BULLETIN

OF THE

CALIFORNIA INSTITUTE

OF

TECHNOLOGY

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

CATALOGUE

FOR

1934

THROOP HALL BUILT ABOUT 1908. HAS CONCRETE
FLOORS. THE WALLS (EXCEPT IN THE BASEMENT) ARE OF
TILE.

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

CATALOGUE NUMBER

PASADENA, CALIFORNIA

DECEMBER, 1933

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Calendar

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DECEMBER 29..Meetings of Registration Committees
JANUARY 2, 1935...Registration (9 A. M. to 3 P. M.)

Administrative Officers of the Institute

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GEORGE E. HALE ARTHUR A. NOYES
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ARTHUR A. NOYES................................Chemistry and Chemical Engineering
FRANKLIN THOMAS....................................Civil and Mechanical Engineering
JOHN P. BUWALDA...Geology and Paleontology
THOMAS H. MORGAN..Biology
CLINTON K. JUDY...Humanities
ROYAL W. SORENSEN...Physical Education

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JOHN R. MACARTHUR..Dean of Freshmen
EDWARD C. BARRETT...Secretary
HARRY C. VAN BUSKIRK...Registrar
W. NOEL BIRCHBY...Assistant Registrar

Advisory Council

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FRANK B. JEWETT, President, Bell Telephone Laboratories, Inc., and
  Vice-President, American Telephone and Telegraph Company.

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

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

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OFFICERS

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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; Asso-
ciate Professor, 1907-1910; Professor, 1910-1921. Sc.D. (hon.), Oberlin
College, 1911; Northwestern University, 1913; University of Pennsyl-
vania, 1915; Amherst College, 1917; Columbia University, 1917; Uni-
versity of Dublin, 1924; Yale University, 1925; Leeds University, 1927;
Princeton University, 1928; New York University, 1929; Harvard Uni-
versity, 1932; LL.D., University of California, 1924; University of
Colorado, 1927; University of Michigan, 1929; University of Southern
California, 1931; Ph.D. (hon.), King John Casimir University, Lwów,
Poland, 1926; University of Ghent, 1927; Docteur Honoris Causa, Uni-
versity of Liege, 1930; Vice-President, American Association for the
Advancement of Science, 1911; President, 1929; President, American
Physical Society, 1916-1918; Lieutenant Colonel, U. S. A., and Chief,
Science and Research Division of Signal Corps, 1917-1919; American
Representative, Troisième Conseil de Physique, Solvay, Brussels, 1921;
Exchange Professor, Belgium, 1922; American Representative, Com-
mittee on Intellectual Cooperation, League of Nations, 1922-1932.
Fellow of the Oberlaendar Trust, 1931. Member, American Philosophi-
cal Society, National Academy of Sciences, American Academy of Arts
and Sciences. Corresponding Member, Société Batave de Philosophie
Expérimentale à Rotterdam, Académie des Sciences de Russie, Institut
de France Académie des Sciences, Royal Accademia della Scienze Dell'
Istituto Bologna, Accademie Lincei, Rome. Hon. Member, Royal Insti-
tution of Great Britain, La Société Hollandaise des Sciences, Royal
Irish Academy, Die Gesellschaft der Wissenschaften zu Göttingen,
Bayeresche Akademie der Wissenschaften zu Muenchen, Association
des Ingénieurs de Liège, Kaiserlich Deutsche Akademie der Naturfor-
scher. Recipient of Comstock Prize, National Academy of Sciences,
1913; of Edison Medal of the American Institute of Electrical Engi-
neers, 1922; of the Nobel Prize in Physics of the Royal Swedish Acad-
emy, 1923; of the Hughes Medal of the Royal Society of Great Britain,
1923; of the Faraday Medal of the London Chemical Society, 1924; of
the Matteucci Medal of the Societa Italana della Scienze, 1925; of the
Gold Medal of the American Society of Mechanical Engineers, 1926; 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;
and of the Gold Medal of Honor, Roosevelt Memorial Foundation, 1932.
Chevalier de l'Ordre National de la Légion d' Honneur, 1931. Califor-
nia Institute, 1916-   1640 Oak Grove Avenue

THOMAS HUNT MORGAN, PH.D., LL.D., Sc.D., Nobel Laureate

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

B.S., University of Kentucky, 1886; M.S., 1888; Ph.D., Johns Hopkins Uni-
versity, 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., University of Michigan, 1924; Ph.D. (Dr. of
Nat. Phil.), Heidelberg University, 1931. Fellow of the American Asso-
ciation for the Advancement of Science (President, 1930); Member,
American Philosophical Society; President, National Academy of

Sciences, 1927-1931; Member, Linnean Society of London; Royal Society
of Sciences of Denmark; Foreign Member, Royal Society of London;
Finnish Society of Sciences; Associate Member, Société Royale des
Sciences Médicales et Naturelles de Bruxelles; Society Belge de
Biologie, Bruxelles; Société de Biologie de France; Corresponding
Member, Zoological Society of London; Académie des Sciences de
Russie; Bavarian Academy of Sciences; Honorary Member, Royal
Irish Academy; Ordinary Member, Royal Society of Sciences of
Upsala; Foreign Associate, Royal Accademia Nazionale dei Lincei,
Rome; Correspondent, Academie des Sciences, Institut de France.
Recipient of the Nobel Prize in Medicine of the Swedish Royal Acad-
emy, 1933. California Institute, 1928-   **1149 San Pasqual Street**

WILLIAM BENNETT MUNRO, PH.D., LL.D., LITT.D.
Professor of History and Government
Member of the Executive Council

B.A., Queens University, 1895; M.A., 1896; LL.B., 1898; M.A., Harvard
University, 1899; Ph.D., 1900, M.A. (hon.), Williams College, 1904;
LL.D., Queens University, 1912; Litt.D., University of Southern
California, 1930; Parker Traveling Fellow, Harvard University, 1900-
1901; Instructor in History and Political Science, Williams College,
1901-1904; Instructor in Government, Harvard University, 1904-1906;
Assistant Professor of Government, 1906-1912; Professor of Municipal
Government, 1912-1925; Jonathan Trumbull Professor of American
History and Government, 1925-1930; Chairman of the Division of His-
tory, Economics and Government, Harvard University, 1920-1928;
Weil Foundation Lecturer, University of North Carolina, 1921; Mc-
Bride Foundation Lecturer, Western Reserve University, 1925; Jacob
H. Schiff Foundation Lecturer, Cornell University, 1926; Marfleet Lec-
turer, University of Toronto, 1929; President of the American Asso-
ciation of University Professors, 1930-1931; President of the American
Political Science Association, 1927; Major, United States Army, 1918-
1919; Fellow of the American Academy of Arts and Sciences. Califor-
nia Institute, 1925-   **268 Bellefontaine Street**

ARTHUR AMOS NOYES, PH.D., LL.D., Sc.D.
Professor of Chemistry
Director of the Gates Chemical Laboratory
Member of the Executive Council

S.B., Massachusetts Institute of Technology, 1886; S.M., 1887; Ph.D.,
University of Leipzig, 1890; LL.D., University of Maine, 1908;
Clark University, 1909; University of Pittsburgh, 1915; Sc.D. (hon.),
Harvard University, 1909; Yale University, 1913. Assistant and In-
structor in Analytical Chemistry, Massachusetts Institute of Tech-
nology, 1887-1892; Instructor in Organic Chemistry, 1892-1894; Assis-
tant and Associate Professor of Organic Chemistry, 1894-1899; Pro-
fessor of Theoretical Chemistry, 1899-1919; Director of the Research
Laboratory of Physical Chemistry, 1903-1919. Acting President,
Massachusetts Institute of Technology, 1907-1909; President, American
Chemical Society, 1904; President, American Association for Advance-
ment of Science, 1927; Honorary Fellow, Royal Society of Edinburgh;
Member, National Academy of Sciences, American Philosophical
Society, and American Academy of Arts and Sciences. Willard Gibbs
Medal, American Chemical Society, 1915. Davy Medal, Royal Society
1927; Richards Medal, American Chemical Society, 1932. California
Institute, 1913-   **1025 San Pasqual Street**

EDWARD CECIL BARRETT, B.A.
Secretary of the Institute

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

942 North Chester Avenue

HARRY BATEMAN, PH.D.

