHARLES F. RICHTER	Seismology

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FRANCIS D. BODE	Geology
RAYMOND A. PETERSON	Geophysics

CURATORS

EUSTACE L. FURLONG	Vertebrate Paleontology
WILLIS P. POPENOE	Invertebrate Paleontology

SCIENTIFIC ILLUSTRATOR

DAVID P. WILLOUGHBY

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PETER DEHLINGER	LOUIS J. REGAN, JR.
WILLARD P. FULLER, JR.	KING A. RICHEY
ALAN J. GROBECKER	ALEXANDER SMITH ³
BENJAMIN F. HOWELL, JR.	WALTER M. TOVELL
JOHN F. LANCE	ROBERT E. WALLACE ³
LLOYD A. LEWIS ¹	H. D. BRUCE WILSON ²

¹Standard Oil Company of California Fellow.²Drake Fellow.³Blacker Fellow.

DIVISION OF BIOLOGY

THOMAS HUNT MORGAN, *Chairman*

PROFESSORS

HENRY BORSOOK	Biochemistry
ARIE JAN HAAGEN-SMIT	Biology
THOMAS HUNT MORGAN	Biology
ALFRED H. STURTEVANT	Genetics
FRITS W. WENT	Plant Physiology

RESEARCH ASSOCIATES

GORDON ALLES	Biology
JACK SCHULTZ	Biology

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ERNEST G. ANDERSON	Genetics
STERLING EMERSON	Genetics
CORNELIS A. G. WIERSMA	Physiology

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JAMES F. BONNER	Plant Physiology
ROBERT EMERSON	Biophysics
ANTHONIE VAN HARREVELD	Physiology
HUGH M. HUFFMAN	Biochemistry
GEORGE E. MACGINITIE	Biology
JOHANNES VAN OVERBEEK	Plant Physiology
ALBERT TYLER	Embryology

NATIONAL RESEARCH FELLOW

JOHN R. RAPER

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NORMAN H. HOROWITZ	ARTHUR N. PRATER ¹
JUSTUS G. KIRCHNER ¹	ARTHUR G. R. STRICKLAND

LALOR FELLOW

E. L. ROBERT STOKSTAD

RESEARCH ASSISTANTS

DAVID M. BONNER	EMORY L. ELLIS
JACOB DUBNOFF	GEOFFREY KEIGHLEY
ROBERT A. RUEHRWEIN	

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JOHN E. CUSHING	EDWARD B. LEWIS, JR.
WALTER B. DANGLIKER	KLAUS J. MAMPELL
CHARLES H. ELLIS	CHARLES B. METZ
LOUIS A. FOURT	EDWARD NOVITSKI
PAUL R. GORHAM	GEORGE T. RUDKIN
SIDNEY GOTTLIEB	PAUL R. SAUNDERS
JOHN B. HATCHER	JOHN SPIZIZEN
WILLIAM HOVANITZ	YUJI A. TAJIMA

¹Hawaiian Pineapple Producers Cooperative Association Fellow.

DIVISION OF THE HUMANITIES

CLINTON K. JUDY, *Chairman*

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GRAHAM A. LAING	Economics and Business Administration
JOHN R. MACARTHUR	Languages
WILLIAM B. MUNRO	History and Government
THEODORE G. SOARES	Ethics

VISITING PROFESSOR

ALFRED NOYES	English Literature
------------------------	--------------------

VISITING LECTURERS

RALPH BARTON PERRY	Philosophy
EDWARD LEE THORNDIKE	Psychology

ASSOCIATES

GODFREY DAVIES	History
EDWIN F. GAY	Economic History
WILLIAM HALLER	English Literature
EDWARD A. WHITNEY	English
LOUIS B. WRIGHT	English Literature

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HARVEY EAGLESON	English Language and Literature
PHILIP S. FOGG	Business Economics
HORACE N. GILBERT ¹	Business Economics
ROBERT D. GRAY	Economics and Industrial Relations
WILLIAM HUSE	English Language and Literature
GEORGE R. MACMINN	English Language and Literature
J. E. WALLACE STERLING	History
RAY E. UNTEREINER	Economics and History

LECTURERS

VLASTIMIL KYBAL	History and Economics
ROBERT ROSS	Psychology
ARCHIBALD B. YOUNG	Business Law
ARTHUR H. YOUNG	Industrial Relations

ASSISTANT PROFESSORS

HARDIN CRAIG, JR.	History
L. WINCHESTER JONES	English Language and Literature
ROGER STANTON	English Language and Literature

INSTRUCTORS

WILLIAM H. PICKERING	History
KERMIT ROOSEVELT, JR.	History
EDWARD M. WALES	Accounting

TEACHING FELLOWS AND GRADUATE ASSISTANTS

HUGO GABRIEL	German
ALAN J. GROBECKER	English
HAROLD S. MICKLEY	German

¹On leave of absence, 1940-41.

DIVISION OF PHYSICAL EDUCATION

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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 the late Mr. Arthur H. Fleming, of Pasadena, President of the Board of Trustees of the Institute 1918-1932.

Ricketts House.

The gift of the late Dr. L. D. Ricketts and Mrs. 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 LIFE

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 buildings are so planned that within each of the four houses there are groupings of rooms for from twelve to twenty students, with a separate entry and toilet and kitchenette facilities for each.

The completion of this group of four residence halls marks the initial step in a plan to meet the housing and living problems of undergraduate students. The plan calls eventually for 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." Each of the four present houses has its own elected officers; each is autonomous in the matter of allotting rooms to residents, arranging dances and other social events, preserving its own traditions, and promoting the general welfare of the house.

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, newly entering students are advised to file room

applications immediately upon being notified by the Registrar of admission to the Institute.

Throop Club. The Throop Club is designed to provide for non-resident students the same sort of focus for undergraduate life that the Student Houses provide for resident students. The Throop Club has its own elected officers and committees and carries on a full program of social and other activities. The Throop Club lounge, made possible by the generosity of a group of friends of the Institute, provides a convenient gathering place on the campus and is the center of Throop Club activities. For non-resident students, membership in the Throop Club greatly facilitates participation in undergraduate social life and intramural sports.

Interhouse Activities. The presidents and vice-presidents of the four Student Houses and the Throop Club make up the Interhouse Committee, which determines matters of general policy for all five organizations. While each sponsors independent activities, there is at least one joint dance held each year. The program of intramural sports is also carried on jointly. At present it includes football, softball, cross-country, swimming, water polo, skiing, basketball, and handball.

Associated Student Body. The undergraduate students are organized as the "Associated Students of the California Institute of Technology, Incorporated." All students who pay their student body fees are automatically members of this organization, which deals with affairs of general student concern and with such matters as may be delegated to it 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.

Board of Directors. 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 interprets the By-Laws, makes awards for athletic and extra-curricular activities, authorizes expenditures from the corporation funds, and exercises all other powers in connection with the corporation not otherwise delegated.

Board of Control. The Honor System is the fundamental principle of conduct of all students. More than merely a code applying to conduct in examinations, it extends to all phases of campus life. It is the code of behavior governing all scholastic and extra-curricular activities, all relations among students, and all relations between students and faculty. The Honor System is the outstanding tradition of the student body, which accepts full responsibility for its operation. The Board of Control, which is composed of elected representatives from each of the four undergraduate classes, is charged with interpreting the Honor System. If any violations should occur, the Board of Control considers them and may recommend appropriate disciplinary measures to the faculty.

Faculty-Student Relations. Faculty-student coördination and coöperation with regard to campus affairs is secured through periodic joint meetings of the Faculty Committee on Student Relations, and the Board of Directors and the Board of Control of the Student Body. These conferences serve as a clearing house for suggestions as to policy, organization, etc., originating with either students or faculty.

Athletics. The California Institute maintains a well-rounded program of athletics and is a member of the Southern California Conference, which includes Whittier College, Occidental College, Redlands University, and Pomona College. A full schedule of competition is carried on in football, basketball, baseball, tennis, track, swimming, and other intercollegiate sports.

By arrangement with the City of Pasadena, the Institute has access to the athletic facilities of Tournament Park, which is adjacent to the campus. The Park contains a fine new baseball stadium, championship tennis courts, a football field, and a track. For basket-

ball and swimming, Institute teams have the use of basketball courts and the pool at the Pasadena Junior College.

In addition to intercollegiate athletics, the Institute sponsors an increasingly important program of intramural athletics. There is spirited competition among the five groups composed of the Student Houses and the Throop Club for the possession of three trophies. The Interhouse Trophy is awarded annually to the group securing the greatest number of points in intramural competition during the year. The Varsity and Freshman Rating Trophy is presented to the group having the greatest number of men participating in varsity and freshman athletics. The third trophy, "Discobolus," is a bronze replica of Myron's famous statue of the discus thrower. "Discobolus" is a challenge trophy, subject to competition in any sport. It remains in the possession of one group only so long as that group can defeat the challengers of any of the other groups.

Student Body Publications. The publications of the Student Body include a weekly paper, the *California Tech*; an annual, the *Big T*; and a student handbook, the *Little T*, which gives a survey of student activities and organizations and serves as a campus directory. These publications are staffed entirely by undergraduates. Through them ample opportunity is provided for any student who is interested to obtain valuable experience not only in the journalistic fields of reporting and editing, but in the fields of advertising and business management as well. As an aid to student journalists, the English department offers a course in journalism each term.

Student Societies and Clubs. There is at the Institute a range of undergraduate societies and clubs wide enough to satisfy the most varied interests. The American Institute of Electrical Engineers, the American Society of Civil Engineers, and the American Society of Mechanical Engineers all maintain active student branches.

The Institute has a chapter (California Beta) of Tau Beta Pi, the national scholarship honor society of engineering colleges. Each year the Tau Beta Pi chapter elects to membership students from

the highest ranking eighth of the junior class and the highest quarter of the senior class.

The Institute also has a chapter of Pi Kappa Delta, the national forensic honor society. Members are elected annually from students who have represented the Institute in intercollegiate debate, or in oratorical or extempore speaking contests.

In addition to the national honorary fraternities there are four local honorary groups: the Beavers, membership in which is a recognition of service to the student body; the Varsity Club, which is composed of students who have earned letters in intercollegiate athletics; the Press Club, which elects members who are active in student publications; and the Drama Club, in which membership is conferred as an award for student dramatic talent.

Special interests and hobbies are provided for by the Chem Club, the Radio Club, the Ski Club, and the Musicale. The Episcopal Group and the Newman Club are organized on the basis of religious interests. The Walrus Club comprises a group interested in the discussion of questions of current national and international importance.

Forensics. Institute debaters engage in an annual schedule of debates with other Southern California colleges, and take part annually in oratorical and extempore speaking contests. To encourage undergraduate forensics the English department offers a course in debate. During the second and third terms a special debating class for freshmen gives first-year men an opportunity to prepare for freshman debates. A number of intramural practice debates, and the annual oratorical contest for the Conger Peace Prize afford all men interested in public speaking an opportunity to develop their abilities. Recently the Speaking Club has been organized for undergraduates who desire practice in public speaking under somewhat less formal circumstances than debate or other forensic contests.

Drama. Opportunities for experience in dramatic work are afforded by the production of two plays each year. As a rule, during the Fall term a classical comedy, Greek or Roman, is presented in translation under the auspices of the Institute chapter of Pi Kappa

Delta, the national forensic honor society. Participation in the play is open to the whole student body. During the Spring term, the English department usually supervises the production of a modern play, which is likewise open to all students. Both of these plays are produced under the direction of Professors Eagleson and Stanton of the English department.

Y. M. C. A. The California Institute Y. M. C. A., whose purpose it is to further the social and religious interests of campus life, is one of the most active student groups on the campus. It welcomes into its membership and into an active part in its program any student who is interested in its purpose. Its program consists of a Freshman Orientation Camp (held in the San Bernardino Mountains each year just before the opening of the Fall term), a Freshman tea dance, discussion groups considering personal and social problems, and intercollegiate meetings. The "Y" services to the student body include part-time employment bureau, a loan fund, a used book exchange and a lending library. Its General Secretary is always available to help students with their problems.

Orientation Lectures. The Faculty Committee on Student Relations, together with the Board of Directors of the Student Body, arranges each year a series of orientation lectures for the benefit of the freshmen. Some of these lectures emphasize the value of undergraduate activities in the development of character and personality, a phase of undergraduate life upon which the business world is setting greater and greater value. Other lectures explain the rudiments of social conventions and conduct. Still other lectures in the series outline the vocational opportunities which are open to graduates of the Institute and so aid the freshman in making a wise choice of the work for which he is to prepare himself.

Exhibit Day. Every year soon after the opening of the Spring term, the Institute is opened for public inspection. Special exhibits are prepared, special demonstration lectures are given. The entire Exhibit Day program is organized and carried out by the undergraduates of the Institute.

STUDENT HEALTH AND PHYSICAL EDUCATION

PHYSICAL EDUCATION

All undergraduate students are required to participate in some form of physical education. This requirement may be satisfied by engaging in organized sports, which include both intercollegiate and intramural athletics, or in other sports such as boxing, wrestling, and fencing, which are not at present a part of intramural or intercollegiate competition. If the undergraduate student does not choose to participate in any of these sports, he may satisfy the physical education requirement by independent exercise, which must be reported regularly to the Division of Physical Education. Corrective exercises are prescribed for physically deficient students.

For graduate students there is no required work in physical education, but opportunities are provided for recreational exercise.

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.

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 four dollars (\$4.00) 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. The Emergency Hospitalization Fund is not applicable to accidents away from the grounds of the Institute. This rule does not apply, i.e., the Fund is applicable, to accidents away from the Institute when these occur in authorized activities connected with regular curricular work.

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 in excess of the maximum amounts prescribed in Section 2 above 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 at least five units in Group B.

Group A:	English	3
	Algebra	2
	Plane Geometry	1
	Solid Geometry	$\frac{1}{2}$
	Trigonometry	$\frac{1}{2}$
	Physics	1
	Chemistry	1
	United States History and Government.....	1
Group B:	Foreign Languages, Shop, additional English, Mathematics, Laboratory Science, History, Drawing, Commercial subjects, etc.	5

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 $1\frac{1}{2}$ units, geometry 1 unit, trigonometry $\frac{1}{2}$ unit, physics 1 unit. All

entrance deficiencies must be made up before registration for the second year.

The Admissions Committee recommends that the applicant's high school course include at least two years of a foreign language, preferably Latin, a year of basic elementary shop work, and as much extra instruction in English grammar and composition as is available in the high school curriculum.

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 school¹.

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 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.

¹Incomplete 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 1942 is as follows: Tuesday, September 22, 9:00 a.m., mathematics; Wednesday, September 23, 9:00 a.m., history and foreign languages.

Regular entrance examinations will be held at the Institute Saturday, March 14, and Saturday, March 21, 1942. Applicants should report in the Lounge of Dabney Hall March 14, at 8:30 a.m. The examinations on March 14 will be chemistry and English and on March 21 mathematics and physics. The examinations in chemistry and English for high school juniors will be held in Dabney Hall on June 13, 1942.

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 22, 1942, 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 83 to 86, 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. (See freshman admission requirements on pages 83 to 86). 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 103.

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 174-187), 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 1942 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 1942 is as follows:

June 6, 9 a.m. Chemistry	Sept. 18, 9 a.m. Mathematics
June 12, 9 a.m. Mathematics	Sept. 19, 9 a.m. Physics
June 13, 9 a.m. Physics	Sept. 19, 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 101 and 102. 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 102.

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

EXPENSES

The following is a list of student expenses at the California Institute of Technology for the academic year 1941-42, together with the dates on which the various fees are due. In addition to the total amount given, approximately \$50 a year should be allowed for books and supplies.

<u>Date</u>	<u>Fee</u>	<u>Amount</u>	
		<u>Resident Student</u>	<u>Non-Resident Student</u>
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. 2, 1941	1st instalment of Room and Board, payable in advance		
	15 meals a week	61.50	
	21 meals a week	72.00	
Sept. 23, 1941: Freshmen	} Tuition, 1st term	120.00†	120.00†
Sept. 26, 1941: Upperclassmen			
	General Deposit	25.00	25.00
	Associated Student Body Dues, 1st term	4.45	4.45
	Emergency Hospitalization Fee, 1940-41	4.00	4.00
	Subscription to the CALIFORNIA TECH	.55	.55
	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	
Nov. 10, 1941	2nd instalment of Room and Board		
	15 meals a week	61.50	
	21 meals a week	72.00	
Jan. 5, 1942	Tuition, 2nd term	\$120.00	\$120.00
	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	61.50	
	21 meals a week	72.00	
	Student House Telephone, 2nd term	1.00	
	Student House Dues, 2nd term	2.50	

*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.

†For those who have already paid the Registration Fee, the Tuition balance due is \$110.00.

<u>Date</u>	<u>Fee</u>	<u>Amount</u>	
		<u>Resident Student</u>	<u>Non-Resident Student</u>
Feb. 16, 1942	4th instalment of Room and Board		
	15 meals a week	51.25	
	21 meals a week	60.00	
Mar. 30, 1942	Tuition, 3rd term	120.00	120.00
	Associated Student Body Dues, 3rd term	5.00	5.00
	Locker Rent, 3rd term	.50**	.50**
	Parking Fee, 3rd term	1.00**	1.00**
	5th instalment of Room and Board		
	15 meals a week	61.50	
	21 meals a week	72.00	
	Student House Telephone, 3rd term	1.00	
	Student House Dues, 3rd term	2.50	
May 11, 1942	6th instalment of Room and Board		
	15 meals a week	51.25	
	21 meals a week	60.00	

TOTAL

For student taking 15 meals	\$763.00†
For student taking 21 meals	822.50†
For non-resident student	\$404.00†

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.

Undergraduate students who have been regularly registered prior to the Fall Term, 1941, will continue at the previous tuition rate of \$300 per year or \$100 per term as long as they are in continuous attendance and working toward the four-year bachelor's degree.

For the academic year 1941-42 the charge for board and room in the Student Houses is \$348.50 for students taking 15 meals per week, \$408 for students taking 21 meals per week. The Institute reserves the right to increase this rate in subsequent years if a rise in general living cost makes such an increase necessary.

**Optional.

†This total does not include optional items.

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 prescribed by the Board of Trustees and administered by the Institute Physician and the Faculty Committee on Student Health (see pages 80-82).

ASSOCIATED STUDENT BODY FEE

The Associated Student Body fee of \$14.45 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.

GENERAL DEPOSIT

Each student is required to make a general deposit of \$25, to cover possible loss and/or damage of Institute property used in connection with his work in regular courses of study. Upon his graduation or withdrawal from the Institute, any remaining balance of the deposit will be refunded.

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 74).

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. Since all prospective students taking the entrance examinations are automatically competing for these freshman scholarships, no formal applications for them are necessary.

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 103 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.

DABNEY SCHOLARSHIP

Mrs. Joseph B. Dabney has made provision for an annual scholarship to be awarded at the discretion of the Institute to some member of the undergraduate student body. The recipient is designated the Dabney Scholar.

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. It is highly inadvisable for freshman students to attempt to earn their expenses.

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 1940-41 the sum of \$1065 per month, which represents 71 units of \$15 each per month during the academic year. This 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 and undergraduates 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 REGULATIONS

<i>Registration Dates</i>	<i>Registration</i>	<i>Instruction Begins</i>	<i>Period for Payment of Fees</i>
Third term, 1941-42	Mar. 16, 1942	Mar. 30, 1942	Mar. 30-Apr. 4, 1942
First term, 1942-43:			
Freshmen	Sept. 22, 1942	Sept. 28, 1942	Sept. 22, 1942
Transfer students	Sept. 24, 1942	Sept. 28, 1942	Sept. 25, 1942
All Other Students . . .	Sept. 25, 1942	Sept. 28, 1942	Sept. 25, 1942

Fees for Late Registration

Registration is not complete until the student has filled out the necessary registration and class assignment cards for a program approved by his registration officer and has paid his tuition and other fees. A penalty fee of two dollars is assessed for failure to register on the scheduled date, and a similar fee is assessed for failure to pay fees within the specified dates.

Change of Registration

All changes in registration must be reported to the Registrar's Office by the student. A fee of one dollar is assessed for any registration change made after the first week of classes, unless made at the suggestion of an officer of the Institute. Registration changes made within four weeks of the end of the term must have the approval of the Registration Committee.

General Regulations

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 courses in such ways as the instructor 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, 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; 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.

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 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.

Deficiency. Any freshman, sophomore, or new transfer student who fails to receive at least 72 credits during any one term will be required to report to the Dean before registering and may be requested to withdraw from all extra-curricular activities and outside employment or reduce the number of subjects he is carrying sufficiently to enable him to meet the scholastic requirements in succeeding terms.

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 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 depart-

*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.

†Any student whose grade-point average is less than 1.9 in freshman and sophomore physics and chemistry may, at the discretion of the Division of the Geological Sciences, be refused permission to register for the junior course in the Geological Sciences Option.

ment 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 no longer be subject to the scholastic regulation requiring that he make at least 270 credits during the school year, except that a student who is *reinstated* to enter the junior or senior year is subject to this requirement during his junior or senior year.

All undergraduate and fifth- and sixth-year Master's candidates are subject to the requirement that they must receive at least 54 credits each term to be eligible for subsequent registration. (Special note should be made of the graduation requirement in the following paragraph.)

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. Any student carrying less than the normal number of units required in his option must make a grade point average of at least 1.9 each term to be eligible for further registration.

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 and sophomores should make application, shortly before the close of the school year, for admission to the second and third years of the Course in Engineering or 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 nebulae; 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 61 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, photo-electric 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

The William G. Kerckhoff Laboratories of the Biological Sciences consist of two units, erected in 1928 and 1938, respectively. These provide research laboratories, undergraduate laboratories, private research rooms, several lecture rooms, seminar rooms, shops, and a large library which is a memorial to Mr. William G. Kerckhoff for his generous gift to the Institute.

Adjacent to the campus there is a laboratory for plant physiology, with two greenhouses. Here is special equipment allowing for the exact control of temperature, light, and humidity that is necessary for much of the research in this field.

At Arcadia, about five miles from the Institute, there is a ten-acre farm, with greenhouse and laboratory, for work in plant genetics. At Corona del Mar there is a marine laboratory. 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.

INSTRUCTION AND RESEARCH

The undergraduate option is designed to give the student an understanding of the outlines of modern Biology, especially on the physiological side. The course serves as a basis for graduate study leading to an advanced degree (M.S. or Ph.D.), or for admission to medical school.

The graduate work is chiefly in the fields of biochemistry, bio-organic chemistry, biophysics, animal physiology, plant physiology, genetics, and embryology. These subjects are grouped in a single division, rather than in the traditionally separate ones (Botany, Zoölogy, etc.), in order to encourage the coöperation of investigators with different backgrounds and methods of attack, and in the hope that general and fundamental properties common to animals and plants may be emphasized and studied.

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 laboratories for inorganic, physical, and organic chemical research, providing space for about eighty research fellows and advanced students.

With the Gates and Crellin Laboratories is associated the Research Laboratory of Applied Chemistry, which is located in the Engineering Research Building. This laboratory has available equipment for carrying on chemical reactions on a fifty or hundred pound scale. The laboratory is especially well equipped for the investigation of the phase relations and thermodynamic properties of fluids at moderately high pressures. Research equipment is provided for intensive study of transfers of matter and energy in systems involving fluids.

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, oppor-

tunities 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. Some of the many fields in which researches are being actively prosecuted are listed on page 207.

The fifth-year course in Chemical Engineering leads to the degree of Master of Science in Chemical Engineering. 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 Chemical Engineer. 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 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 invertebrate 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 buildings 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. The western of the two structures was given by Mrs. Seeley W. Mudd as a memorial to her late husband. Each building has five floors and the total space available for instruction and research in the geological sciences probably exceeds 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 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,

additional graduate work and research should 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 metaliferous 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, and 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 five members, devoting themselves to different phases of the subject. Instruc-

tion is given in seismic, gravity, electrical, magnetic and other methods of prospecting. The design and construction of geophysical instruments in the shop of the seismological laboratory receive attention. Geophysical researches of various types are in progress.

SEISMOLOGICAL LABORATORY

The Seismological Laboratory of the California Institute is located about three miles west of the campus 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 general program of research is outlined by a committee consisting of J. P. Buwalda, chairman, and Messrs. J. A. Anderson, 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 164-168.

MATHEMATICS

Study and research in pure mathematics leading to the degree of Doctor of Philosophy were 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 156-164.) 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 Laboratory 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 128-143 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 two 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, in the research laboratories of the government, and in the increasing number of industrial research laboratories of the country. There is at present a rapidly growing demand for physicists in the National Defense activities of the government and many graduates are entering upon such work.

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. A sixth year leads to the degree of Aeronautical, Mechanical, Electrical, or Civil Engineer. 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 adviser 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.

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. 110 to 112.)

CIVIL ENGINEERING

The branches of Civil Engineering in which advanced work is offered include the control, development and conservation and treatment 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; the study of properties and economical utilization of construction materials; 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. A 2,000,000 volt 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 provides ample facility for the study of high voltage transients. 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, 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, 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 for studying high velocity flow. This platform can be adjusted to any gradient up to 12 per cent. 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 con-

crete flume 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. 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 $\frac{1}{2}$ revolution per minute from 500 r.p.m. to 5,500 r.p.m.

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. 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. (b) A circulating type of flume for the study of rate of reduction of bed load. (c) A glass-walled flume for special studies. (d) For studies of field problems an outdoor model basin has been erected with provision for either clear or silt-laden flow.

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 is 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 (including industrial relations) 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.

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 room for the exhibition of pictures and other works of art, a library—reading room, a large senior room, conference rooms, and offices, 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 additional endowment of \$750,000 was received for the same purpose from a donor who desires to remain anonymous.

In 1939 the Industrial Relations Section was established for a five-year experimental period. Financial support is provided by a generous grant from the Earhart Foundation of Detroit and by con-

tributions from more than sixty individuals, industrial concerns, and labor unions. The study of industrial relations was added to the curriculum of the Institute largely because engineers must deal with men as well as with machines and material. The program of the Industrial Relations Sections is fourfold: (1) to provide class instruction; a course for seniors and one for graduate students are now being given; (2) to arrange periodic conferences for the discussion of labor problems; (3) to conduct field and research studies in industrial relations; and (4) to build up a library of materials relating to such problems.

In addition to the regular staff of the Institute, several scholars from other institutions are giving instruction or lectures in the Division of the Humanities during the current year. Among these are Mr. Godfrey Davies, Dr. Edwin F. Gay, Mr. Edward A. Whitney, Dr. Louis B. Wright, of the Huntington Library; Professor William Haller, of Columbia University, Research Fellow of the Huntington Library; Mr. Daniel Berkeley Updike, founder and director of the Merrymount Press; Dr. Alfred Noyes, formerly Professor of Modern English Literature at Princeton University; Professor E. L. Thorndike, of Columbia University; Professor Ralph Barton Perry, of Harvard University; and Professor Robert Ross, of Stanford University. 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

Ordinarily pages 128 to 143, inclusive, are reserved for the annual bibliography of the publications of the staff. This year, however, this material has been printed as a separate bulletin, Volume 50, Number 4, which may be secured by addressing a request to the Editor of Institute Publications, California Institute of Technology, Pasadena, California.

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 the following degrees: Master of Science after a minimum of one year of graduate work; professional degrees of Aeronautical Engineer, Chemical Engineer, Civil Engineer, Electrical Engineer, and Mechanical Engineer, after a minimum of two years of graduate work; 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 should be made on a form which can be obtained from the Dean of the Graduate School. If the applicant's preliminary training has not been substantially that given by the four-year undergraduate courses at the Institute, he may be admitted subject to satisfactory completion of such undergraduate subjects as may be assigned. Admission to graduate standing will be granted *only to a limited number of students of superior ability*, and application should be made as early as possible, preferably by the first of May. Later applications will be considered, but admission may have to be refused solely on the basis of limited facilities in the department concerned. 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 pages 165 to 166.

3. Admission to graduate standing does not of itself admit to candidacy for a degree. Application for admission to candidacy for

the degree desired must be made as provided in the regulations governing work for the degree.

II. TUITION FEES

Beginning with the Fall Term, 1941, the tuition charge for all students newly registering for graduate work will be \$360 per year, payable in three equal installments of \$120 at the beginning of each term. Graduate students who cannot devote full time to their studies are allowed to register only under special circumstances. Students desiring permission to register for less than 33 units 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 \$90 a term for 25 to 32 units, and at the rate of \$3.60 per unit for less than 25 units, with a minimum of \$36 a term. If the courses registered for do not correspond to the full educational facilities made available to the student, additional tuition will be charged.

Graduate students who have been regularly registered for the full academic year 1940-41 will continue at the tuition rate of \$300 per year or \$100 per term as long as they are in continuous attendance and working toward a definite degree. For any such students who receive permission to register for less than the normal program of study, the following tuition rates will be charged: 25 to 32 units, \$75 per term; less than 25 units, \$3 per unit per term, with a minimum of \$30 per 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 \$4 to assist in the defraying of expenses in cases

of emergency requiring hospitalization is required.* Each graduate student is required to make a general deposit of \$25 to cover possible loss and/or damage of Institute property used in connection with his work in regular courses of study. Upon completion of his graduate work, or upon withdrawal from the Institute, any remaining balance of the deposit will be refunded.

No degrees are awarded until all bills due the Institute have been paid.

In regard to *fellowships and assistantships*, see pages 165 to 169 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 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 fifth-year courses (see pages 188 to 193) as well as in the schedule of the four-year course in science or in engineering, 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 higher 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.

*See page 80.