Professor of Mathematics, Theoretical Physics, and Aeronautics

B.A., Cambridge University, 1903; Smith Prize, 1905; Fellowship, Trinity College, Cambridge, 1905-1911; Universities of Göttingen and Paris, 1905-1906; M.A., Cambridge University, 1906; Ph.D., Johns Hopkins University, 1913. Lecturer in Mathematics, University of Liverpool, 1906-1907; Reader in Mathematical Physics, University of Manchester, 1907-1910; Lecturer in Mathematics, Bryn Mawr College, 1910-1912; Lecturer in Applied Mathematics, Johns Hopkins University, 1915-1917. Fellow of the Royal Society of London, 1928. Member, American Philosophical Society, National Academy of Sciences. California Institute, 1917-

1101 San Pasqual Street

STUART JEFFERY BATES, PH.D.

Professor of Physical Chemistry

B.A., McMaster University, Toronto, 1907; M. A., 1909; Ph.D., University of Illinois, 1912. Chemist, Comfort Soap Works, Toronto, 1907-1908; Research Assistant, McMaster University, 1909-1910; Fellow in Chemistry, University of Illinois, 1910-1912; Research Associate in Physical Chemistry, 1912-1913. Instructor in Analytical Chemistry, University of Illinois, 1913-1914; Research Associate in Physical Chemistry, Massachusetts Institute of Technology, 1922-1923 (on leave from California Institute of Technology). California Institute, 1914-

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. Bôcher Prize, American Mathematical Society, 1924; Vice-President, American Mathematical Society, 1926-; Colloquium Lecturer, American Mathematical Society, 1927. Professor, summer quarters, University of Chicago, 1924-1928; Visiting Lecturer, Harvard University, first half 1926. Vice-President, American Association for the advancement of Science, 1929-1930; President, Mathematical Association of America, 1931-. Member of National Academy of Sciences. 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. Graduate student, University of Chicago, 1908-1910. Instructor in Chemistry, University of Washington, 1910-1911, 1913-1916. Associate Professor, California Institute, 1916-1918; Professor, 1918-

R. D. 1, Box 639

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. Instructor, California Institute, 1921-1926; Assistant Professor, 1926-1928; Associate Professor, 1928-1931; Professor, 1931-

1147 Constance Street

John Peter Buwalda, Ph.D.

Professor of Geology

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

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. 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, Leland Stanford Junior University, 1909; M. E., 1914. Assistant in Mechanics, Leland Stanford Junior University, 1907-1908; Assistant in Hydraulics, 1908-1909; Instructor in Mechanical Engineering, 1909-1910; Assistant Professor of Hydraulics, Sibley College, Cornell University, 1910-1916; Professor of Hydraulic Engineering, Rensselaer Polytechnic Institute, 1916-1919. Member of Council, American Society of Mechanical Engineers, 1925-1928; Vice-President, 1928-1930. Vice-Chairman and Chairman, Board of Directors, City of Pasadena, 1927-1931. California Institute, 1919-

373 South Euclid Avenue

William Morris Davis, Ph.D., Sc.D.

Professor of Physiographic Geology

B.S., Harvard University, 1869; M.E., 1870. Sc.D. (hon.) University of Cape Town, 1905; Melbourne University, 1914. Ph.D., (hon.) University of Greifswald, 1906; University of Christiania, 1911. Instructor in Physical Geography, Harvard University, 1879-1885; Assistant Professor, 1885-1890; Professor, 1890-1899; Sturgis-Hooper Professor of Geology, 1899-1912; Emeritus Professor, 1912-. Member: National Academy of Sciences, American Academy of Arts and Sciences, Geological Society of America, American Philosophical Society. Honorary Member, Geographical Societies of New York, Berlin, Leipzig, Greifswald, Frankfurt, Petrograd, Amsterdam, Stockholm, Geneva, Neuchatel, Vienna, Budapest, Rome and Madrid. Corresponding Member, Berlin Academy, Paris Academy, Academy dei Lincei. Foreign Member, Stockholm and Christiania Academies. Recipient of Cullom medal, American Geographical Society; Culver medal, Geographical Society of Chicago; Kane medal, Geographical Society of Philadelphia; Patron's medal, Royal Geographical Society of London; Vega medal, Geographical Society of Stockholm; Hayden medal, Academy of Natural Sciences, Philadelphia; Penrose medal, Geological Society of America. California Institute, 1930-

656 South Mentor Avenue

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

C.Sc., Moscow University, 1906; M.Sc., 1909; Ph.D., University of Munich, 1914. Assistant in Physics, Moscow Institute of Agriculture, 1906-1907; Assistant in Physics, Moscow University, 1907-1909; Privat docent, Moscow University, 1909-1913; Privat docent, University of Zurich, 1919-1922. Member National Academy of Sciences. California Institute, 1921-

1484 Oakdale Street

Beno Gutenberg, Ph.D.
Professor of Geophysics

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

399 Ninita Parkway

Frederic W. Hinrichs, Jr., M.A.
Professor of Mechanics
Dean of Upper Classmen

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

1071 North Garfield Avenue

William Vermillion Houston, Ph.D.
Professor of Physics

B.A. and B.Sc. in Ed., Ohio State University, 1920; M.S., University of Chicago, 1922; Ph.D., Ohio State University, 1925. Instructor in Physics, Ohio State University, 1922-1925. National Research Fellow in Physics, 1925-1927. Foreign Fellow of the John Simon Guggenheim Foundation, 1927-1928. National Research Fellow, California Institute, 1925-1927; Assistant Professor, 1927-1929; Associate Professor, 1929-1931; Professor, 1931-

2428 Ridgeway Road, San Marino

Clinton Kelly Judy, M.A.
Professor of English Language and Literature

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

1325 Woodstock Road, San Marino

Theodor von Kármán, Ph.D., Dr. Ing.
Professor of Aeronautics
Director of the Daniel Guggenheim Laboratory

M.E., Budapest, 1902; Ph.D., Göttingen, 1908. Honorary degree of Doctor of Engineering, University of Berlin, 1929. Privat docent, Göttingen, 1910-1913; Professor of Mechanics and Aerodynamics, Director of the Aerodynamical Institute, University of Aachen, 1913- Member of Gesellschaft de Wissenschaften zu Göttingen, 1925; foreign member of the Royal Academy of Sciences, Torino, 1928. California Institute, 1928-

1620 East California Street

William Noble Lacey, Ph.D.

Professor of Chemical Engineering

A.B. in Chemical Engineering, 1911, and Chemical Engineer, 1912, Leland Stanford Junior University; M.S., 1913, Ph.D., 1915, University of California. Assistant in Chemistry, Leland Stanford Junior University, 1911-1912; Assistant in Chemistry, University of California, 1912-1915; Research Chemist for Giant Powder Co., San Francisco, 1915; Research Associate, Massachusetts Institute of Technology, 1916. Instructor, California Institute, 1915-1917; Assistant Professor, 1917-1919; Associate Professor, 1919-1931; Professor, 1931-

2136 Minoru Drive

Graham Allan Laing, M.A.

Professor of Economics and Business Administration

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

1081 Elizabeth Street

John Robertson Macarthur, Ph.D.

Professor of Languages
Dean of Freshmen

B.A., University of Manitoba, 1892; Ph.D., University of Chicago, 1903. Lecturer in Modern Languages, Manitoba College, 1893-1898; Professor of English, New Mexico Agricultural College, 1903-1910, 1911-1913; Professor of English, Kansas State Agricultural College, 1914-1920. Agent of International Committee of Young Men's Christian Association, Ellis Island, 1910-1911. Associate Professor, California Institute, 1920-1923; Professor and Dean, 1923-

866 South Pasadena Avenue

Romeo Raoul Martel, S.B.

Professor of Structural Engineering

S.B., Brown University, 1912. Instructor in Civil Engineering, Rhode Island State College, 1913-1914; Instructor in Civil Engineering, Mechanics Institute, 1914-1915. With Sayles Finishing Plants, Saylesville, R. I., 1915-1918; with Atchison, Topeka and Santa Fe Railway, Amarillo, Texas, 1918; Resident Engineer, California Highway Commission, Willits, California, summer of 1921. Consulting Engineer on Bridge Design for City of Pasadena, 1921-1924. Representative of Southern California Council on Earthquake Protection at Third Pan-Pacific Science Congress, Tokyo, 1926, and at the World Engineering Congress at Tokyo in 1929. Instructor, California Institute, 1918-1920; Assistant Professor, 1920-1921; Associate Professor, 1921-1930; Professor, 1930-

690 South Mentor Avenue

LINUS PAULING, PH.D.
Professor of Chemistry

B.S., Oregon State Agricultural College, 1922; Ph.D., California Institute of Technology, 1925. National Research Fellow in Chemistry, 1925-1926. Foreign Fellow of the John Simon Guggenheim Memorial Foundation, 1926-1927. Lecturer in Physics and Chemistry, University of California, 1928-, Massachusetts Institute of Technology, 1932. Langmuir Prize of the American Chemical Society, 1931. Member of National Academy of Sciences. Assistant in Chemistry, California Institute, 1922-1923; Teaching Fellow, 1923-1925; Research Fellow, 1926-1927; Assistant Professor, 1927-1929; Associate Professor, 1929-1931; Professor, 1931-

1245 Arden Road

FREDERICK LESLIE RANSOME, PH.D.
Professor of Economic Geology

B.S., University of California, 1893; Ph.D., 1896. Assistant in Mineralogy and Petrography, Harvard University, 1896-1897; Assistant Geologist, U. S. Geological Survey, 1897-1900; Geologist, 1900-1923; in charge of sections of western areal geology, 1912-1916, and of metalliferous deposits, 1912-1923; Professor of Economic Geology, 1923-1927, and Dean of the Graduate College, 1926-1927, University of Arizona. Fellow, Geological Society of America, American Association for the Advancement of Science; Member, National Academy of Sciences, National Research Council; President, Geological Society of Washington, 1913; President, Washington Academy of Sciences, 1918; Corresponding Member, Societe Géologique de Belgique; President, Society of Economic Geologists, 1928. California Institute, 1927-

543 South San Marino Avenue

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. 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.
Professor of Electrical Engineering

B.S., in Electrical Engineering, University of Colorado, 1905; E.E., 1928. Associated with General Electric Co., Schenectady, N. Y., and Pittsfield, Mass., 1905-1910; Consulting Engineer, Pacific Light and Power Corporation, 1913-1917. Consulting Engineer, U. S. Electrical Manufacturing Company, 1917-1929, 1930-32. Consulting Engineer, Circuit Breaker Research Department, General Electric Company, 1929-1930. Member, Board of Consulting Engineers, Metropolitan Water District of Southern California, 1931-. Associate Professor, California Institute, 1910-11; Professor, 1911-

384 South Holliston Avenue

CHESTER STOCK, PH.D.
Professor of Paleontology

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

1633 Linda Vista Avenue

ALFRED HENRY STURTEVANT, PH.D.
Professor of Genetics

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

761 Lakewood Place

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-. Associate Professor, California Institute, 1913-1914; Professor, 1914-

685 South El Molino Avenue

RICHARD CHACE TOLMAN, PH.D.
Professor of Physical Chemistry and Mathematical Physics

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

345 South Michigan Avenue

HARRY CLARK VAN BUSKIRK, PH.B.
Professor of Mathematics
Registrar

Ph.B., Cornell University, 1897. Associate Professor, California Institute, 1904-1915; Professor, 19_5-

390 South Holliston Avenue

EARNEST CHARLES WATSON, PH.B.
Professor of Physics

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

1124 Mar Vista Avenue

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

Samuel Jackson Barnett, Ph.D.

Research Associate in Physics

A.B., University of Denver, 1894; 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 (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, 1923-

939 Thayer Avenue, Westwood Hills, Los Angeles

Hardin Craig, Ph.D.

Associate in English

B.A., Centre College, 1897; M.A., Princeton University, 1899; Ph.D., 1901. Charles Scribner Fellow in English, Princeton University, 1899-1901; Instructor in English, 1901-1905; Egerstoune Preceptor in English, 1905-1910; Professor of English, University of Minnesota, 1910-1919; Professor of English and Head of Department, State University of Iowa, 1919-1928; Professor of English, Stanford University, 1928-. Research Associate, Huntington Library, 1930-. California Institute, 1930-1931, 1933-1934.

Athenæum

Avery Craven, Ph.D.

Associate in History

A.B., Simpson College, 1908; A.M., Harvard University, 1913; Ph.D., University of Chicago, 1923. Professor of History, College of Emporia, 1920-1922; Assistant Professor, Michigan State College, 1923-1924; Assistant Professor and Associate Professor, University of Illinois, 1924-1927; Professor of American History, University of Chicago, 1927-. Visiting Scholar, Huntington Library, 1931-. California Institute, 1931-

2382 North Holliston Avenue, Altadena

Godfrey Davies, M.A.

Associate in History

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

Athenæum

*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.

JESSE WILLIAM MONROE DuMOND, PH.D.

Research Associate in 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; Research Associate, 1931-

1585 Homewood Drive, Altadena

SIR HERBERT JACKSON, K.B.E., F.R.S.

Research Associate in Instrument Design

Director of the British Scientific Instrument Research Association. Lately Daniell Professor of Chemistry in the University of London (King's College). California Institute, 1929-

JOSEPH BLAKE KOEPFLI, D.PHIL.

Research Associate in Chemistry

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

342 S. Mariposa Avenue, Los Angeles

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 Geological Society (London), American Geological Society; member of American Ornithological Union. California Institute, 1929-

Meadow Grove Avenue, Flintridge

SEELEY G. MUDD, M.D.

Research Associate in Radiation

B.S., Columbia University, 1917; M.D., Harvard University, 1924. California Institute, 1931-

1000 Avondale Road

FRANCIS GLADHEIM PEASE, D.SC.

Associate in Optics and Instrument Design*

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

824 North Holliston Avenue

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

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

Carl Clapp Thomas, M.E.

Associate in Engineering Research

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

165 Linda Vista Avenue

Casey Albert Wood, M.D., D.C.L., LL.D.

Research Associate in Vertebrate Zoology

C.M., M.D., University of Bishop's College, 1877; D.C.L., 1903; M.D., C.M., McGill University, 1906; LL.D., 1921. Professor of Chemistry, University of Bishop's College, 1878-1881; Professor of Pathology, 1881-1885; Clinical Professor of Ophthalmology and Head of the Department, University of Illinois, 1898-1906; Professor of Ophthalmology and Head of Department, Northwestern University, 1906-1908; Emeritus Professor of Ophthalmology, University of Illinois since 1914; Honorary Collaborator on Birds, Smithsonian Institution, 1927; Lecturer on Ornithology, Stanford University, 1928. California Institute, 1932-

295 Wigmore Drive

Harry Oscar Wood, M.A.

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-

220 North San Rafael Avenue

Louis Booker Wright, Ph.D.

Associate in English

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; Guggenheim Research Fellow in England and Italy, 1928-1929; Visiting Professor, Emory University, winter quarter, 1929; Assistant Professor of English, University of North Carolina, 1929-1930; Associate Professor, 1930-1932. Visiting Scholar of the Huntington Library, 1931-1932; Member of the Research Staff, 1932-. California Institute, 1931-

589 South Berkeley 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

Roscoe Gilkey Dickinson, Ph.D.