All programs of study, and applications for admission to candidacy for the degree of Master of Science shall be in charge of the Committee on Courses in Science (in case the advanced work is to be in Physics, Chemistry, Chemical Engineering, Mathematics, Geology, Paleontology, Geophysics, 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 the 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 these degrees 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 pages 98-104 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. Students registering for more than 50 units but less than 63 units in any term must have the approval of their department. Registration for more than 62 units must in addition have the approval of the Registration Committee.

5. In the case of a student registered for the degree of Master of Science, and holding a position as Assistant or Teaching Fellow, the actual number of hours per week required by his teaching and preparation shall be deducted from the total number of units for which he may register.

III. SCHOLASTIC REQUIREMENTS

1. A minimum of 150 units of residence work is required for a fifth-year degree.

2. Scholastic requirements given on pages 100-104 of the catalogue for undergraduate students also apply to fifth-year students.

3. Candidates for the degree of Master of Science who have completed the senior year at the Institute are subject to the same regulations as are juniors and seniors, as listed on page 103.

Candidates for the degree of Master of Science who have completed their undergraduate work at other institutions are subject to the same scholastic regulations applying to new transfer students as listed on page 102.

IV. THESIS

In the case of a required thesis two final copies 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 a thesis presented in partial fulfilment 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 PROFESSIONAL DEGREE

1. The work for a professional degree must consist of advanced studies and research in the field appropriate to the degree desired. It must conform to the special requirements established for the degree desired and should be planned in consultation with the members of the faculty concerned.

2. *Residence.* At least six terms of residence subsequent to a baccalaureate degree equivalent to that given by the California Institute are required for a professional degree. Of these, at least the

last three must be in residence at the California Institute. It must be understood that these are minimum requirements, and students must often count on spending a somewhat longer time in graduate work.

3. *Admission to Candidacy.* Before the end of the first term of the academic year in which the student expects to receive the degree he must file in the office of the Dean of the Graduate School an application for admission to candidacy for the degree desired. Upon receipt of this application, the Dean of the Graduate School, in consultation with the chairman of the appropriate division, will appoint a committee of three members of the faculty to supervise the student's work and to certify to its satisfactory completion. One of the members of this committee must be in a field outside of the student's major field of study. The student should then consult with this committee in planning the details of his work.

The student will be admitted to candidacy for the degree when his supervising committee certifies

a. That all the special requirements for the desired degree have been met, with the exception that certain courses of not more than one term in length may be taken after admission to candidacy.

b. That the thesis research has been satisfactorily started and can probably be finished at the expected time.

Such admission to candidacy must be obtained by the end of the first week of the term in which the degree is to be granted.

4. *Thesis.* At least one week before the degree is to be conferred, the student is required to submit to the Dean of the Graduate School two copies of a satisfactory thesis describing his research, including a one-page digest or summary of the main results obtained. In form, the thesis must satisfy the requirements for theses for the degree of Doctor of Philosophy.

Before submitting his thesis, the candidate must obtain approval of it by the chairman of the division and the members of his supervising committee. This approval must be obtained in writing on a form which will be furnished at the office of the Dean of the Graduate School.

D. 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.

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 fulfilment 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 fulfilment 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 Fulfilment 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, in the Division of Physics, Mathematics, and Electrical Engineering, and in the Division of Civil and Mechanical Engineering, Aeronautics, and Meteorology. It is awarded without designation in the Divisions of Biology, Chemistry and Chemical Engineering, and the Geological Sciences.

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 152-156), 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

and 45 units selected from the following courses:

Ph. 101 c	Electricity and Magnetism
Ph. 103 c	Analytical Mechanics
Ph. 105 c	Optics
Ph. 107 a b c	Atomic Physics
Ph. 110 a	Kinetic Theory
Ph. 114	Principles of Quantum Mechanics
Ph. 115	Applications of Quantum Mechanics
Ph. 211	Thermodynamics
Ph. 236 a b c	Theory of Relativity
Ch. 224 a b c	Statistical Mechanics

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
{ Ma. 201	Modern Analysis
	or
{ Ma. 205	Theory of Functions
Ma. 256 a b c	Modern Differential Geometry
Ma. 102 a b c	Introduction to Higher Geometry

and any *one* of the following subjects:

Ph. 101 a b c	Electricity and Magnetism
Ph. 103 a b c	Analytical Mechanics
{ Ph. 105 a b	Optics
	and
{ Ph. 114	Quantum Mechanics

One of the year sequences given by Professor Epstein.

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
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and one of the following subjects:

Ph. 103 a b c	Analytical Mechanics
{ AM. 1 a b	Applied Mechanics
{ together with	
{ 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	Advanced Calculus
{ together with	
{ 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 any of the course requirements described above by taking an examination in the subject with the instructor in charge. Every examination of this type will cover the *whole* of the course specified and the student will not be permitted to take it either in parts (e.g. term by term) or more than twice.

These so-called candidacy examinations will be given early in the fall term of each year and the student must apply for permission to take them before the end of the second week of the term. Such application must be in writing and, if approved, will be regarded as one of the two permitted trials, whether or not the student actually takes the examination. (Note: The above regulations are not to be interpreted as preventing the student, with the permission of the instructor in charge, from satisfying the candidacy requirements by taking the term examinations in a course without actual class attendance.)

No course which has been taken more than twice will be counted towards the fulfilment of the above candidacy requirements, nor will the student be permitted a total of more than three trials at the removal of any part of the candidacy requirements.

Students are advised to satisfy the conditions for admission to candidacy in their respective departments as rapidly as possible.

Students registered for the Ph.D. degree who fail to meet at least two-thirds of the candidacy requirements by the end of their first year of graduate study will not be allowed to register for further work without special permission 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 and the final doctoral examination will be based upon this work rather than upon the candidacy courses.

4. Candidates for the degree of Doctor of Philosophy with a major in Physics or Mathematics 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.

These examinations will ordinarily be given once a year: that in organic chemistry at about the end of the first term; inorganic chemistry, middle of second term; physical chemistry, end of second term; colloid and surface chemistry, end of third term.

Each of the examinations will be graded as a whole. A grade of A or B is to be accepted as passing in each of the examinations; in addition C is to be accepted as passing in organic chemistry for students working mainly in physical or inorganic chemistry, and in physical chemistry for students working in organic chemistry.

After a second failure in any one of these examinations, the student will not be allowed to reregister in a subsequent academic year except with special permission of the Division of Chemistry and Chemical Engineering.

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

* 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.

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

3. The forty-five units of study offered for satisfaction of a minor requirement are to consist in general of graduate courses other than research; however, the Division of Chemistry and Chemical Engineering may, by special action, permit up to twenty-three units to consist of appropriate research.

4. 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.

5. The candidate must submit to the Division of Chemistry and Chemical Engineering a copy of his thesis, in final form, at least two weeks before the date of his final examination.

6. 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 proposi-

tions 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 related to the contemplated direction of study 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
{	A.E. 266 a 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 for each term:

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 d	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

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. To be recommended for candidacy for the doctor's degree in Biology a student must pass a comprehensive written examination covering advanced work in the major and minor fields at least two terms before the degree is to be conferred. 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 a major in Animal Physiology, the subjects in this field 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 is prerequisite. 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 examination for admission to candidacy is taken. At least one of the minors must be in another department of the Division of Biology.

2c. *Bio-organic Chemistry*. For a major in Bio-organic Chemistry, either the Biology or the Chemistry Option or its equivalent is prerequisite. 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*. For a major in Embryology, the Biology Option or its equivalent is prerequisite. 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*. For a major in Genetics the Biology Option or its equivalent is prerequisite. 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*. For a major in Plant Physiology the Biology Option or its equivalent is prerequisite. 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.

3. A minor in the Division of Biology must be taken in *one* of the departments of study listed above, unless special arrangements are made otherwise.

E. 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 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 73 and 169) 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 professional 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 144), 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. Successful applicants for appointment may expect to receive notification thereof sometime in March or April. 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 theoretical 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 Bureau of Reclamation, United States Soil Conservation Service, Metropolitan Water District of Southern California, Los Angeles County Flood Control District, Los Angeles City 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 73) 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.

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, Paleontology and Geophysics Options and the graduate courses in these fields prepare students for teaching and research positions in colleges and universities, for Government posts in connection with geological and mining surveys, for places as investigators and field explorers of museums and, above all, for professional work as geologists, paleontologists and geophysicists in the petroleum or 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 194-265. 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
Drafting and 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
Ma 1 abc	Mathematics* (4-0-8)	12
Ph 1 abc	Physics* (3-3-6)	12
Ch 1 abc	Chemistry* (3-6-3)	12
En 1 abc	English* (3-0-3)**	6
H 1 abc	History (3-0-2)	3
D 1, 3 ab	Drafting*** (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 102.

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 Drafting (0-6-0)	6 or	6	..
D 6b	Engineering Drafting (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 174 and 175)

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 102.

		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 2a	Electrical Machinery (3-0-6)	..	9	..
EE 3a	Electrical Machinery Laboratory (0-3-3)	..	6	..
EE 2b	Electrical Machinery (3-0-6)	..	..	9
EE 3b	Electrical Machinery Laboratory (0-3-3)	..	..	6
A: Ma 11	Differential Equations (3-0-6)	..	9	..
ME 21	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 70 abc	Engineering Conferences	2	2	2
Ph 9 ab	Electrical Measurements (0-3-1)	4	4	..
A†: EE 12	Electric Circuits (3-0-9)	12	..	..
EE 162	Vacuum Tubes (4-0-8)	..	12	..
EE 165	Electronics Laboratory (0-3-3)	..	..	6
Ph 7 abc	Electricity and Magnetism (2-0-4)	6	6	6
ME 27	Mechanical Laboratory (0-3-6)	9	..	..
ME 18	Heat Engineering (3-0-7)	..	..	10
B†: EE 14	Electric Circuits (3-0-6)	9	..	..
EE 163	Radio (3-0-6)	..	6	..
EE 162	Vacuum Tubes (4-0-8)	..	12	..
EE 165	Electronics Laboratory (0-3-3)	..	..	6
Ph 8	Electricity and Magnetism (3-0-6)	9	..	..
ME 21	Heat Engineering (3-3-6)	12	..	..
Hy 5	Hydraulics (3-3-6)	..	..	12

***Humanities Electives**

- Pl 1 Philosophy (Soares)
- Pl 4 Ethics (Soares)
- En 8 Contemporary Literature
(Eagleson, Judy)
- En 9 American Literature (MacMinn)

- En 10 Modern Drama (Stanton, Huse)
- En 11 Literature of the Bible (MacMinn)
- L 40 German Literature (Macarthur)
- 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 174 and 175)

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 102.

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 6	Transportation Engineering	6	..	..
CE 7	Curves and Earthwork (2-0-4)	..	6	..
CE 8	Route Surveying (0-6-0)	..	..	6
CE 10 ab	Theory of Structures (3-3-6) (3-0-6)	12	..	9
CE 11	Design of Structures (3-3-6)	..	12	..
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 176.

COURSE IN ENGINEERING MECHANICAL ENGINEERING OPTION

(For First and Second Years, see pages 174 and 175)

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 102.

		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 ab	Hydraulics (3-3-6) (3-0-6)	12	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 abc	Engineering Conferences (1-0-1)	2	2	2
AM 3	Testing Materials (0-3-3)	..	..	6
CE 9	Structures (3-3-5)	..	11	..
ME 5 abc	Machine Design (3-0-6) (2-4-3) (2-4-3)	9	9	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 Current Laboratory (0-3-2)	5	..	..
Ec 2	Economics (4-0-6)	..	10	..
EE 10	Alternating Currents (3-0-4)	..	..	7
EE 11	Alternating Current Laboratory (0-3-2)	..	..	5
	Elective	..	..	9

Men who expect to attend the graduate school of aeronautics should substitute Ma. 11 (9 units) and ME 50c (2 units) for ME 16 in the third term of the third year and in the fourth year should substitute:

Ma 15 abc	Higher Mathematics for Engineers (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	..	..	6
for ME 5 abc, ME 17, ME 50 abc, CE 9, and the 9 unit Elective.				

*See first footnote on page 176.

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 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 102.

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	Paleontology (4-1-4) or	(Except Ph., Ap. Ph., and		
Bi 17	Vertebrate Anatomy (2-4-3) or			
Ay 1	Astronomy (3-1-5)	] Geol. Op. C.)		
	Options as below	..	..	10

OPTIONS

PHYSICS AND APPLIED PHYSICS

(Students in these options do not take Ch 12 ab or Ay 1)

Ch 11	Analytical Chemistry (2-6-2)	..	10
L 32 abc	German (4-0-6)	10	10

MATHEMATICS

(Students in this option do not take Ch 12 ab)

L 32 abc	German (4-0-6)	10	10
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CHEMISTRY AND APPLIED CHEMISTRY

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

Bi 4	Invertebrate Zoology (2-6-2)	..	10
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GEOLOGY (Options A, B, and C)**

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 majoring in the Geological Sciences, Options A (Geology) and B (Paleontology), do not take mathematics the third term. Students in Option C (Geophysics) take Ma 2 c d.

***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 174 and 179)

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 102.

THIRD YEAR

		Units per Term		
		1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 35 a	German (4-0-6)	10	..	..
L 1 ab	French (4-0-6)	..	10	10
Ch 23 abc	Chemical Principles (4-0-8)	10	10	10
Ph 5 abc	Intro. to Math. Physics (4-0-8)	12	12	12
Ma 8 abc	Advanced Calculus (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	..
Ph 101 abc	Electricity and Magnetism (3-0-6)	9	9	9
Ph 9 ab	Electrical Measurements (0-3-1)	4	4	..
EE 165	Electronics Laboratory (0-3-3)	..	..	6
Ma 10 abc	Differential Equations (3-0-6)	9	6	6
Ay 1	Astronomy (3-1-5)	..	..	9
EE 162	Vacuum Tubes (4-0-8)	..	12	..
Ch 43	Organic Chemistry (2-6-2)	..	..	10
Ma 118 a	Statistics (3-0-6)	9	..	..
Ph 107 a	Atomic Physics (3-0-6)	9	..	..

*See first footnote on page 176.

COURSE IN SCIENCE APPLIED PHYSICS OPTION

(For First and Second Years, see pages 174 and 179)

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 102.

		Units per Term		
		1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 35 a	German (4-0-6)	10	..	..
L 1 ab	French (4-0-6)	..	10	10
Ch 23 abc	Chemical Principles (4-0-6)	10	10	10
Ph 5 abc	Intro. to Math. Physics (4-0-8)	12	12	12
EE 8, 9	Direct Currents (3-3-6)	12	..	..
EE 10, 11	Alternating Currents (3-3-6)	..	12	..
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
Ay 1	Astronomy (3-1-5)	..	..	9
Ph 8	Electricity and Magnetism (3-0-6)	9	..	..
Ph 9 ab	Electrical Measurements (0-3-1)	4	4	..
EE 165	Electronics Laboratory (0-3-3)	..	..	6
EE 162	Vacuum Tubes (4-0-8)	..	12	..
AM 1 abc	Applied Mechanics (4-3-7)	14	14	14
Ch 43	Organic Chemistry (2-6-2)	..	..	10
Ma 11	Differential Equations (3-0-6)	..	9	..
ME 21	Heat Engineering (3-3-6)	12	..	..