Associate Professor of Physical Chemistry

S.B., Massachusetts Institute of Technology, 1915; Ph.D., California Institute of Technology, 1920. Assistant in Theoretical Chemistry, Massachusetts Institute of Technology, 1915-1916; Research Assistant in Physical Chemistry, 1916-1917. National Research Fellow in Chemistry, 1920-1923. Fellow of the International Education Board in Europe, 1924-1925. Instructor, California Institute, 1917-1920; National Research Fellow, 1920-1923; Research Associate, 1923-1926; Assistant Professor, 1926-1928; Associate Professor, 1928-

530 Bonita Avenue

Horace Nathaniel Gilbert, M.B.A.

Associate Professor of Business Economics

Resident Associate in Ricketts House

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-

Ricketts House

Alexander Goetz, Ph.D.

Associate Professor of Physics

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

1185 Banyan Street

CHARLES CHRISTIAN LAURITSEN, PH.D.

Associate 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-

1671 Oakdale Street

HOWARD JOHNSON LUCAS, M.A.

Associate Professor of Organic Chemistry

B.A., Ohio State University, 1907; M.A., 1908; Assistant in Organic Chemistry, Ohio State University, 1907-1909; Fellow in Chemistry, University of Chicago, 1909-1910; Chemist, Bureau of Chemistry, United States Department of Agriculture, 1910-1912. Chemist, Government of Porto Rico, 1912-1913. Instructor, California Institute, 1913-1915; Associate Professor, 1915-

97 North Holliston Avenue

SAMUEL STUART MACKEOWN, PH.D.

Associate Professor of Electrical Engineering

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

1240 Arden Road

GEORGE RUPERT MacMINN, A.B.

Associate Professor of English Language and Literature

A.B., Brown University, 1905. Instructor in English, Brown University, 1907-1909; Iowa State College, 1909-1910; University of California, 1910-1918. Manager of the University of California Press, 1912-1913. Editor, University of California Chronicle, 1915. Member of the Faculty, Summer Sessions, University of California at Los Angeles, 1920-1931. California Institute, 1918-

255 South Bonnie Avenue

WILLIAM W. MICHAEL, B.S.

Associate Professor of Civil Engineering

B.S., in Civil Engineering, Tufts College, 1909. With New York City on topographic surveys, 1909-1911; with The J. G. White Engineering Corporation, 1912-1913 and 1915; Instructor, Department of Drawing and Design, Michigan Agricultural College, 1914; Office Engineer with The Power Construction Company of Massachusetts, 1914-1915; in private engineering practice, 1916-1918. Engineer, Palos Verdes Estates, summer of 1922; Associate and Consulting Engineer with County Engineer, Ulster County, N. Y., summers of 1925, 1928-1932. California Institute, 1918-

388 South Oak Avenue

ARISTOTLE D. MICHAL, PH.D.

Associate 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-

2002 Oakdale Street

Gennady W. Potapenko

Associate Professor of Physics

Dipl. in Phys., University of Moscow, 1917; Habilitation, 1920. Assistant in Physics, Moscow Institute of Petrographie, 1914-1916; Research Fellow, University of Moscow, 1917-1920; Docent of Physics, 1920-1932. Professor of Physics, University of Iaroslawl, 1924-1926; Associate Professor, Mining Academie 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, Agriculture Academie 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-. California Institute, 1930-

786 South Mentor Avenue

William L. Stanton, B.A.

Physical Director

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

515 Manzanita Avenue, Sierra Madre

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

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 Loraine Road, San Marino

Carl David Anderson, Ph.D.

Assistant Professor of Physics

B.S., California Institute of Technology, 1927; Ph.D., 1930. Assistant in Physics, California Institute, 1927-1930; Research Fellow, 1930-1933; Assistant Professor, 1933-

520 South Lake Avenue

Richard McLean Badger, Ph.D.

Assistant 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-

503 California Terrace

Arnold Orville Beckman, Ph.D.

Assistant Professor of Chemistry

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

1970 Crescent Drive, Altadena

William Noel Birchby, M.A.

Assistant Professor of Mathematics
Assistant Registrar

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

251 South Catalina Avenue

Henry Borsook, Ph.D.

Assistant Professor of Biochemistry

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

1121 Constance Street

Ian Campbell, Ph.D.

Assistant 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- California Institute, 1931-

627 Drexel Place

Fred J. Converse, B.S.

Assistant Professor of Civil Engineering

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

239 South Sierra Bonita Avenue

Theodosius Dobzhansky
Assistant Professor of Genetics

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

360 South Wilson Avenue

Harvey Eagleson, Ph.D.
Assistant Professor of English Language and Literature
Resident Associate in Blacker House

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

Blacker House

Robert Emerson, Ph.D.
Assistant Professor of Biophysics

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

1175 Woodbury Road

Sterling H. Emerson, Ph.D.
Assistant Professor of Genetics

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

1666 Rose Villa Street

Philip Shearer Fogg, M.B.A.
Assistant Professor of Business Economics
Resident Associate in Fleming House

A.B., Stanford University, 1925; M.B.A., Harvard University, 1929. California Institute, 1930-

Fleming House

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

William Huse, Jr., M.A.
Assistant Professor of English Language and Literature

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. California Institute, 1929-

321 South Mentor Avenue

Arthur Louis Klein, Ph.D.

Assistant 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-

125 Fremont Place, Los Angeles

Robert Talbot Knapp, Ph.D.

Assistant Professor of Mechanical Engineering

B.S., Massachusetts Institute of Technology, 1920; Ph.D., California Insti-
tute of Technology, 1929. Designer with C. M. Gay & Son. Refrigerat-
ing Engineers, 1920-1921; Consulting Engineer, Riverside Cement Com-
pany, 1927-1929; American Society of Mechanical Engineers Freeman
Scholar in Europe, 1929-1930. Instructor, California Institute, 1922-
1930; Assistant Professor, 1930-

2526 North Roosevelt Avenue

Frederick Charles Lindvall, Ph.D.

Assistant Professor of Electrical Engineering

B.S., University of Illinois, 1924; Ph.D. California Institute of Technology,
1928. Electrical Engineering Department, Los Angeles Railway Corp-
oration, 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-

1860 Allen Drive, Altadena

George Eber MacGinitie, M.A.

Assistant Professor of Biology

A.B., Fresno State College, 1925; M.A., Stanford University, 1928. In-
structor 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

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. California Institute, 1919-

1666 North Grand Oaks Avenue, Altadena

Clark Blanchard Millikan, Ph.D.

Assistant 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-

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Educational Policies

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

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

(2)   The four-year Undergraduate Course in Engineering shall be of a general, fundamental character, with a minimum of specialization in the separate branches of engineering. It shall include an unusually thorough training in the basic sciences of physics, chemistry, and mathematics, and a large proportion of cultural studies; the time for this being secured by eliminating some of the more specialized technical subjects commonly included in undergraduate engineering courses. It shall include, however, the professional subjects common to all branches of engineering. It is hoped in this way to provide a combination of a fundamental scientific training with a broad human outlook, which will afford students with engineering interests the type of collegiate education endorsed by leading engineers—one which avoids on the one hand the narrowness common among students in technical schools, and on the other the superficiality and the lack of purpose noticeable in many of those taking academic college courses.

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

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

(4) The four-year Undergraduate Course in Science shall afford, even more fully than is possible in the Engineering Course, an intensive training in physics, chemistry, and mathematics. In its third and fourth years groups of optional studies shall be included which will permit either some measure of specialization in one of these basic sciences or in geology, paleontology, biology, 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, engi-

neering, 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.

Educational Buildings and Facilities

THROOP HALL

Throop Hall, named for Amos G. Throop, founder of Throop Polytechnic Institute, out of which the California Institute developed, is the central building on the campus. It was erected in 1910, with funds supplied by a large number of donors. It now contains the offices of administration, the class rooms and drafting rooms of the engineering departments, and some of the engineering laboratories.