*See first footnote on page 176.

COURSE IN SCIENCE MATHEMATICS OPTION

(For First and Second Years, see pages 174 and 179)

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 102.

		Units per Term		
		1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 35 a	German (4-0-6)	10	..	..
L 1 ab	French (4-0-6)	..	10	10
Ph 5 abc	Intro. to Math. Physics (4-0-8)	12	12	12
Ma 8 abc	Advanced Calculus (3-0-6)	9	9	9

Schedule A (1939-40, 1941-42, etc.):

Ma 3	Theory of Equations (3-0-7)	10	..	..
Ma 4 ab	Analytic Geometry (3-0-7)	..	10	10

Schedule B (1940-41, 1942-43, etc.):

Ma 10 abc	Differential Equations (3-0-6)	9	9	9
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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
Ma 106 ab	Functions of a Real Variable (3-0-6)	9	9	..

Schedule A (1940-41, 1942-43, etc.):

Ma 10 abc	Differential Equations (3-0-6)	9	9	9
Ma 102 abc	Higher Geometry (4-0-8)	12	12	12
Ma 16	Introduction to Higher Algebra (3-0-6)	9	..	..
Ma 111	Elementary Theory of Tensors (3-0-6)	..	9	..
Ph 114	Quantum Mechanics (3-0-6)	..	..	9

Schedule B (1941-42, 1943-44, etc.):

Ma 3	Theory of Equations (3-0-7)	10	..	..
Ma 4 ab	Analytic Geometry (3-0-7)	..	10	10
Ma 101 abc	Modern Algebra (3-0-6)	9	9	9
Ma 114 abc	Mathematical Analysis (4-0-8)	12	12	12

*See first footnote on page 176.

COURSE IN SCIENCE CHEMISTRY OPTION

(For First and Second Years, see pages 174 and 179)

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	Physical Chemistry Laboratory (0-6-2; 0-3-1) ..		8	4
Ch 41 abc	Organic Chemistry (3-0-5 or 2-0-4)	8	8	6
Ch 46 abc	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	Thermodynamic Chemistry (3-0-6)	..	9	..
Ch 13 ab	Inorganic Chemistry (2-0-4)	6	6	..
Ch 29	Colloid and Surface Chemistry (3-0-5)	..	..	8
	Elective Subjects (see below)	22	17	14

Elective Subjects***

Ch 80-86	Chemical Research	†	†	†
Ch 61 abc	Industrial Chemistry (2-0-4 or 2-0-2)	6	4	6
Ch 13 c	Inorganic Chemistry (2-0-2)	..	..	4
Ch 48	Qualitative Organic Chemical Analysis	12	..	..
Ch 49	Quantitative Organic Chemical Analysis	..	10	..
Ch 50	Organic Preparations	..	..	9
	Advanced subjects in Physical Chemistry	6-9	6-9	6-9
Ph 5 abc	Introduction to Mathematical Physics	12	12	12
	Advanced undergraduate subjects in Mathematics	6-12	9-12	9-12

*See first footnote on page 176.

**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 should fill out their schedules to a total of not less than 49 units each term from the elective courses. Before registration the student's program must be approved by a representative of the division.

†Units to be arranged.

COURSE IN SCIENCE APPLIED CHEMISTRY OPTION

(For First and Second Years, see pages 174 and 179)

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

H 5 ab	Humanities Electives* (3-0-6)	9	9	9
H 10	Current Topics (1-0-1)	2	2	..
L 35 abc	U. S. Constitution (1-0-1)	..	..	2
Ch 41 abc	German (4-0-6 or 3-0-3)	10	6**	6**
Ch 46 ab	Organic Chemistry (3-0-5 or 2-0-4)	8	8	6
Ch 29	Organic Chemistry Laboratory (0-9-0)	9	9	..
Ch 63c	Colloid and Surface Chemistry (3-0-5)	..	..	8
Ch 61 abc	Chem. Eng. Thermodynamics (2-0-4)	6	..	..
EE 8, 9	Industrial Chemistry (2-0-4 or 2-0-2)	6	4	6
EE 10, 11	Direct Currents (3-3-6)	..	12	..
	Alternating Currents (3-3-6)	..	..	12

*See first footnote on page 176.

**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 174 and 179)

Attention is called to the fact that any student whose grade-point average is less than 1.9 in freshman and sophomore physics and chemistry may, at the discretion of the Division of the Geological Sciences, be refused permission to register for the junior course in the Geological Sciences Option.

		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
Ge 14	Geologic Illustration (0-10-0)	10	..	..
Ge 21 ab	Field Geology (1-8-1)	..	10	10
A. Ch 24 ab	Physical Chemistry (4-0-6)	10	10	..
Ge 3 abc	Mineralogy (3-6-3)	12	12	12
CE 3	Plane Table Surveying (1-6-1)	..	..	8
B. Ge 3 abc	Mineralogy (3-6-3)	12	12	12
Bi 3	General Botany (2-2-2)	6	..	..
	or			
Bi 13	Mammalian Anatomy (1-2-2)	5	..	..
Bi 4	Invertebrate Zoology (2-6-2)	..	..	10
	or			
Bi 17	Vertebrate Anatomy (2-4-5)	..	..	9
CE 3	Plane Table Surveying (1-6-1)	..	8	..
C. Ph 5 abc	Introduction to Math. Physics (4-0-8)	12	12	12
Ch 24 ab	Physical Chemistry (4-0-6)	10	10	..
CE 3	Plane Table Surveying (1-6-1)	..	..	8
Summer Camp, Ge 123, 12 units, required for Groups A and B.				

COURSE IN SCIENCE GEOLOGICAL SCIENCES OPTION

Students of the Geological Sciences Option whose grade-point average is less than 1.9 in the required geology subjects of the third year will be admitted to the required geology subjects of the fourth year only with the special permission of the Division of the Geological Sciences.

		Units per Term		
		1st	2nd	3rd
	Humanities Electives* (3-0-6)	9	9	9
Ge 100	Geology Club	1	1	1
Ge 102	Oral Presentation**	1	1	1
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 121 ab	Advanced Field Geology Registration to total 50 units†	..	..	..
A. Ge 105	Optical Mineralogy (2-6-2)	10	..	..
Ge 106 ab	Petrography (2-6-2)	..	10	10
Ge 111 ab	Invertebrate Paleontology (2-6-2)	10	10	..
B. Ge 111 ab	Invertebrate Paleontology (2-6-2)	10	10	..
Ge 112 ab	Vertebrate Paleontology (2-6-2)	..	10	10
Bi 3	General Botany (2-2-2)	6	..	..
	or			
Bi 13	Mammalian Anatomy (1-2-2)	5	..	..
C. Ma 8 abc	Advanced Calculus (3-0-6)	9	9	9
Ma 10 abc	Differential Equations (3-0-6)	9	9	9
EE 8	Direct Currents (3-0-4)	..	7	..
EE 9	Direct Current Laboratory (0-3-2)	..	5	..
Ge 175	Elementary Geophysics (2-0-3)	..	..	5

Summer Camp, Ge 123, 12 units, required for Groups A and B.

*See first footnote on page 176.

**Required of all candidates for a degree. The number of terms required will be determined by the degree of proficiency attained.

***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.

†A minimum of 20 units of Advanced Field Geology, Ge 121 a, b is required for graduation.

COURSE IN SCIENCE BIOLOGY OPTION

(For First and Second Years, see pages 174 and 179)

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 102.

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 41 abc	Organic Chemistry (3-0-5, 3-0-5, 2-0-4)	8	8	6
Ch 46 c	Organic Chemistry Laboratory (0-8-0)	..	..	8

Schedule A (1940-41, 1942-43, etc.):

Ch 23 abc	Chemical Principles	10	10	10
Bi 3	General Botany (3-8-2)	13	..	..
Bi 5	Plant Physiology (3-6-3 and 2-4-2)	..	12	8

Schedule B (1941-42, 1943-44, etc.):

Bi 12	Histology (1-6-2)	9	..	..
Bi 13*	Mammalian Anatomy (0-3-1)	4	..	..
Bi 16	Animal Physiology (3-3-4)	10	10	..
Bi 6	Embryology (2-8-4)	..	14	..
Bi 2	Genetics (2-4-2)	..	..	8
Ec 2	Economics	..	..	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
L 35 abc	German (4-0-6 or 3-0-3)	10	6§	6§
Bi 9	Bacteriology (2-2-2)	6‡	..	..
Bi 7	Biochemistry (2-4-4)	..	10	10
Bi 22	Biology Research	..	..	5
	Schedule A (1940-41, 1942-43)	23	22	18
	Schedule B (1941-42, 1943-44)	23	24	18

*Also as Bi 93 for graduate chemical credit.

†See first footnote on page 176.

§Students may, with the approval of the Language Department and of the Registrar, substitute French, 10 units, for German in the second and third terms.

‡Properly qualified students should elect the full 8 unit course in Bacteriology (2-4-2).

SCHEDULES OF FIFTH- AND SIXTH-YEAR COURSES

SUBJECTS COMMON TO ALL COURSES

		Units per Term		
		1st	2nd	3rd
H 100	Seminar in American History and Government . . .	9	9	9
En 100	or English Literature			
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 a	{Advanced Alternating Current}	12	..	..
EE 120 b	{Analysis and 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 91 abc	Introduction to Mathematical Physics	8	8	8
EE 165	Electronics Laboratory	..	..	6

CIVIL ENGINEERING

Ec 100 abc	Business Economics	12	12	12
CE 120 a	Statically Indeterminate Structures	12	..	..
CE 121 abc	Structural and Civil Engineering Design	12	9	9
CE 125	Irrigation and Water Supply	..	..	12
CE 126	Masonry Structures	..	9	..
CE 127	Sewerage	..	..	9
Ma 15 abc	Higher Mathematics for Engineers	9	9	9
AM 105 ab	Soil Mechanics	6	6	..
CE 130 abc	Seminar	2	2	2
	Research or Thesis as arranged	3	9	3

SUPPLEMENTARY SUBJECTS

		Units per Term		
		1st	2nd	3rd
CE 120 bc	Statically Indeterminate Structures	..	..	..
CE 122	Earthquake Effects Upon Structures	..	..	..
CE 131 ab	Sewage Treatment Plant Design	..	..	..
CE 132 ab	Water Power Plant Design	..	..	..
CE 134 ab	Ground Water Investigations	..	..	..
CE 135 ab	Geodesy and Precise Surveying	..	..	..
Ge 110	Engineering Geology	..	..	9
AE 270	Elasticity	12	6	6
AE 273 abc	Synoptic Meteorology	12	12	12
Hy 100	Fluid Mechanics	..	12	..
Hy 103	Hydraulic Problems	..	..	6
Bi 9	Bacteriology	8	..	..

MECHANICAL ENGINEERING

Ec 100 abc	†Business Economics	12	12	12
ME 110a	Science of Metals	6	..	..
ME 111a	Metallography Laboratory	6	..	..
ME 120	Heat Engineering	12	..	..
ME 150 abc	Mechanical Engineering Seminar	2	2	2
Ma 15	Higher Mathematics for Engineers	9	9	9
	Electives, as below	..	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

	Humanities (page 188)	9 or 12	9 or 12	9 or 12
AE 251 abc	Aerodynamics of the Airplane	9	9	9
AE 252 abc	Airplane Design	12	12	12
AE 253 abc	Design of Aircraft Components	6	6	6
*EE 226 ab	Engineering Mathematical Physics	15	15	..
or				
*Ma 114 ab	Mathematical Analysis	12	12	..
Ma 14	Vector Analysis	..	..	9
AE 290 abc	Aeronautics Seminar	2	2	2
AE 260	Research in Aeronautics	..	..	6

†Or another Humanities elective (see page 188), 9 units each term.

*Men who lack the prerequisites for these courses may postpone them until the sixth year, replacing them by Ma 15 a, b, c.

SIXTH YEAR

		Units per Term		
		1st	2nd	3rd
AE 254 abc	Advanced Problems in Airplane Design	9	9	9
AE 266 ab	Theoretical Aerodynamics I	12	12	..
AE 267	Theoretical Aerodynamics II	..	..	12
AE 270 abc	Elasticity Applied to Aeronautics	12	6	6
AE 270 d	Vibration Problems in Aeronautics	..	..	6
AE 290 abc	Aeronautics Seminar	2	2	2
AE 260	Research in Aeronautics	15	15	15
	Electives	..	6	..

METEOROLOGY

FIFTH YEAR

	Subjects common to all courses (page 188)	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

*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 188)	11	11	11
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*AE 272 will replace Ph 91 abc on fifth-year students' curricula when a one-year course is pursued.

ELECTIVES

		Units per Term		
		1st	2nd	3rd
Ph 110 ab	Kinetic Theory	9	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	6	6	6
Ph 106 ab	Optics Laboratory	3	3	..
Ma 114 abc	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

	Humanities Electives (see page 188)	9	9	9
Ma 114 abc	Math. Anal. (4-0-8) (<i>Schedule B, page 182</i>)	12	12	12
	or			
Ma 102 abc	Higher Geometry (4-0-8) (<i>Schedule A, page 182</i>)	9	9	9
Ma 101 abc	Modern Algebra (3-0-6)			
	or			
Ma 16	Introd. to Higher Algebra (3-0-6), Ma 111 Elementary Theory of Tensors (3-0-6), and Ph 114 Quantum Mechanics (3-0-6)	21	21	21
	Electives and Research			

CHEMISTRY

	Subjects common to all courses (page 188)	11-14	11-14	11-14
Ch 280-286	Research	12-18	12-18	12-18
	Advanced elective subjects, including thesis, to constitute a program of study approved by a member of the Division.			

CHEMICAL ENGINEERING

FIFTH YEAR

	Subjects common to all courses (page 188)	11-14	11-14	11-14
Ch 166 abc	Chemical Engineering	12	12	12
Ch 167 abc	Chemical Engineering Laboratory	15	15	15
	Advanced elective subjects, mainly in Chemistry, Physics, Mathematics, and Mechanical Engineering to constitute a program of study approved by a member of the Division.			

SIXTH YEAR

Ch 186	Research	20-30	20-30	20-30
	Advanced elective subjects, including thesis, mainly in Chemistry, Physics, Mathematics, and Mechanical Engineering to constitute a program of study approved by a member of the Division.			