NORMAN BRIDGE LABORATORY OF PHYSICS

The Norman Bridge Laboratory of Physics, the gift of the late Dr. Norman Bridge of Chicago, consists of two units of five floors each, connected at the north by a third unit of two floors, so as to form three sides of a hollow square. One of these units has in addition a special photographic laboratory on a partial sixth floor, and each has on its large flat roof excellent facilities for outdoor experimentation. The building contains the Norman Bridge Library of Physics, to provide for which Dr. Bridge gave $50,000.

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

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

The central unit has in the basement eight more research rooms, thus bringing the number of rooms devoted exclusively to research up to sixty-five. On the first floor is the general library and the engineering library of the Institute.

THE HIGH-POTENTIAL RESEARCH LABORATORY

A high-potential laboratory, provided by the Southern California Edison Company, forms a companion building to the first unit of the Norman Bridge Laboratory, which it closely resembles in external design and dimensions. The equipment in this laboratory includes a million-volt transformer specially designed by R. W. Sorensen, which 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. It is available both for the pursuit of special scientific problems connected with the structure of matter and the nature of radiation, and for the conduct of the pressing engineering problems having to do with the improvement in the art of transmission at high potentials. It also provides opportunities for instruction in this field, such as are not at present easily obtainable by students of science and engineering.

GATES CHEMICAL LABORATORY

The first unit of the Gates Chemical Laboratory, the gift of C. W. Gates, and his brother, the late P. G. Gates, includes laboratories used for undergraduate instruction in Inorganic Chemistry, Analytical Chemistry, Organic Chemistry, Physical Chemistry, and Instrumental Analysis.

The remainder of this unit is devoted to facilities for research work. There are six unit laboratories for physico-chemical research; organic and biochemical research laboratories; and research laboratories of photochemistry and radiation chemistry. In separate rooms special research facilities are also provided, including a well-equipped instrument shop, a students' carpenter

shop, a glass-blowing room, a storage battery room, and large photographic dark rooms.

The second unit of the laboratory adjoins the first unit on the west, and is two stories in height. It contains a lecture room, seating 150 and completely equipped for chemical demonstrations of all sorts; a seminar room, a chemistry library, a small lecture room seating about 30 persons, class rooms, four research laboratories, professors' studies, a storeroom for inflammable chemicals, and the usual machinery, switchboard, and service rooms.

RESEARCH LABORATORY OF APPLIED CHEMISTRY

With the Gates Chemical Laboratory is associated the Research Laboratory of Applied Chemistry, which is located in the Engineering Research Building. This research laboratory is equipped for carrying on chemical reactions on a fifty or a hundred pound scale. The machinery is as nearly like commercial plant equipment as is consistent with its size. It includes apparatus for grinding and pulverizing, melting, mixing, dissolving, extracting, pumping, decanting, centrifuging, filtering (by gravity, pressure, suction, plate and frame, and leaf filters), evaporating under pressure or vacuum, fractionating, condensing, crystallizing, drying under pressure or vacuum, and absorbing gases and vapors.

ENGINEERING RESEARCH LABORATORY AND HEATING PLANT

Through funds provided in part by the late Dr. Norman Bridge, and in part from other sources, the Institute has erected an engineering building 50 by 140 feet in size. One section of this is occupied by the boiler plant which supplies all the steam for both heating and laboratory purposes. The equipment consists of two Babcock and Wilcox Sterling boilers, each of 300 boiler horse-power capacity and capable of operation at 200 per cent of rating and with a steam pressure of 250 pounds per square inch. The plant is also fully equipped with all the auxiliary equipment necessary for comprehensive tests of all portions of the installation. There are also heat exchangers in which

water is heated by steam, and centrifugal pumps driven by steam
turbines to circulate the hot water for heating some of the build-
ings on the campus.

The other half of the building is devoted to an engineering
research laboratory, and is equipped with water, gas, direct and
alternating current, compressed air, and steam, so as to provide
both space and facilities for a variety of engineering work. Some
space is also given over to the research section of chemical
engineering.

STEAM, GAS ENGINE, AND HYDRAULIC LABORATORIES

The undergraduate laboratory work in the fields of thermo-
dynamics and hydraulics is provided for in a building of tempo-
rary construction. Facilities are there available for the customary
tests of steam engines, turbines, gas and oil engines, air com-
pressors, blowers, centrifugal and other pumps, hydraulic
turbines, and for various experiments on the flow of fluids.

Adjoining the hydraulic laboratory is a model basin of about
40 feet square in which river flow and similar experiments can
be made. This equipment, which has been provided by the Los
Angeles Gas and Electric Corporation and the Los Angeles
County Flood Control jointly, is being used at present to study
the effect of proposed changes in the outlet of the San Gabriel
River into Alamitos Bay.

DANIEL GUGGENHEIM AERONAUTICAL LABORATORY

Funds for the construction of the Daniel Guggenheim Aero-
nautical Laboratory and to aid in its operation for a period of
ten years have been provided through a gift of $350,000 from
the Daniel Guggenheim Fund for the Promotion of Aeronautics.
The building is 160 feet long by about 55 feet wide, and has
five floors. The largest item of equipment is a wind tunnel
of the Göttingen closed circuit type with a working section
10 feet in diameter. Provision is made for using the working

section either as an open or closed type. A 750 horse-power, 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 permit testing and research work of all kinds to be performed in the wind tunnel. An aerodynamics laboratory contains three small wind tunnels and a considerable amount of auxiliary apparatus for the study of the basic problems connected with turbulent flows. A large structures laboratory has been equipped with specially designed testing machines with which a series of researches are now in progress, dealing chiefly with the problems connected with the modern use of stressed skin or monocoque structures. A completely equipped photoelasticity laboratory in the basement is being used for researches on the distribution of stresses in various complicated types of structure. On the first floor are the observation room of the wind tunnel, a wood shop large enough for the building of complete airplanes, and the structures laboratory. On the seecond floor are offices and a group of six small laboratories for research. The third floor contains the balance room in which the wind tunnel measurements are made, a seminar room, library, drafting room, aerodynamics laboratory, and five offices.

DABNEY HALL OF THE HUMANITIES

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

CULBERTSON HALL

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

SEISMOLOGICAL RESEARCH LABORATORY

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

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

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

THE WILLIAM G. KERCKHOFF LABORATORIES
OF THE BIOLOGICAL SCIENCES

The first unit of the William G. Kerckhoff Laboratories of the Biological Sciences, the present quarters of the department, contains over 60 rooms, including lecture rooms, seminar rooms, undergraduate laboratories, private research rooms, and four constant temperature rooms. For work in plant genetics there is a ten-acre farm with greenhouses located at Arcadia, about five

miles from the Institute. In addition there is land in the immediate vicinity available for plant work.

A marine station has also been established at Corona del Mar. The building that has been acquired contains four large rooms and several smaller ones which give ample opportunity for research work in experimental embryology 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 and at Laguna Beach, which is near-by, is exceptionally rich and varied, and is easily accessible.

W. K. KELLOGG LABORATORY OF RADIATION

The facilities for research in the field of radiation have been greatly increased by the erection of a building designed and equipped especially for high potential X-ray work. The building and its special equipment are the gift of Mr. W. K. Kellogg of Battle Creek, Michigan. It is located south of Throop Hall and adjacent to the High Potential Laboratory, which it resembles closely in architecture. The principal feature of the new building is the large equipment room, 60 feet long, 30 feet wide, and 68 feet from floor to ceiling. In this room the high potential X-ray tube is located, together with the transformers and other high potential accessories. The room is surrounded by heavy concrete walls and all operation and observation is carried out in adjoining rooms thoroughly protected from the radiation. In addition there are twenty-five rooms located on five floors, used as research rooms and offices for the staff and graduate students.

The major portion of the work carried on in this laboratory during the past three years has been therapeutic research under the direction of Dr. Seeley G. Mudd. Irradiation is used in the treatment of selected cases of inoperable cancer. The potential first used in this treatment was 550,000 volts, but since June, 1933, this has been increased to 850,000 volts.