GEOLOGICAL SCIENCES

		Units per Term		
		1st	2nd	3rd
H 10	Seminar in History and Gov't., or	}		
En 100	English Literature, or			
Pl 100	Philosophy, or			
Ec 100 abc	Business Economics	12	12	12
Ge 100	Geology Club	1	1	1
Ge 102	Oral Presentation	1	1	1
Elected units from group A or B (see below)		39	39	39

A. GEOLOGY AND PALEONTOLOGY

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	10	10	..
Ge 112 ab	Vertebrate Paleontology	..	10	10
Ge 115	Micropaleontology	..	8	..
Ge 121 ab	Advanced Field Geology	8-12	8-12	8-12
Ge 122	Spring Field Trip	..	..	1
Ge 123	Summer Field Geology	..	..	12
Ge 175	Elementary Geophysics	..	..	5
Ge 176	Elementary Seismology	6*	..	..
Ge 200	Mineragraphy	10	..	..
Ge 202	Metalliferous Deposits	..	10	..
Ge 209	Sedimentary Petrology	..	8†	..
Ge 210	Metamorphic Petrology	..	8*	..
Ge 211	Petrology (Seminar)	..	..	5
Ge 212	Non-metalliferous Deposits	..	..	10*
Ge 213	Mineral Deposits (Seminar)	..	5†	..
Ge 214	Mineral Economics (Seminar)	..	5*	..
Ge 215	Mineralogy (Seminar)	5	..	..
Ge 220	History of Geology	5†	..	..
Ge 225	Geology of Western America	3*	..	..
Ge 226	Geomorphology	10	..	..
Ge 227	Shoreline Geomorphology	..	..	6†
Ge 228	Geomorphology of Arid Regions	..	..	6*
Ge 230	Geomorphology (Seminar)	..	..	5
Ge 232 ab	Introduction to Petroleum Geology	10	10	..
Ge 235	Petroleum Geology (Seminar)	..	..	5
Ge 237	Tectonics	..	..	10
Ge 238	Structural Geology (Seminar)	5	..	..
Ge 245 ab	Vertebrate Paleontology (Seminar)	..	5	5
Ge 248	Fossils of the California Tertiary	..	5	..
Ge 249	Stratigraphy of the Coast Ranges	5	5	..
Ge 250 ab	Invertebrate Paleontology (Seminar)	5	..	..

*Given 1941-1942.

†Given 1940-1941.

B. GEOPHYSICS

		Units per Term		
		1st	2nd	3rd
AE 275	Structure of the Atmosphere	..	..	3
CE 2	Advanced Surveying	12	..	..
CE 122	Analysis of Earthquake Effects upon Structures (units by arrangement)	..	..	..
EE 8/9	Direct Currents	12	or 12	..
EE 10/11	Alternating Currents	..	12	or 12
EE 156	Electrical Communication	6	..	..
EE 162	Vacuum Tubes	..	12	..
EE 165	Electronics Laboratory	..	..	6
Ge 3	Mineralogy	12	12	12
Ge 109	Structural Geology	10	..	..
Ge 121 ab	Advanced Field Geology	8-12	8-12	8-12
Ge 122	Spring Field Trip	..	..	1
Ge 175	Elementary Geophysics	..	..	5
Ge 176	Elementary Seismology	5*	..	..
Ge 225	Geology of Western America	3*	..	..
Ge 226	Geomorphology	10	..	..
Ge 232 ab	Introduction to Petroleum Geology	10	10	..
Ge 238	Structural Geology (Seminar)	5	..	..
Ge 261	Theoretical Seismology	6†	..	..
Ge 262/3	Interpretation of Seismograms	..	5†	5†
Ge 265	Introduction to General Geophysics	..	6†	..
Ge 270	Seismic Instruments	9	..	..
Ge 273	Applied Geophysics I	5*	..	..
Ge 274	Applied Geophysics II	5*	5*	..
Ge 275	Applied Geophysics III	..	5†	5†
Ge 278	Interpretation of Field Seismograms	..	5*	..
Ge 279	Laboratory and Field Work in Electrical Methods ..	..	..	7*
Ge 280	Laboratory, Gravitational and Magnetic Methods ..	7*	..	..
Ge 282	Geophysics Seminar	..	..	2
Ge 283	Geophysical Instruments Seminar	..	2	..
Ge 285 ab	Geophysics Research Conference	1	1	..
Ge 297	Advanced Study (297u or 297w, or 297x) (units by arrangement)	..	..	..
Ge 299	Research (299u, or 299w, or 299x) (units by arrangement)	..	..	..
Ma 8	Advanced Calculus	9	9	9
Ma 12	Probability and Least Squares	6	..	..
Ma 118	Statistics	9	9	9
Ph 9	Electrical Measurements	4	4	4
Ph 91	Introduction to Mathematical Physics	8	8	8
Ph 101	Electricity and Magnetism	9	9	9
Ph 221	Potential Theory	..	..	15

BIOLOGY

Subjects common to all courses (see page 188) .. 11 11 11

Approved elective courses in Biology or other subjects, to be arranged
with the professor in charge.

*Given 1941-1942

†Given 1940-1941

SUBJECTS OF INSTRUCTION

SUBJECTS IN SCIENCE

BIOLOGY

PROFESSORS: THOMAS HUNT MORGAN, HENRY BORSOOK, A. J. HAAGEN-SMIT,
ALFRED H. STURTEVANT, FRITS W. WENT

ASSOCIATE PROFESSORS: ERNEST G. ANDERSON, STERLING EMERSON, CORNELIS
A. G. WIERSMA

ASSISTANT PROFESSORS: JAMES BONNER, ROBERT EMERSON, ANTHONIE VAN
HARREVELD, HUGH M. HUFFMAN, GEORGE E. MACGINITIE, ALBERT TYLER,
JOHANNES VAN OVERBEEK

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: Sturtevant, van Harreveld, Bonner.

Bi. 2. Genetics. 8 units (2-4-2); third term.

An introductory subject presenting the fundamentals of genetics in connection with some general biological problems, such as variation and evolution.

Instructor: Sturtevant.

Bi. 3. General Botany. 13 units (3-8-2); first term.

A general survey of the morphology and life histories of plants.

Instructor: van Overbeek.

Bi. 4. Invertebrate Zoology. 10 units (2-6-2); third term.

A survey of the main groups of invertebrates.

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, van Overbeek, R. Emerson.

Bi. 6. Embryology. 14 units (2-8-4); 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. 9. Bacteriology. 8 units (2-4-2) or 6 units (2-2-2); first term.

A course in general bacteriology, emphasizing the biochemical and physiological properties of bacteria.

Instructor: Ellis.

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. 4 units (0-3-1); 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. 9 units (2-4-3); third term.

This subject 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. Units to be arranged in individual cases.

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

A. Subjects open to graduates, but not to be counted toward a major for the degree of Doctor of Philosophy:

Bi. 92. Biological Assays. 8 units (1-5-2); two terms.

A course, with lectures and laboratory practice, on certain biological tests for physiologically active substances.

Instructors: Went, Haagen-Smit, Bonner, van Overbeek.

Bi. 93.

Same as Bi. 13.

Bi. 94. Immunology. 10 units (2-6-2); third term.

A course on the principles and methods of immunology and their application to various biological problems. Some previous knowledge of organic chemistry, biochemistry, embryology and genetics is desirable.

Instructor: S. Emerson.

Bi. 96 a, b. Animal Physiology. 10 units (3-2-5); first and second terms.

Same as Bi. 16.

Bi. 97 a, b. Biochemistry. 10 units (2-4-4); second and third terms.

Same as Bi. 7.

Bi. 99. Bacteriology. 8 units (2-4-2); first term.

Same as Bi. 9, with additional reading.

B. Subjects that may be counted toward either a major or a minor for the degree of Doctor of Philosophy:

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: Sturtevant.

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. 106. Immunology Seminar.

Reports and discussion.

In charge: Tyler.

Bi. 110 a, b, c. Advanced Biochemistry. 12 units.

Lectures and laboratory studies of biological oxidations, fermentations, preparation of enzymes and study of their action, chemistry and physiology of vitamins. To be given once every three years.

Instructors: Borsook, Huffman.

Bi. 111. Applications of Thermo-chemistry to biological problems.

To be given if enough students apply for it.

Instructor: Huffman.

Bi. 114 a, b, c. Chemistry of Bio-Organic Substances. 8 units (1-3-4); three terms.

Prerequisite: Ch. 41 a, b, c.

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.

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 a, b, c. Graduate Genetics. 12 units (2-3-7).

In the first term a systematic survey of the field will be presented. In the second and third terms special subjects will be treated in more detail. The material in the second and third terms will not ordinarily be duplicated in a period of three years, and students majoring in Genetics will be expected to register for six terms. The laboratory work will consist of individual problems.

Instructors: Sturtevant, Anderson, 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 micro-chemical 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 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, HOWARD J. LUCAS, RICHARD C. TOLMAN, LÁSZLÓ ZECHMEISTER
ASSOCIATE PROFESSORS: RICHARD MCLEAN BADGER, BRUCE H. SAGE, ERNEST H. SWIFT, DON M. YOST
RESEARCH ASSOCIATES: EDWIN R. BUCHMAN, JOSEPH B. KOEFLI
ASSISTANT PROFESSORS: CARL NIEMANN, JAMES H. STURDIVANT
SENIOR FELLOWS IN RESEARCH: ROBERT B. COREY, VERNER SCHOMAKER
INSTRUCTORS: J. NORTON WILSON, ARTHUR J. STOSICK

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.

Instructors: Bell, Pauling, Yost, Stosick, 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, c. Inorganic Chemistry. 6 units (2-0-4), first and second terms; 4 units (2-0-4), third term.

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. 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.

Instructors: Wilson and Teaching Fellows.

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.

Instructor: Bates.

Ch. 22. Thermodynamic Chemistry. 9 units (3-0-6); second term.

A continuation of subject Ch. 21, given in much the same way. The topics considered include 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, c. Chemical Principles. 10 units (4-0-6); first, second, and third terms.

Prerequisites: Ch. 11 or Ch. 12 b; Ph. 2 a, b, c, d; Ma. 2 a, b, c, d.

A selection of topics from Ch. 21 a, b, c, and from Ch. 22 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: Corey.

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.

Instructor: Badger.

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.

Text: *Colloid Chemistry*, Weiser.

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: *Organic Chemistry*, Lucas.

Instructor: Niemann.

Ch. 46 a, b, c. Organic Chemistry Laboratory. 9 units (0-9-0) or 6 units (0-6-0), first and second terms; 10 units (1-9-0), third 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. 48. Qualitative Organic Chemical Analysis. 12 units (2-9-1); first term.

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

Instructor: Lucas.

Ch. 49. Quantitative Organic Chemical Analysis. 10 units (1-9-0); second term.

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

Instructor: Niemann.

Ch. 50. Advanced Organic Laboratory. Units to be arranged; any term.
Laboratory practice in the synthesis of typical organic compounds.
Instructors: Buchman, Koepfli, Lucas, Niemann, Zechmeister.

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*, Read.

Instructor: Wilson.

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: Wilson.

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

Prerequisite: Ch. 21 a.

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

Text: *Thermodynamics of One-component Systems*, Lacey and Sage.

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; first and second terms.

Selected groups of inorganic compounds will be considered from modern physico-chemical view-points; thus with reference to their physical properties, their thermodynamic constants (their heat-contents, free-energies, and entropies), their rates of conversion into one another (including effects of catalysis and energy radiations), and their molecular structure and valence relations.

Instructor: Yost.

Ch. 122 a, b. Thermodynamic Chemistry. 6 units (2-0-4), first term; 9 units (3-0-6), second term.

This subject is open to students who have had a course in physical chemistry.

During the first term the elements of thermodynamics are reviewed. The second term is the same as Ch. 22.

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.

Instructor: Badger.

Ch. 148. Qualitative Organic Chemical Analysis. 12 units (2-9-1); first term.

This course is the same as Ch. 48.

Instructor: Lucas.

Ch. 149. Quantitative Organic Chemical Analysis. 10 units (1-9-0); second term.

This course is the same as Ch. 49.

Instructor: Niemann.

Ch. 150. Advanced Organic Laboratory. Units to be arranged; any term.

This course is the same as Ch. 50.

Instructors: Buchman, Koepfli, Lucas, Niemann, Zechmeister.

Ch. 166 a, b, c. Chemical Engineering. 12 units (3-0-9); first, second, and third terms.

Prerequisites: Ch. 61; Ch. 63 a, b, c.

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 unit operations of chemical industry (such as materials transfer, 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 to research encountered by the chemical engineer.

Instructor: Sage.

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 1941-42, 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 1942-43, 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 1942-43, 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. 9 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 electrons by gases, liquids, glasses, and crystals.

Instructors: Sturdivant, Schomaker, Hughes.

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. 243. Quantitative Organic Microanalysis. 20 units (0-20-0); any term by arrangement.

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. The Reactions of Organic Compounds. 6 units; first and second 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 1942-43, and every third year thereafter.

Instructor: Niemann.

Ch. 245 a, b. The Synthesis of Organic Compounds. 6 units; first and second 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: Zechmeister, Niemann, Buchman, Koepfli, Lucas.

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

Instructor: Lucas.

Ch. 250 a, b, c. Current Problems of Biochemistry. 3 units; first, second, and third terms.

A course of lectures covering the formation and fate of natural products in organisms.

Instructor: Zechmeister.

Ch. 251. The Chemistry of Natural Pigments. 3 units; second and third terms.

A course of lectures on the chemistry and biochemistry of the carotenoids and related substances.

(Not given in 1940-41.)

Instructor: Zechmeister.

Ch. 252. The Chemistry of Carbohydrates. 3 units (1-0-2); third term.

Lectures and discussions on the chemistry of the mono- and disaccharides.

This subject will be presented in 1942-43, and every third year thereafter.

Instructor: Niemann.

Ch. 253. The Chemistry of the Lipids. 3 units; second term.

Lectures on the chemistry of phosphatides, cerebrosides, and related substances.

Instructor: Niemann.

Ch. 254. The Chemistry of Amino Acids and Proteins. 4 units (2-0-2); third term.

Lectures on the properties of proteins and related substances.

Instructor: Niemann.

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. 257. The Chemistry of Vitamins. 4 units (2-0-2); third term.

Lectures on recent advances in knowledge of the chemical nature of vitamins and related substances.

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

Instructor: Buchman.

Ch. 260. Volumetric and Phase Behavior in Fluid Systems. 6 units (2-0-4); first term.

Prerequisite: Ch. 21.

A discussion of pure substances and of binary, ternary and multicomponent systems restricted primarily to liquid and gas phases. Problem work relating to the prediction of behavior in relation to pressure, temperature and composition is included.

Instructor: Sage.

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, primarily in solid-liquid systems.

Instructor: Lacey.

Ch. 262 a, b. Thermodynamics of Multi-Component Systems. 8 units (2-0-6); second and third terms.

Prerequisites: Ch. 260 and 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:

- The free-energies, equilibria, and electrode-potentials of reactions.
- Low temperature calorimetry; the determination of thermodynamic properties of substances from structural data.
- The study of crystal structure and molecular structure by diffraction of X-rays and electrons.
- The application of quantum mechanics to chemical problems.
- Band spectra and Raman spectra in their chemical relations.
- The infra-red spectroscopic study of the hydrogen bond.
- The magnetic properties and structure of hemoglobin and related substances.
- The magnetic properties of absorbed gases.
- The diamagnetic anisotropy of crystals.
- The crystal structure of amino acids, peptides, and proteins.
- The kinetics of chemical reactions including photochemical reactions.
- The chemistry of carotenoids and other plant pigments.
- The use of chromatographic methods of analysis and separation of stereoisomers; especially the study of the nature of carotenoid isomers.
- The Walden inversion.
- Isomerism, hydration, and complex formation of unsaturated compounds.
- The synthesis and study of vitamin B₁ analogs.
- The viscosity of gases and liquids at high pressures.
- The influence of turbulence upon heat transfer in fluids.
- Phase and thermodynamic behavior of hydrocarbons.
- The flow of fluids through porous media.
- The synthesis of hydrocarbons containing three- and four-membered rings.
- The structure of the naphthenic acids.
- Studies on the constitution of the phosphatides 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 study of plant hormones and related substances of physiological importance.
- The chemistry of protozoa.
- Chemical genetics.
- Immunochemistry; the structure of antigens and antibodies.

For a fuller survey of the researches in progress, see publications of the Gates and Crellin Laboratories of Chemistry (pages 132-136).

Ch. 290-296. Chemical Research Conferences.

Each 2 units; given all three terms.

Ch. 290. General Research Conference in Chemistry.

Ch. 291. Crystal and Molecular Structure.

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.

GEOLOGICAL SCIENCES

PROFESSORS: JOHN P. BUWALDA, BENO GUTENBERG, CHESTER STOCK

ASSOCIATE PROFESSORS: HUGO BENIOFF, IAN CAMPBELL, GENNADY W. POTAPENKO

ASSISTANT PROFESSORS: HORACE J. FRASER, ROBERT MINNSEN KLEINPELL, JOHN H. MAXSON, CHARLES F. RICHTER

INSTRUCTORS: FRANCIS D. BODE, 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, Bode, 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, Richey.

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: *Dana's Textbook of Mineralogy*, W. E. Ford, 4th Edition; *Principles of Economic Geology*, W. H. Emmons, 2nd Edition.

Instructors: Fraser (Ge. 3 a, b), Campbell (Ge. 3 c), Fuller.

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 exer-

cises 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 a, b. Introduction to Field Geology. 10 units (1-6-3); second and third terms.

Prerequisites: Ge. 1 a, b, c; 3 a.

An introduction to the fundamental principles and technique used in geologic mapping involving the interpretation of geologic maps, field studies of rock types, the solution of simple field problems in structure and stratigraphy, and geologic computations. To these ends, small areas are mapped in great detail and reports prepared in professional form.

Text: *Field Geology*, Lahee.

Instructor: Bode.

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, second, and third terms.

Training in the technique of oral presentation. Practice in the effective organization and delivery of reports before groups.

Successful completion of this course is required of all candidates for the bachelor's, master's, and doctor's degrees in the Division. The number of terms taken will be determined by the proficiency shown in the first term's work.

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, Regan, A. Smith.

Ge. 106 a, b. Petrography. 10 units (2-6-2); second and third terms.

Prerequisites: Ge. 3 a, b, c; 105; Ch. 24 a, b.

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, Regan.

Ge. 109. Structural Geology. 10 units (4-0-6); first term.

Prerequisite: Ge. 21 a, b.

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. 10 units (2-6-2); first and second terms.

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.

Instructors: Popenoe, Tovell.

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); third term, 1940-41.

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. Advanced Field Geology. 8-12 units any term for graduate students; units to bring total to 50 per term for seniors.

Prerequisites: Ge. 3 a, b, c; 21 a, b.

The student investigates a limited geologic problem in the field. Individual initiative is developed, principles of research are acquired, and practice is gained in technical methods. The student prepares a report setting forth the results of the research and their meaning. This report constitutes the Senior Thesis, which must be submitted by May 25.

Instructor: Bode.

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, Bode.

Ge. 123. Summer Field Geology. 12 units.

Prerequisites: Ge. 3 a, b, c; Ge. 21 a, b.

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.

Instructor: Bode.

Ge. 175. Elementary Geophysics. 5 units (2-0-3); third term.

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, 1941-1942.
A survey of the geology and physics of earthquakes.

Instructor: Richter.

GRADUATE SUBJECTS

Courses given in alternate years are so indicated. Courses in which the enrollment is less than five may, at the discretion of the instructor, be postponed.

GEOLOGY

Ge. 200. Mineragraphy. 10 units (2-6-2); first term.

Prerequisite: Ge. 3.

Methods of identification of opaque minerals in crushed samples and polished sections, together with applications to research and practical problems.

Texts: *Microscopic Determination of Ore Minerals*, M. N. Short; U. S. G. S. Bull., 914; *Mineral Deposits*, 4th edition, Lindgren.

Instructors: Fraser, B. Wilson.

Ge. 202. Metalliferous Deposits. 10 units (2-6-2); second term.

Prerequisites: Ge. 106, 200.

A study of metalliferous deposits with respect to geographic distribution, structure, alteration, and mode of formation. The laboratory work will consist of a study of ore suites and altered rocks in hand specimens, polished and thin sections.

Text: *Mineral Deposits*, 4th edition, Lindgren.

Instructors: Fraser, A. Smith.

Ge. 209. Sedimentary Petrology. 8 units; second term, 1940-1941.

Prerequisite: Ge. 106 a, b.

Discussion, reports and conferences on sediments, particularly from the petrographic view-point. The work in the laboratory affords an introduction to the various quantitative methods for detailed analysis of sediments.

Text: *Manual of Sedimentary Petrography*, Krumbein and Pettijohn.

Instructors: Campbell, Wallace.

Ge. 210. Metamorphic Petrology. 8 units; second term, 1939-1940; 1941-1942.

Prerequisite: Ge. 106 a, b.

A study of metamorphic processes.

Text: *Metamorphism*, Harker.

Instructor: Campbell.

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 Deposits. 10 units (2-6-2); third term, 1940-1941.

Prerequisites: Ge. 3, 106 a, b.

A study of the nonmetallic deposits, other than fuels; their occurrence, exploitation, beneficiation. In the laboratory the petrographic microscope is applied not only to problems of identification and paragenesis of the ores, but also to problems involving processed and fabricated materials. Occasional field trips.

Text: *Industrial Minerals and Rocks*, Seeley W. Mudd Series (A. I. M. E.).

Instructor: Campbell.

Ge. 213. Mineral Deposits (Seminar). 5 units; second term, 1940-1941.

Prerequisite: Ge. 202.

Discussion of problems and current literature concerning ore deposits.

In charge: Fraser.

Ge. 214. Mineral Economics (Seminar). 5 units; second term, 1941-1942.

Prerequisite: Ge. 202.

Discussion and investigation of factors involved in ore estimation, economics of mining and evaluation of mineral deposits.

In charge: Fraser.

Ge. 215. Mineralogy (Seminar). 5 units; first term.

Prerequisite: Ge. 200.

Discussion of current literature and special problems related to mineralogy.

In charge: Fraser.

Ge. 220. History of Geology. 5 units; first term, 1942-43.

A study of the development of the geological sciences. The evolution of fundamental theories as influenced by earlier and contemporary geological investigators, and a presentation in a connected sequence of the development of geological ideas.

Lectures, assigned reading, and reports.

Instructor: Maxson.

Ge. 225. Geology of Western America. 3 units; first term, 1941-1942.

Presents an organized concept of the geologic history of the Rocky Mountains, the Colorado Plateau, Basin and Range, and Coast Range Provinces. Lectures, mainly by staff members personally familiar with the regions discussed, and assigned reading.

Instructors: Buwalda, Campbell, Fraser, Maxson.

Ge. 226. Geomorphology. 10 units (3-0-7); 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. Brief discussion of the arid, shoreline, and glacial cycles.

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. 227. Shoreline Geomorphology. 6 units (2-0-4); third term, 1940-1941.

Prerequisite: Ge. 226.

Processes of marine erosion and the shoreline cycle.

Field trips along the coast of California.

Text: *Shore Processes and Shoreline Development*, Johnson.

Instructor: Maxson.

Ge. 228. Geomorphology of Arid Regions. 6 units (2-0-4); third term, 1941-1942.

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. 232a. Introduction to Petroleum Geology. 10 units (3-0-7); first term.

Prerequisites: Ge. 109, 121 a, b.

Theories of origin, principles of movement and accumulation of oil and gas; types of reservoir structures.

Instructor: Maxson.

Ge. 232b. Introduction to Petroleum Geology. 10 units (3-0-7); second term.

Prerequisite: Ge. 232 a.

Studies of individual oil fields involving discussion of structural conditions, preliminary estimates of reservoir capacity, practical methods of surface and sub-surface mapping, and sub-surface correlation.

Instructor: Bode.

Ge. 235. Petroleum Geology (Seminar). 5 units; third term.

Problems of petroleum geology. Current literature and discussion of new discoveries.

In charge: Bode, Maxson.

Ge. 237. Tectonics. 10 units (3-0-7); third term.

Prerequisites: Ge. 109, or equivalent, and Ge. 121 a, b, or equivalent.

Advanced structural and tectonic geology. Structure of some of the great mountain ranges; theories of origin of mountains, mechanics of crustal deformation; isostasy; continental drift.

Lectures and seminar.

Instructor: Buwalda.

Ge. 238. Structural Geology (Seminar). 5 units; first term.

Critical review of literature dealing with some part of the field of structural geology.

In charge: Buwalda.

PALEONTOLOGY

Ge. 245 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. 248. Fossils of the California Tertiary. 5 units; second term.

Study of some of the more important invertebrate fossils of the California Tertiary with especial emphasis on their use as horizon markers in field geology.

Instructor: Popenoe.

Ge. 249. Stratigraphy of the Coast Ranges (Seminar). 5 units; first and second terms.

Review, discussion, and criticism of literature of the California Coast Ranges, with especial emphasis on correlation and fauna.

In charge: Popenoe.

Ge. 250 a. Invertebrate Paleontology (Seminar). 5 units; first term.

Critical review of classic and current literature in invertebrate paleontology. Study of paleontologic principles and methods.

In charge: Popenoe.

GEOPHYSICS

Ge. 261. Theoretical Seismology. 6 units (2-0-4); first term, 1942-1943.

Prerequisites: Ma. 8 a, b, c, or Ma. 10 a, b, c, or Ph. 5 a, b, c.

Studies and conferences on the principles of physical seismology.

Instructor: Gutenberg.

Ge. 262. Interpretation of Seismograms of Teleseisms. 5 units (0-3-2); second term, 1940-1941.

Prerequisite: Ge. 261.

Instructor: Gutenberg.

Ge. 263. Field Work in Earthquakes and Interpretation of Seismograms of Local Earthquakes. 5 units (0-3-2); third term, 1940-1941.

Prerequisite: Ge. 261.

Instructor: Richter.

Ge. 265. Introduction to General Geophysics. 6 units (2-0-4); second term, 1940-1941.

Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d.

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.

Prerequisites: Ma. 8 a, b, c, or Ma. 10 a, b, c, or Ph. 5 a, b, c.

Description and theory of seismographs. Laboratory experiments.

Instructor: Benioff.

Ge. 273. Applied Geophysics I. 5 units (2-0-3); first term, 1941-1942.

Prerequisites: Ma. 8 a, b, c, or Ma. 10 a, b, c, or Ph. 5 a, b, c.

Methods of seismology applied to geological problems and prospecting.

Instructor: Gutenberg.

Ge. 274 a, b. Applied Geophysics II. 5 units (2-0-3); first and second terms, 1941-1942.

Prerequisites: Ma. 8 a, b, c, or Ma. 10 a, b, c, or Ph. 5 a, b, c.

Theory of methods of electrical prospecting.

Instructor: Potapenko.

Ge. 275 a, b. Applied Geophysics III. 5 units (2-0-3); second and third terms, 1940-1941.

Prerequisites: Ma. 8 a, b, c, or Ma. 10 a, b, c, or Ph. 5 a, b, c.

Theory of gravitational and magnetic methods of prospecting.

Instructor: Potapenko.

Ge. 278. Interpretation of Field Seismograms. 5 units (2-3-3); second term, 1941-1942.

Prerequisite: Ge. 273.

Instructor: Gutenberg.

Ge. 279. Laboratory and Field Work in Electrical Methods of Prospecting. 7 units (2-4-3); third term, 1941-1942.

Prerequisite: Ge. 274.

Instructor: Potapenko.

Ge. 280. Laboratory and Field Work in Gravitational and Magnetic Methods of Prospecting. 7 units (0-4-3); first term, 1941-1942.

Prerequisite: Ge. 275.

Instructor: Potapenko.

Ge. 282. Geophysics (Seminar). 2 units; third term.

Prerequisite: At least two subjects in geophysics.

Discussion of papers in both general and applied geophysics.

In charge: Gutenberg, Buwalda, Potapenko, Richter.

Ge. 283. Geophysical Instruments (Seminar). 2 units; second term.

Prerequisite: Ge. 270.

Discussion of papers relating to geophysical field and station instruments.

In charge: Benioff.

Ge. 285 a, b. Geophysical Research Conference. 1 unit; first and second terms.

Prerequisite: Ge. 282 or Ge. 283.

Discussion of geophysical problems. For advanced students.

In charge: Gutenberg, Buwalda, Potapenko, Richter.

GENERAL

Ge. 295. Master's Thesis Research. Units to be assigned. List as to field according to the letter system under Ge. 299.

Ge. 297. Advanced Study.

Students may register for 8 units or less of advanced study in fields listed under Ge. 299. Occasional conferences; final examination.

Ge. 299. 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: (e) engineering geology, (f) petroleum geology, (g) ground water geology, (h) metalliferous geology, (i) non-metalliferous geology, (j) geochemistry, (m) mineralogy, (n) areal geology, (o) stratigraphic geology, (p) structural geology, (q) geomorphology, (r) petrology, (s) vertebrate paleontology, (t) invertebrate paleontology, (u) seismology, (w) general geophysics, (x) applied geophysics.

MATHEMATICS

PROFESSORS: HARRY BATEMAN, ERIC T. BELL, ARISTOTLE D. MICHAL, HARRY C. VAN BUSKIRK, MORGAN WARD
 RESEARCH ASSOCIATE: DINSMORE ALTER, Statistics
 ASSOCIATE PROFESSOR: 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, and an introduction to the differential and integral calculus.

Texts: *Calculus*, Smith, Salkover, Justice; *Analytic Geometry*, Sisam.

Ma. 2 a, b, c. Sophomore Mathematics. 12 units (4-0-8); first and second terms; 8 units third term.

Includes an introduction to solid analytical geometry, and completes the usual topics of the differential and integral calculus.