The research on the purely physical phases of high-voltage X-Rays is conducted under the direction of Dr. C. C. Lauritzen.

LIBRARIES

The library of the Institute comprises the General Library and six departmental libraries: for Physics, Chemistry, Geology, Biology, Aeronautics, and the Humanities.

ASTROPHYSICS LABORATORY AND SHOPS

Statements concerning these buildings will be found on pages 100 to 103.

Athenæum

The Athenæum is a beautiful structure in the Mediterranean style of architecture, elegantly and fittingly furnished and equipped, and with grounds beautifully landscaped and planted. It is the gift of Mr. and Mrs. Allan C. Balch. The building was designed by Gordon B. Kaufmann.

The purpose of the Athenæum is 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," in addition to a completely-equipped kitchen and the necessary service rooms. 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.

Student Houses

On the California Street side of the Institute campus, four student houses have been erected and are known as Dabney House, Ricketts House, Blacker House, and Fleming House. The first three are the gifts of the late Mr. Joseph B. Dabney and Mrs. Dabney, Dr. and Mrs. L. D. Ricketts, and the late Mr. R. R. Blacker and Mrs. Blacker, respectively. The last is the gift of some twenty donors and is named Fleming House, in recognition of Mr. Fleming's great part in the development of the California Institute.

These four houses in Mediterranean style harmonizing with the Athenæum, were, like the latter building, designed by Gordon B. Kaufmann. While built in a unified group, each house is a separate unit providing accommodations for about seventy-five students; each has its own dining-room, reading 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 rooms, but there are a limited number of rooms for two. All the rooms are plainly but adequately and attractively furnished. The plans of the buildings are such that within each of the four houses there are groupings of rooms for from twelve to twenty students, to which there is access from each entry.

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

By action of the Board of Trustees, all undergraduate students are expected to live in the Student Houses unless permission is given by the Dean to live elsewhere, which will commonly be granted when the student is living at home.

Extra-Curriculum Opportunities

LECTURE AND CONCERT COURSES

Through a cooperative arrangement with the Pasadena Lecture Course Committee there are given at the Institute assemblies a number of lectures on science, literature, current events, and other subjects of general interest, by speakers of national and international note brought to Pasadena by the Committee. Weekly public lectures in science, illustrated by experiments, are given by the members of the Institute faculty in the lecture rooms of the Norman Bridge Laboratory of Physics and the Gates Chemical Laboratory. Lectures given from time to time at the Institute under the auspices of Sigma Xi and of the Astronomical Society of the Pacific are open to the students. They may also arrange to visit the Huntington Library and Art Gallery, and members of the Institute staff give talks to small groups of students preceding the visits to the art gallery on the pictures there exhibited.

STUDENT ORGANIZATIONS AND ACTIVITIES

The students are organized into an association known as the Associated Student Body, of which all are members, to deal with affairs of general concern to the students, and with such matters as may be delegated to them by the faculty. The Student Body elects its officers and a board of control, which investigates breaches of the honor system, or cases of misconduct, and suggests disciplinary penalties to the Associated Student Body for recommendation to the faculty.

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

The Associated Students exercise general direction of matters of undergraduate concern in cooperation with the faculty.

Athletic contests are managed by the Athletic Council, composed of faculty and student representatives. The student body, through its elected representatives, manages THE CALIFORNIA TECH, a weekly paper, and the BIG T, the annual. A glee club, an orchestra, and a band are maintained, with assistance from the Institute. There are at the Institute student branches of the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, and the American Society of Civil Engineers. A Chemists' Club and a Geology-Paleontology Club include men interested in these particular fields. Other organizations are the Dramatic Club, the Press, the Non-Resident, the Varsity, the Walrus, the Cosmopolitan, the Photo, the Radio, and the Newman Clubs.

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

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

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

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

The forensic interests of the Institute include also membership in the Southern California Public Speaking Association. Under the auspices of this association the Institute debaters

engage in an annual schedule of six debates with other Southern California colleges, and in annual oratorical and extempore contests. Debates are also scheduled with near-by colleges, and frequently with eastern teams traveling through California. On the Pi Kappa Delta trips to the National Conventions, debates are scheduled with the best of the institutions that can be met en route.

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

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

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

Student Health and Physical Education

In 1929 the Institute inaugurated a student health program consisting of three principal features. The first is a thorough physical examination of all students entering the Institute by specialists on the staff of the Pasadena Hospital. The second feature of the program is the appointment of a consulting physician, Dr. E. D. Kremers, who is in his office on the campus in the William G. Kerckhoff Laboratory of the Biological Sciences each day, and may be consulted by the students without charge. The third is the provision by the Institute of an insurance fund, through the payment of an annual fee of $3 by every graduate and undergraduate student, to assist in the defraying of expenses in cases of emergency requiring hospitalization.

The program of physical education is designed to give physical development to all undergraduate students and to provide graduate students with opportunity for recreational exercise. The required work is divided into three parts: (1) corrective exercises for those physically deficient; (2) group games; (3) fundamentals of highly organized athletics. This work is modified by various activities designed to encourage voluntary recreational exercises, including intercollegiate and intramural games and sports.

Requirements for Admission to Undergraduate Standing

ADMISSION TO THE FRESHMAN CLASS

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

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

Group B: Foreign Languages, Shop (up to 1 unit); additional English, Mathematics, Laboratory Science, or History.

Group C: Drawing, Commercial subjects, additional Shop, etc.

Applicants who offer for entrance a total of fifteen recommended units, but whose list of subjects is not in accord with this table, may be admitted at the discretion of the faculty, if they are successful in passing the general entrance examinations; but no applicant will be admitted whose preparation does not include English 2 units, Algebra 1½ units, Geometry 1 unit, Trigonometry ½ unit, Physics 1 unit. All entrance deficiencies must be made up before registration for the second year.

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

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[1]Incomplete scholastic records may be supplemented by examinations in particular subjects taken at the Institute. The scope of subject matter for these examinations is the same as that covered by standard high schools. Applicants taking examinations in Physics, Chemistry, or United States History and Government must present their notebooks at the time

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

Regular entrance examinations will be held at the Institute Friday, April 27th, and Saturday, April 28th, 1934. Applicants should report in the Lounge of Dabney Hall April 27th, at 8:30 A.M. These examinations will also be given September 7th and 8th if a sufficient number of duly qualified applicants is not selected from among those taking the spring examinations.

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*; or they may, if they prefer, take the New Plan (Plan B) College Board examinations in Comprehensive English, Comprehensive Mathematics (Elementary and Advanced), Physics, and Chemistry. No candidate will be registered by the College Entrance Examination Board under this plan unless he is at the end of his high school course.

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of the examination. The schedule for 1934 is as follows: Wednesday, September 19, 9:00 A.M., Mathematics; 2:00 P.M., English. Thursday, September 20, 2:00 P.M., History and Foreign Languages.

These examinations may also be taken under the direction of the College Entrance Examination Board. The examinations are held at various points in the United States on June 18-23, 1934. Application for these examinations must be addressed to the College Entrance Examination Board, 431 West One Hundred and Seventeenth Street, New York, N. Y., and must be received by the Board on or before May 21, 1934.

*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.

Each applicant must pass a physical examination showing that he is able to do the work of the Institute. These examinations will be conducted for the Institute by the staff of the Pasadena Hospital on September 17-19, 1934. 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 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. All students entering the Institute for the first time are required to be vaccinated or to submit satisfactory evidence of recent vaccination.

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 April, or even earlier. This enables the Institute to make full use of all information available from high school sources. Applicants whose preparatory work is finished should submit their complete scholastic records before taking the entrance examinations. Applicants who expect to complete their preparatory work at the close of the year will be admitted to the examinations if such a request is received from their principals. The scholarship records of students who have taken the examinations under the above arrangement should be forwarded to the Institute as soon as possible after the completion of the preparatory work.