Texts: *Calculus*, Smith, Salkover, Justice; *Analytical Geometry*, Sisam.

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, 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.

Instructor: Wear.

Ma. 4 a, b. Analytic Geometry. 10 units (3-0-7); second and third terms.

Prerequisites: Ma. 1, Ma. 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 units (3-0-6); 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. Intended for students interested primarily in experimental science.

Text: *Advanced Calculus*, Woods.

Instructors: Birchby, Pinney.

Ma. 9 a, b, c. Advanced Calculus. 9 units (3-0-6); first, second, and third terms.

Prerequisites: Ma. 1, Ma. 2.

The same as Ma. 8, except that it is intended for students of mathematics and theoretical physics.

Instructors: Birchby, Pinney.

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, Avann.

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. 9 units (3-0-6); 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. This course is intended especially for graduate students in Aeronautics, Meteorology, and Mechanical Engineering.

Instructor: Sears.

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, Lentz.

Ma. 16. Introduction to Higher Algebra. 9 units; first term.

Prerequisites: Ma. 1, Ma. 2.

The more frequently used parts of linear transformations, quadratic forms, matrices, etc.

Instructor: Bell.

UNDERGRADUATE OR GRADUATE SUBJECTS

Ma. 81 a, b, c. Advanced Calculus. 6 units; first, second and third terms.

Prerequisites: Ma. 1, 2.

This subject is the same as Ma. 8, but with reduced credit for graduate students.

Graduate students in mathematics receive no credit for taking this subject.

Instructors: Birchby, Pinney.

Ma. 91 a, b, c. Advanced Calculus. 6 units; first, second and third terms.

Prerequisites: Ma. 1, 2.

This subject is the same as Ma. 9, but with reduced credit for graduate students.

Graduate students in mathematics receive no credit for taking this subject.

Instructors: Birchby, Pinney.

Ma. 101 a, b, c. Modern Algebra. 9 units; first, second and third terms.

Prerequisites: Ma. 8, reading knowledge of German.

Abstract algebra as developed since about 1910.

Instructor: Bell.

Ma. 102 a, b, c. Introduction to Higher Geometry. 12 units; first, second and third terms.

Prerequisites: Ma. 1 a, b, c, 2 a, b, c, d, 4 a, b.

The course covers selected topics in metrical differential geometry and in algebraic geometry.

Instructor: Wear.

Ma. 106 a, b. Introduction to Theory of Functions of Real Variables. 9 units; first and second 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. 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 a, b, c. Mathematical Analysis. 12 units; first, second and third terms.

Prerequisites: Ma. 8, 10, and reading knowledge of German.

This course will be offered every alternate year, and covers essentially the same topics as Ma. 201.

Text: *Functions of a Complex Variable*, Copson.

(Not given in 1940-41.)

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.

Ma. 119 a, b, c. Introduction to Theory of Numbers. 9 units.

Prerequisites: Ma. 1 a, b, c, 2 a, b, c.

The fundamental theorem of arithmetic, continued fractions, congruences, Bernoulli numbers, quadratic residues, quadratic forms and other topics in elementary number theory.

Instructor: Ward.

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.

Instructor: Bateman.

Ma. 202 a, b, c. Modern Theory of Differential Equations. 12 units; first, second and third terms.

Prerequisites: Ma. 10, 107.

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.

(Not given in 1940-41.)

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.

(Not given in 1940-41.)

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; first term.

Prerequisite: Graduate standing.

Topics selected to suit the class.

In charge: Bell.

Ma. 251 b. Mathematical Logic. 9 units; second term.

Instructor: Bell.

Ma. 251 c. Theory of Algebraic Numbers. 9 units; third term.

Prerequisite: Graduate standing.

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.

Lattice theory, Boolean rings and algebras. Decomposition theorems in rings and hypercomplex systems.

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.

(Not given in 1940-41.)

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, CARL D. ANDERSON, HARRY BATEMAN, IRA S. BOWEN, PAUL S. EPSTEIN, WILLIAM V. HOUSTON, CHARLES C. LAURITSEN, J. ROBERT OPPENHEIMER, WILLIAM R. SMYTHE, RICHARD C. TOLMAN, EARNEST C. WATSON

ASSOCIATE PROFESSORS: JESSE W. M. DUMOND, ALEXANDER GOETZ, H. VICTOR NEHER, GENNADY W. POTAPENKO, FRITZ ZWICKY

ASSISTANT PROFESSORS: WILLIAM A. FOWLER, JOHN D. STRONG

RESEARCH FELLOW: JOSEF J. JOHNSON

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, Neher, Strong, and Teaching Fellows.

Ph. 2 a, b, c. Light, Electricity, and Electron Physics. 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, Light and Atomic Physics*, Millikan, Roller and Watson.

Instructors: Anderson, 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 Anderson.

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 course in theoretical electricity and magnetism, primarily for electrical engineering students. Ph. 9 a, b (Electrical Measurements) must accompany this course.

Text: *Principles of Electricity and Magnetism*, Harnwell.

Instructor: Fowler.

Ph. 8. Electricity and Magnetism. 9 units (3-0-6); first term.

Prerequisites: Ph. 5 a, b, c.

A special course open only to students who have completed Ph. 5.

Text: *Principles of Electricity and Magnetism*, Harnwell.

Instructor: Fowler.

Ph. 9 a, b. Electrical Measurements. 4 units (0-3-1); first and second 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.

Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; Ma. 2 a, b, c, d.

This subject is the same as Ph. 5 a, b, c but with reduced credit for graduate students.

Instructors: Houston and Anderson.

Ph. 101 a, b, c. Electricity and Magnetism. 9 units (3-0-6); first, second and third terms.

Prerequisites: 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 laws of motion as formulated by Newton, d'Alembert, Lagrange, Euler, Jacobi, Hamilton, etc. Integration of the differential equations of mechanics by exact methods and by methods of successive approximation. Theory of small oscillations around statically and dynamically stable states; normal modes. Elementary theory of hydrodynamics and elasticity. Applications of the tensor calculus to mechanical problems.

Text: *Dynamics*, Webster.

Instructor: Zwicky.

Ph. 105 a, b, c. Optics. 6 units (2-0-4); first, second and third 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.

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, Lauritsen.

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; first and second or second and third terms.

Prerequisites: Ph. 1 a, b, c, d; Ma. 2 a, b, c, d.

During the first term, the fundamental concepts of the molecular theory of matter are treated from the theoretical, experimental and technical viewpoints (Clausius, Maxwell, Boltzmann, van der Waals, Knudsen equations). During the second term, advanced problems of the constitution of matter as well as practical applications are discussed (such as the thermodynamics of low temperature phenomena, liquefaction of gases, phase relations, specific heats, crystallization, plasticity). The course is supplemented by a weekly seminar, Ph. 239, participation in which is required.

Instructor: Goetz.

Ph. 114. Principles of Quantum Mechanics. 12 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 indetermina-

tion, 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 1940-41.)

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 1940-41.)

Instructor: Bateman.

Ph. 222. Theory of Electricity and Magnetism. 12 units; first term.

Prerequisites: Ph. 5 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.

Prerequisite: Ph. 222.

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 1940-41.)

Instructor: Bateman.

Ph. 225. Theory of Electrons. 12 units; third term.

Prerequisites: Ph. 222 and 223.

Retarded potentials. Radiation of a point charge. Theory of dielectrics. Electron theory of dia-, para- and ferromagnetism. 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. 103 a, b, c, 211.

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 1940-41.)

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.

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.

Prerequisites: Ph. 103 a, b, c, 107 a, b, c.

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 quantization.

Instructor: Epstein.

Ph. 232. Physics of Ultra-Short Electromagnetic Waves. 6 units (2-0-4); first term.

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.

(Not given in 1940-41.)

Instructor: Potapenko.

Ph. 233. High Frequency Measurements. 6 units (2-0-4); first term.

Methods of physical measurements using high frequencies. Recent developments in methods of generation of ultra-short waves.

Instructor: Potapenko.

The content of this subject will vary from year to year. Typical topics: Theory

Ph. 234. Topics in Theoretical Physics. 9 units (3-0-6); third term.
of atomic collisions; relativistic quantum theory; theory of radiation; statistical mechanics. The course deals 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.

(Not given in 1940-41.)

Text: *Relativity, Thermodynamics and Cosmology*, Tolman.

Instructor: Tolman.

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. Seminar on the Solid State. 4 units; first, second and third terms.

Meets once a week for the report and discussion of problems and selected current publications on the physics of the solid state. The field covered concerns especially low temperature phenomena (every second week), the physics of photographic emulsions and biophysical problems (each every fourth week). Participation is required of students taking Ph. 110.

In charge: Goetz, in collaboration with Dember and Tracy.

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.

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, CLARK B. MILLIKAN
ASSOCIATE PROFESSORS: ARTHUR L. KLEIN, IRVING P. KRICK, ERNEST E. SECHLER
ASSISTANT PROFESSORS: ALBERT E. LOMBARD, JR., WILLIAM R. SEARS
INSTRUCTORS: LOUIS G. DUNN, ROBERT D. ELLIOTT, RAY H. ODELL, WILLIAM H. REMPEL, PAUL E. RUCH, H. J. STEWART, NEWTON C. STONE

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 and Newell.

Instructor: Dunn.

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.

Airfoils, wings, and tail groups, stability and control, drag, performance and spinning.

Texts: *Technical Aerodynamics*, Wood; *Engineering Aerodynamics*, Diehl; *Airplane Design*, Warner.

Instructor: Millikan.

AE. 252 a, b, c. Airplane Design. 12 units; first, second and third terms.

Prerequisites: AM. 1 a, b, c, AM. 3, ME. 8.

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; *Airplane Design*, K. D. Wood.

Instructors: Sechler, Dunn.

AE. 253 a, b, c. Design of Aircraft Components. 6 units; first, second and third terms.

Prerequisites: AM. 1 a, b, c.

253a, factory equipment and methods; 253b, control systems, flap systems, landing gears, power plants, electrical and instrument installations; 253c, heating and ventilating problems, acoustics, other nonstructural components of the airplane; 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; third term.

A one-term course 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 and second terms.

Prerequisites: Ma. 14; 114 a, b, or EE. 226 a, b.

266 a: Hydrodynamics of perfect fluids, potential motion, circulation, laws of vortex motion, elements of conformal transformation, streamline bodies, two-dimensional airfoil theory.

266 b: Three dimensional wing theory, monoplane, biplane, interference, propellers, theory of airfoils in non-uniform motion.

Students who are not primarily interested in aeronautics may enroll for 266 a only, if they so desire.

Texts: *Aerodynamic Theory*, Vols. I and II, Durand.

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, Millikan, or Sears.

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: AM. 1 a, b, c, 3; Ma. 11 and Ma. 8 a, b, c, or Ma. 15 a, b, c.

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. 270 d. Vibration Problems in Aeronautics. 6 units; third term.

Prerequisites: AE. 270 a, b.

Fundamentals of vibration analysis. Vibration problems occurring in airplane design with particular reference to the problems of flutter.

Instructor: Kármán.

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.

ASSOCIATE 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: *Analytical Mechanics for Engineers*, Seely and Ensign.

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: *Analytical Mechanics for Engineers*, Seely and Ensign; *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 a, b. 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 198)

CIVIL ENGINEERING

PROFESSORS: FRANKLIN THOMAS, ROMEO R. MARTEL

ASSOCIATE PROFESSORS: FREDERICK J. CONVERSE, WILLIAM W. MICHAEL

ASSISTANT PROFESSOR: A. PERRY BANTA

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 and geological 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. 6. Transportation Engineering. 6 units (3-0-3); first term.

Prerequisites: CE. 1, 2.

A study of economic railway location and operation; waterways and motor traffic; railway plant and equipment; signaling; the solution of grade problems.

Text: *Elements of Railroad Engineering*, Raymond.

Instructor: Thomas.

CE. 7. Curves and Earthwork. 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. Route Surveying. 6 units (0-6-0); third term.

Prerequisite: CE. 7.

The class devotes one entire day a week to field surveys of a route location, applying the principles as outlined under course CE. 7.

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: Thomas.

CE. 10 a, b. Theory of Structures. 12 units (3-3-6), first term; 9 units (3-0-6), third term.

Prerequisite: AM. 1 c.

Methods used in the calculation of stresses in beams, girders, and columns; study of the effects of moving load systems; graphic statics applied to roofs and bridges. A study of arch, cantilever, and continuous bridges; and deflection of trusses.

Text: *Structural Theory*, Sutherland and Bowman.

Instructor: Martel.

CE. 11. Design of Structures. 12 units (3-3-6); second term.

Prerequisite: CE. 10 a.

The computation of stresses in girders, truss members, and building frames; the design of structural parts and their connections.

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 AND ADVANCED SUBJECTS

CE. 120 a. Statically Indeterminate Structures. 12 units; first term.

Prerequisites: CE. 11, 12.

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. 120 b, c. Statically Indeterminate Structures. Units to be based upon work done; second and third terms.

A continuation of the study of indeterminate structures as begun in CE. 120 a. with the use of analytical and instrumental methods of solution.

Instructor: Martel.

CE. 121 a. Structural Design. 12 units (0-12-0); first term.

Prerequisites: CE. 10 a, b; CE. 11.

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. 121 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. 121 c. Civil Engineering Design. 9 units (0-9-0); third term.

Prerequisite: CE. 125.

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. 122. 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. 125. Irrigation and Water Supply. 12 units (5-0-7); third term.

Prerequisite: Hy. 1.

A study of modern practice of the collection, storage, purification 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. 126. 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. 127. Sewerage. 9 units (3-0-6); third term.

Prerequisite: Hy. 1.

A study of systems for the collection and treatment of sewage; the design of sewers and storm drains; characteristics of various treatment processes; factors affecting treatment plant design; inspection of local plants.

Text: *Sewerage and Sewage Disposal*, Metcalf and Eddy.

Instructor: Banta.

CE. 130 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 fields of civil engineering and related sciences, with special consideration given to the progress of research being conducted at the Institute.

CE. 131 a, b. Sewage Treatment Plant Design. Units to be based upon work done; any term.

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: Banta.

CE. 132 a, b. Water Power Plant Design. Units to be based upon work done; any term.

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. 133 a, b. 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. 134 a, b. Ground 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. 135 a, b. Geodesy and Precise Surveying. Units to be based upon work done; any term.

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. 141 a, b, c. Structural Engineering Research. Units to be based upon work done; any term.

Selected problems and investigations to meet the needs of advanced students.

Instructor: Martel.

CE. 142 a, b, c. 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: Banta.

CE. 143 a, b, c. Highway Research. Units to be based on work done; any term.

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.

ELECTRICAL ENGINEERING

PROFESSOR: ROYAL W. SORENSEN

ASSOCIATE PROFESSORS: FREDERICK C. LINDVALL, S. STUART MACKEOWN

ASSISTANT PROFESSORS: FRANCIS W. MAXSTADT, WILLIAM H. PICKERING.