No decision can be reached as to the admission of a student until his complete scholastic record is received.

Blanks for application for admission to the Institute and for transcript of record will be provided upon request.

Applicants who comply with these conditions not later than June 23rd will be notified by the Registrar as to their acceptance on or about July 1st.

Upon receipt of the registration fee of $10.00 (which will be deducted from 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 20th, 1934, at 8:30 A.M.

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

The number admitted to the freshman class is limited to 160, by action of the Trustees.

ADMISSION TO UPPER CLASSES

For admission to the upper classes of the Institute applicants who have been students at other institutions of collegiate rank must present letters of honorable dismissal, together with statements showing in detail the character of their previous training, and the grades which have been received. It is advisable for students planning to transfer to send their credentials to the registrar at an early date. A personal interview is desirable; during the summer months it is well to arrange for this in advance. These students take examinations in Mathematics, Physics, and Chemistry; 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 128-141) or as soon as possible after admission make up their deficiencies. 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.

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, sophomore, or freshman, 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 the basis of the results of all the examinations taken.

The examinations may be taken either in June or in September. The schedule for 1934 is as follows: Thursday, June 7, 9 A.M., Chemistry; Friday, June 8, 9 A.M., Mathematics; Saturday, June 9, 9 A.M., Physics; Friday, September 14, 9 A.M., Mathematics; Saturday, September 15, 9 A.M., Physics; 1:00 P.M., Chemistry.

Applicants are advised to take the examinations in June if possible. Those 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.

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.

Applicants are advised to read the descriptions of the freshman and sophomore Physics, Mathematics, and Chemistry courses,

and to note especially that the work in freshman Mathematics is chiefly calculus.

Because of the very thorough, intensive study of these subjects required in the first two years, students from other colleges, unless of ability above the average of Institute students, can not hope to transfer to the higher years of the Institute courses without incurring 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.

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.

Expenses

ASSOCIATED STUDENT BODY FEE

The Associated Student Body fee, payable by all undergraduate students, is $11.00 a year, payable in three installments on registration day at the beginning of each term. This fee is used for the support of athletics and of other student activities.

EMERGENCY HOSPITALIZATION FEE

There is an emergency hospitalization fee of $3.00, payable by each student at the beginning of each year, to provide a certain amount of hospitalization, 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.

DEPOSITS AND LOCKER RENTAL

In the Division of Chemistry and Chemical Engineering an annual deposit of $15.00 is required (payable on registration day at the beginning of the first term) to cover breakage and loss of laboratory materials. There are also small deposits for locker keys, and for padlocks issued in the drawing rooms. Deposits, in amounts specified by the departments concerned, are also required to cover the expenses of inspection trips taken by

students in various courses. Lockers in Throop Hall may be rented by those who desire them at 50 cents a term.

BOOKS AND SUPPLIES

The cost of books and supplies for the first year is about $65.00. In the upper classes the cost is generally less than this, but varies in different courses.

STUDENT HOUSES

Expenses in the Student Houses are as follows:

For room and 15 meals a week $323.00 a year, payable in six installments during the academic year, as specified in the contract which is signed by each applicant for accommodations in the Houses. For room and 21 meals a week, $382.50 a year, payable as in the case of the above specified rate.

There is also a charge of $1.00 a term for telephone service; long distance toll charges being billed monthly.

Students in the Houses must supply their own blankets, bed linen and towels. Laundry service, including the supplying of bed linen and towels, is provided, however, at a charge of 25 cents a week if desired.

House dues of $2.00 a term are payable with other fees on registration day. These dues are collected by the Institute for the House organizations in the four Houses and are used by them to cover the expenses of their social and other House activities.

There is a deposit of $10.00 payable by each student making reservation for accommodations in the Student Houses, this payment, upon occupancy of the room, constituting a deposit against breakage and loss. This deposit is not refunded if a student leaves the Student House during the year.

Application for rooms in the Student Houses may be made by addressing the Secretary of the Institute.

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 $5,000 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 may be made to the Secretary of the Institute.

STUDENT EMPLOYMENT

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

Registration and General Regulations

Registration for the second term, 1933-1934, will take place January 2, 1934 (9 A.M. to 3 P.M.); for the third term, March 26, 1934 (9 A.M. to 3 P.M.). Registration for the first term, 1934-1935, will take place, for freshmen, September 20, 1934 (8:30 A.M.), for transfers from other colleges, September 20-21, 1934 (9 A.M. to 3 P.M.), and for other students, September 21, 1934 (9 A.M. to 3 P.M.). A special fee of two dollars is charged for registration after these dates.

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

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

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

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

It is taken for granted that students enter the Institute with serious purpose. The moral tone is exceptionally good; and the honor system prevails in examinations, and in all student affairs. A student who is known to be exercising a harmful influence on the student life of the Institute may be summarily dismissed, whatever be his scholastic standing.

Scholastic Grading and Requirements

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

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

Incomplete means that the student has been prevented from completing the required work of the subject on account of sickness or other emergency. This mark will only be given in those cases where the student has carried with a grade of 2 or better at least three-fourths of the required work of the subject. The balance of the work should be completed during the next term in residence by the date fixed for the removal of conditions and the grade of incomplete, unless an extension of time is granted by the Dean. When thus completed the record of incomplete shall not be considered a deficiency on the student's record.

Conditioned indicates deficiencies other than incomplete that may be made up without actually repeating the subject. A grade of 1 is given when the work is completed.

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

Term examinations will be held in all subjects unless the instructor in charge of any subject shall arrange otherwise. No student will be exempt from these examinations. Leave of absence from examinations may be obtained only from the Deans, and will be granted only in the case of sickness or other emergency.

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.

SCHOLASTIC REQUIREMENTS

The number of credits allowed for any subject is the number of units multiplied by the grade received. The number of units assigned to any subject in any term corresponds to the total number of hours per week devoted to that subject, including (1) classwork, (2) laboratory, drawing, or field work, and (3) estimated outside preparation. For fulfilling scholastic requirements set forth in the following paragraphs, *not less than 90 per cent of the credits required must be received in subjects other than Assembly and Physical Education.*

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

Any student placed on probation must withdraw from student activities or from outside employment, or must reduce the number of subjects he is taking, to a sufficient extent to enable him to meet the requirements. Any such student must report to the Dean of Freshmen in case he is a member of the freshman class, or to the Dean of Upper Classmen in case he is a member of a higher class, before entering upon the work of the ensuing term, and must arrange his schedule of studies and limit his outside activities in accordance with the advice of his Dean.

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

*At the end of the first term of his first year at the Institute a student who has failed to secure 80 credits may be refused registration (instead of being placed on probation), if it has become clear that he has not the qualifications required for the successful prosecution of an engineering or scientific course.

the preceding school year he did not receive 300 credits (corresponding to an average of 100 credits per term).

3. A student ineligible for registration because of failure to meet the requirements stated in the preceding paragraph may, if he desires, submit immediately to the Registrar a petition for reinstatement, giving any reasons that may exist for his previous unsatisfactory work and stating any new conditions that may lead to better results. Each such application will be considered on its merits. A student so reinstated who again fails to fulfil the scholastic requirements for registration will be granted a second reinstatement only under very exceptional conditions.

4. For *graduation* a total of 1,200 credits is required (corresponding to an average of 100 credits per term), as well as the satisfactory completion of the work of some one Option of the Course in Engineering or of the Course in Science, amounting to approximately 650 units.

5. At the close of each school-year the Committee on Honor Students awards *honor standing* to approximately 16 students who have completed the freshman year, and to 12-16 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 subsequent 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 special privileges and opportunities, such 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 3 or better in the work prerequisite to that subject.

6. A student will be *graduated with honor* who has received

on the average throughout his course, 145 credits per term, 130 of which result from grades 3 and 4 in subjects other than Physical Education and Assembly, 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.

If for any reason a student is carrying less than 40 units, the credits required (as stated in paragraphs 1 and 2 on pages 83-84) shall be prorated on the basis of 40 as a standard. For example, a man carrying 32 units of work shall be expected to obtain four-fifths of 80, or 64 credits, to remain off probation.