UNDERGRADUATE SUBJECTS

EE. 2 a, b. Electrical Machinery. 9 units (3-0-6); second and third terms.

Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d.

A study of electric and magnetic circuits, electromagnets, direct and alternating current machinery and apparatus. Numerous problems relating to circuits and machinery are solved.

Texts: *Electrical Engineering*, Christie; *Problems in Alternating Current Machinery*, Lyon.

Instructors: Maxstadt, Pickering.

EE. 3 a, b. Electrical Machinery Laboratory. 6 units (0-3-3); second and third terms.

Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d.

Use of measuring instruments, operation of direct current and alternating current machinery and determination of their characteristics.

Text: Laboratory notes.

Instructors: Maxstadt, Worcester, Zarem, Feiker, Shelton, Alcock.

EE. 6 a, b. Electrical Engineering. 6 units (2-0-4), second term; 9 units (3-0-6), third term.

Prerequisites: EE. 2a, b; 3a, b.

Windings, special characteristics, graphical methods, commutation, machine reactances, and short circuit currents. System stability; short transmission lines.

Texts: *Electrical Engineering*, Christie; *Problems in Alternating Current Machinery*, Lyon.

Instructors: Lindvall, Maxstadt.

EE. 7. Electrical Engineering Laboratory. 9 units (0-3-6); third term.

Prerequisites: EE. 2a, b; 3a, b; 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, Feiker, Shelton.

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 and Practice of Electrical Engineering*, Gray and Wallace.

Instructors: Maxstadt, Pickering, Worcester.

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, Alcock, Feiker, Shelton, Zarem.

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 and Practice of Electrical Engineering*, Gray and Wallace.

Instructors: Maxstadt, Pickering, Worcester.

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, Alcock, Feiker, Shelton, Zarem.

EE. 12. Electric Circuits. 12 units (4-0-8); first term.

Prerequisites: EE. 2a, b; 3a, b.

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.

Instructors: Sorensen, McMaster, Havens.

EE. 14. Electric Circuits. 9 units (3-0-6); first term.

Prerequisites: EE. 2a, b; 3a, b.

A course similar to EE. 12, for Electrical Engineering students following Option B.

EE. 70 a, b, c. Engineering Conference. 2 units (1-0-1); first, second and third terms.

Prerequisites: EE. 2a, b; 3a, b.

Presentation and discussion of new developments in the industry. Review of current literature.

Instructors: Sorensen, Lindvall, McMasters, Zarem, Maxstadt, Stanton.

FIFTH-YEAR SUBJECTS

EE. 120 a. Advanced 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.

Instructors: Sorensen, McMasters.

EE. 120 b. 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: *Alternating Current Machinery*, Bryant and Johnson; *Problems in Alternating Current Machinery*, Lyon.

Instructors: Sorensen, McMasters.

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, Wouk.

EE. 128. Electric Traction. 9 units (3-0-6); third term.

Prerequisites: EE. 2a, b; 6a, b.

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. 2a, b; 6a, b.

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. 120a, b, 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. 120a, b, 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: *Theory of Dielectrics*, Schwaiger and Sorensen.

Instructor: Sorensen.

EE. 156. Electrical Communication. 6 units (2-0-4); first term.

Prerequisites: EE. 2a, b; 3a, b.

A study of modern means of communication with special emphasis on recent developments. Includes a study of four terminal networks and filter theory.

Instructor: Lentz.

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: Lentz.

EE. 162. Vacuum Tubes. 12 units (4-0-8); second term.

Prerequisites: EE. 6a, b, and preceding subjects.

Fundamental theory, and uses as detectors, amplifiers, and oscillators. Special uses of vacuum tubes in both radio and line communication.

Instructor: Pickering.

EE. 163. Radio. 9 units (3-0-6); first term.

Prerequisite: EE. 6a, b.

Elementary subject dealing with fundamentals of Radio Transmission.

Text: *Radio Engineering*, Terman.

Instructor: Pickering.

EE. 165. Electronics Laboratory. 6 units (0-3-3); third term.

Prerequisite: EE. 162.

Laboratory measurements at audio and radio frequencies, using modern electronic devices.

Instructor: Pickering.

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, Lindvall, Maxstadt.

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 and 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: Lentz.

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.

ENGINEERING DRAFTING

ASSISTANT PROFESSOR: HOWELL N. TYSON

INSTRUCTOR: 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 and Assistants.

Descriptive Geometry, D. 3 a, b, c, d and D. 5 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.

Instructors: Tyson and Assistants.

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.

Instructor: Tyson.

D. 6 a. Engineering Drafting. 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 drafting 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.

Instructors: Tyson and Assistants.

D. 6 b. Engineering Drafting. 6 units (0-6-0); second or third term.

Prerequisites: D. 1, 3 a, b, c; 6 a.

This is a continuation of the course described above.

Text: *Drafting for Engineers*, second edition, Svensen.

Instructor: Tyson.

D. 7. Advanced Engineering Drafting. 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.

HYDRAULICS

PROFESSOR: ROBERT L. DAUGHERTY

ASSOCIATE PROFESSOR: ROBERT T. KNAPP

INSTRUCTOR: JAMES W. DAILY

RESEARCH FELLOW: VITO A. VANONI

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: Knapp, Daily.

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: Daily and Assistants.

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: Knapp, Daily.

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, Vanoni.

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 specific 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: Vanoni.

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: Knapp.

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 PROFESSORS: ROBERT T. KNAPP, FREDERICK C. LINDVALL

ASSISTANT PROFESSORS: DONALD S. CLARK, ALBERT E. LOMBARD, JR.*, ERNEST E. SECHLER, 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.

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 (2-4-3), second and third terms.

Prerequisites: ME. 1; AM. 1 a, b, c.

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: *Machine Design*, Maleev.

Instructor: Clapp.

*On leave of absence 1940-1941.

ME. 8. Machine Design. 12 units (4-0-8); 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 Members*, Vallance.

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.

Instructor: Lindvall.

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.

Instructors: Daugherty, Tyson.

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); third term.

An abridgement of ME. 15, 16, and 17 for students in Civil Engineering.

Instructor: Lindvall.

ME. 21. Heat Engineering. 12 units (3-3-6); first term.

An abridgement of ME. 15, 16, and 17 for students in Electrical Engineering.

Instructor: Lindvall.

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: Daily and Assistants.

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, Daily.

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: Daily and Assistants.

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.

Instructor: 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.

Pyrrometry, 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.

A study of internal combustion engines, fuels, and lubricants. Analysis of real fuel-air cycles, combustion in both spark-ignition and compression-ignition engines, carburetion, detonation, engine performance.

Text: The Internal Combustion Engine, Taylor and Taylor.

Instructor: Daugherty.

ME. 121. Heat Engineering. 12 units (2-0-10); second term.

Prerequisite: ME. 120.

Advanced work in engineering thermodynamics. Special problems, air conditioning, refrigeration.

Instructor: Daugherty.

ME. 122. Heat Engineering. 12 units (2-0-10); third term.

Prerequisite: ME. 120.

Study of the laws of heat transmission, and their application to selected engineering problems.

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.

Instructor: Daugherty.

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.

Instructor: Daily.

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: ANTAR DERAGA, ROBERT D. ELLIOTT, RAY H. ODELL, WILLIAM REMPEL, PAUL RUCH, H. J. STEWART, NEWTON C. STONE

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 extra-tropical 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: Elliott, Krick, Odell, Rempel, Ruch, Stone.

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.

Instructors: Klein, Deraga.

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

VISITING LECTURER: ARTHUR H. YOUNG

ASSOCIATE PROFESSORS: PHILIP S. FOGG, HORACE N. GILBERT*, ROBERT D. GRAY,
RAY E. UNTEREINER

INSTRUCTOR: EDWARD M. WALES

READER: ALAN J. GROBECKER

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); first, 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.

Instructors: Laing, Fogg, Untereiner, with occasional lectures by Dr. E. F. 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: Wales.

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

*On leave of absence 1940-1941.

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: Archibald B. 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 at 8 p. m. on Thursday evenings at the home of Professor Laing.

In charge: Laing.

Ec. 48. Introduction to Industrial Relations. 9 units (3-0-6); first, second or third terms.

An examination of the causes of, and the proposed remedies for, some of the labor problems present in our modern industrial economy: unemployment, industrial accidents, illness, old age, wages, hours of work, and industrial disputes. In appraising solutions to these problems, consideration is given to (a) the history and functions of organized labor, (b) the efforts of employers to solve labor problems, especially through some of the techniques of personnel administration, and (c) the role of government in regulating labor conditions.

Instructors: Gray, Arthur H. Young.

Ec. 50. Industrial Management. 9 units (3-0-6); third term.

Open to senior engineers. Not offered in 1940-41.

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; *Management of an Enterprise*, Balderston, Karabasz, and Brecht; *Fundamentals of Industrial Marketing*, Elder.

Instructors: Fogg, Gray.

Ec. 106. Business Economics Seminar. 3 units; second and third terms. Open to graduate students. Not offered in 1940-41.

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.

Ec. 110. Industrial Relations. 12 units (4-0-8); third term.

Prerequisite: Ec. 100 a, b.

The course will include the study of labor relations, personnel managements, and labor economics. The seminar method, permitting general participation through individual investigation and special reports will be largely followed. Training in research methods and in the use of pamphlet and other material in the Industrial Relations Library will also be given.

Instructors: Gray, Arthur H. Young.

ENGLISH

PROFESSOR: CLINTON K. JUDY

VISITING PROFESSOR: ALFRED NOYES.

ASSOCIATES: WILLIAM HALLER, LOUIS B. WRIGHT

ASSOCIATE PROFESSORS: HARVEY EAGLESON, WILLIAM HUSE, GEORGE R. MACMINN

ASSISTANT PROFESSORS: L. WINCHESTER JONES, ROGER STANTON

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: *Harper's Magazine*; *Reading and Thinking*, McCloskey and Dow; *Index to English*, Perrin; *American Plays*, ed. by Watson and Pressey; *College Readings in the Modern Short Story*, MacMinn and Eagleson; *Webster's Collegiate Dictionary*.

Instructors: Eagleson, Huse, Jones, MacMinn, Stanton.

En. 7 a, b, c. Survey of English Literature. 8 units (3-0-5); first, second and third terms.

Prerequisite: En. 1 a, b, c.

A selective study of English literature from the 16th Century to the 20th, focused on representative works by major authors: in the first term, Shakespeare; in the second, Swift, Wordsworth, and the Romantic Movement; in the third, Arnold, Browning, and Masefield.

Instructors: Eagleson, Huse, Jones, Judy, MacMinn, Stanton.

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.

Text: *This Generation*, Anderson and Walton.

Instructors: Eagleson, Judy.

En. 9. Contemporary American Literature. 9 units (3-0-6); first or second term.

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: *Oxford Anthology of American Literature*, Vol. II, Benet and Pearson, editors.

Instructor: MacMinn.

En. 10. Modern Drama. 9 units (3-0-6); second and third terms.

Prerequisite: En. 7 a, b, c.

A study of the leading European and British dramatists, from Ibsen to the writers of the present time. Special attention may be given to new movements in the theatre, to stage decoration and production.

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.

First Term: The Literary Tradition of American Freedom.

Instructor: Wright.

Second Term: Character and Ideas in English Literature in the Seventeenth Century.

Instructor: Haller.

Third Term: Tennyson, Dickens, and Kipling.

Instructor: Noyes.

En. 101. Reading and Research. Units to be arranged with the instructor.

HISTORY AND GOVERNMENT

PROFESSOR: WILLIAM B. MUNRO

VISITING LECTURER: VLASTIMIL KYBAL

ASSOCIATES: GODFREY DAVIES, EDWIN F. GAY, EDWARD A. WHITNEY

ASSOCIATE PROFESSORS: J. E. WALLACE STERLING, RAY E. UNTEREINER

ASSISTANT PROFESSOR: HARDIN CRAIG, JR.

INSTRUCTORS: KERMIT ROOSEVELT, 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 1939, presented as the background and development of movements underlying present conditions.

Instructors: Munro, Sterling, Roosevelt.

H. 4. The British Empire. 9 units (3-0-6); third term.

A study of the expansion of England and of the development of empire which has led to the existing British Commonwealth. Attention will be paid to such topics as: The beginnings of English overseas commerce; England in the Age of Discovery; the growth of the Royal Navy; England's struggle against Spain, the Netherlands and France for commerce and colonies; colonial policy and the organization of the Old Empire (to 1763); the American Revolution, the effect on the Empire of the revolution in industry, transport and communication; the development of the self-governing dominions; the problem of Home Rule for India; the World War and its effect on the Empire; the Empire as a Commonwealth of Nations.

Instructor: Sterling.

H. 5 a, b. Current History. 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.

Instructor: Sterling (with lectures by other members of the Division of Humanities).

H. 6. Oliver Cromwell and His Times. 9 units (3-0-6); second term.

Open as a Humanities elective to seniors.

A study of certain phases of English history, political and religious, during the period in which the colonization of America was getting under way.

Instructor: Roosevelt.

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: English History in the Nineteenth Century.

In charge, Davies.

Second term: The Industrial Revolution.

In charge: Gay.

Third term: Politics and Thought in England in the Eighteenth and Nineteenth Centuries.

In charge: Whitney.

H. 101. Reading and Research. Units to be arranged with the instructor.

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 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 that will provide the student with a vocabulary and 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. Students who have had French in the secondary school should not register for this subject 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 if a sufficient number of graduate students in Mathematics request it.

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 Elementary French. Students who have had German in the secondary school or junior college should not register for this subject without consulting the Professor of Languages.

Texts: *First German Course for Science Students*, Fiedler and Sandbach; *Einführung in die Chemie*, Curts (for Chemistry sections); *Technical and Scientific German*, Greenfield.

Instructors: Macarthur and Teaching Fellows.

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: *Berühmte Forscher und ihre Beiträge*, Sokol and Nye.

Instructors: Macarthur and Teaching Fellows.

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
VISITING LECTURER: ROBERT ROSS

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, *An Introductory Course in Philosophy*, Nicholson.

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: *Wisdom in Conduct*, Garnett; *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.

Lecturer: Robert Ross.

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 in some form of physical education. This requirement may be satisfied by engaging in organized sports, which include both intercollegiate and intramural athletics, or in other sports such as boxing, wrestling, and fencing, which are not at present a part of intramural or intercollegiate competition. If the student does not choose to participate in any of these sports, he may satisfy the physical education requirement by independent exercise, which must be reported regularly to the Division of Physical Education.

The intramural sports comprise competition among Student House, Throop Club, and class teams in baseball, basketball, swimming, tennis, handball, etc. Representative freshman 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 focus for a unity of student interest.

During the freshman year, all students are given physical strength and skill tests in the first and third terms. These tests are used as a basis for determining the proper exercise for individual students and for measuring the benefits obtained therefrom. Corrective or special exercises are prescribed for physically deficient students.

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