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

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

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

CANDIDACY FOR THE BACHELOR'S DEGREE

A student must file with the Registrar a declaration of his candidacy for the degree of Bachelor of Science on or before the first Monday of December preceding the date at which he expects to receive the degree. His record at the end of that term must show that he is not more than 21 units and not more than 40 credits behind the requirement in the regular work of his course. All subjects required for graduation, with the exception of those for which the candidate is registered during the last term of his study, must be completed by the second Monday of May preceding commencement.

Scholarships and Prizes

Twelve or more freshmen scholarships carrying $150 or $300 are awarded by the Institute upon the basis of a competition open to properly qualified male students in the senior classes of high schools or college preparatory schools. A group of competitors for these scholarships is selected by the committee from among the regular candidates for admission who take the spring entrance examinations given by the Institute. There is no special application blank for these scholarships.

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 will be designated Blacker Scholars or Drake Scholars, in recognition of the donors, Robert Roe Blacker and Nellie Canfield Blacker, or Mr. and Mrs. A. M. Drake.

Popular scientific lectures were given last year in San Diego, Santa Barbara, and Santa Ana by members of the Institute staff, the entire proceeds of which were devoted to providing scholarships for students of high standing in these communities who were in need of financial assistance. It is expected that these lectures will be continued this year and extended to other localities.

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, were granted honor standing on the basis described in paragraph 5 on page 84 of this Catalogue. In addition, a smaller number of tuition grants may be awarded to students of 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.

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.

Study and Research at the California Institute

Mathematics, Physics, and Chemistry are universally recognized as the fundamental sciences the development of which has supplied the main-spring of modern civilization. Accordingly, these subjects have been given an outstanding place in the program of the Institute.

Further, since the best education is that which comes from the contact of youth with creative and resourceful minds, the staff of the Norman Bridge Laboratory of Physics has been from the beginning a group of productive physicists rather than merely a group of teachers. The entering freshman makes some contact in his first year with practically all of the members of that 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.

It is the combination of a large graduate school of physics and a limited number of undergraduate students which makes the distinctive feature of the work in physics at the Institute. The instruction is done by the small group method, eighteen to a section, save for one rather elaborate demonstration lecture each week throughout the freshman and sophomore years. All of the members of the staff participate in giving these lectures. The undergraduate student who elects physics is usually given opportunity to participate as early as his junior or senior year in some one of the from thirty to sixty researches which are always under way in the laboratory. The average yearly output of the laboratory during the past five years has been from fifty to sixty major papers. There are three general seminars per week, which are regularly attended by all research workers, including in general ten or a dozen National and International Research Fellows and all graduate students, numbering from

forty to fifty. In addition there is a weekly theoretical seminar conducted for the benefit of those interested primarily in mathematical physics.

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

MATHEMATICS

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

CHEMISTRY AND CHEMICAL ENGINEERING

In the last two years of the Undergraduate Course of 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, as chemists in charge of the operation and control of manufacturing processes, and, in the case of the fifth-year Chemical Engineering Course, for 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 unusual professional opportunities both on the scientific and applied sides, more specialized study and research leading to the degree of Doctor of Philosophy is provided at the Institute in the fields of inorganic, physical, organic, and biological chemistry.

The character of the instruction in chemistry may be briefly described as follows: The freshman course, which is taken by all students of the Institute, differs much from that usually given in American colleges in that it consists in intensive work in certain important fields of the subject, rather than in an attempt to give a general survey of the subject, which has been in some measure already afforded by the required high-school course. Thus the freshman work begins with instruction in accurate volumetric analysis, since the student appreciates chemical principles and can effectively deal with their applications in the laboratory only after he has learned to think and work quantitatively. In the first term, along with the volumetric analysis, there are taken up stoichiometry and the principles relating to reactions in aqueous solutions, such as mass-action, solubility effects, neutralization, indicators, strength of acids and bases, hydrolysis of salts, and distribution between phases. The second term is devoted to exact qualitative analysis, where these principles and those relating to oxidation and reduction are further applied to solutions; and the third term is devoted to a laboratory course in selected inorganic preparations and to a survey, in the lectures and class exercises, of descriptive inorganic chemistry.

The second-year work in chemistry, which is taken by all students in the Course in Science, consists on the laboratory side of gravimetric, advanced qualitative, and electrometric analysis; but the class work is largely devoted to the discussion of 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, undertake minor researches in place of the regular 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. Also in the subjects of organic and applied chemistry problems are a feature.

The supervision of the research work of graduate students is distributed among the whole staff of the Division of Chemistry. Each staff member takes charge of only three to five students who desire to work in his special field, so that each student receives a large amount of attention. Thus in physical chemistry the lines of research now being actively pursued by graduate students in cooperation with the staff are: equilibria and free-energies at high temperatures; reduction-potentials in solution, especially of the rarer elements; the rates of homogeneous gas reactions; the photochemistry of reactions; band spectra in their chemical relations; crystal and molecular structure determined by X-rays and correlated with the newer quantum theories.

ENGINEERING

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

The plan of instruction 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. Additional work is offered leading to the Ph.D. degree. The Civil, Mechanical and Electrical Engineering groups are not separated until the third year, all 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. Courses 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 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.

CIVIL ENGINEERING

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

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.

ELECTRICAL ENGINEERING

The science of electrical engineering has, due to great expansion in the use of networks and complicated circuits and the invention of new types of intricate machinery, been compelled to apply to the analysis of the phenomena occurring therein many of the recent advances in physics and mathematics. Such a status demands electrical engineers qualified to conduct researches involving a knowledge of mathematics, physics, and electrical engineering far in excess of that obtainable in an undergraduate engineering course. To meet this need the Institute has provided courses of graduate study and research in electrical engineering which may be taken by students who have completed the five-year engineering course at the Institute, or by students from other colleges who have substantially the same preparation. 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 school of 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 by providing special work for undergraduate students wishing to do a limited amount of research work.

AERONAUTICS

With the aid of the Daniel Guggenheim Fund for the Promotion of Aeronautics, the California Institute of Technology has established a Graduate School of Aeronautics and has constructed

The Daniel Guggenheim Laboratory of Aeronautics containing a ten-foot, high-speed wind tunnel. The Daniel Guggenheim Fund has also provided funds for the Daniel Guggenheim Airship Institute located at Akron, Ohio. This laboratory contains a six-foot wind tunnel and other experimental facilities for lighter-than-air research, so that the Institute is carrying on theoretical and experimental work in the lighter-than-air field both at Pasadena and at Akron. Both laboratories are under the direction of Dr. Th. von Kármán, who is in charge of the experimental and theoretical researches.

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 and mechanics, taught by Professors Theodor von Kármán, Harry Bateman, Eric T. Bell, Paul S. Epstein, Beno Gutenberg, Clark B. Millikan, and Arthur L. Klein.

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

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 American air masses.

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 departments 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 a definite option leading to such graduate study and research. This affords a broad and thorough preparation in the basic science and engineering upon which aeronautics rests, and includes an introductory survey course in aeronautics in the senior year.

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

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 is offered for the degree of Doctor of Philosophy. This degree is given under the same general conditions as those that obtain in the other courses offered at the Institute.

GEOLOGICAL SCIENCES

Through the generosity of Mr. and Mrs. Allan C. Balch, there has been established at the California Institute the Balch Graduate School of the Geological Sciences. The work of this school at the present time comprises the instruction and research being carried on in the various branches of geology, in vertebrate and invertebrate paleontology, and in seismology, the last named in cooperation with the Carnegie Institution of Washington.

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

The curriculum outlined for undergraduate study provides a broad and thorough preparation in the related basic sciences and an introduction to the fundamental principles of geology and paleontology. Fifth year courses lead to the degree of Master of Science. During the senior year of the undergraduate course and throughout the fifth year courses in geology and paleontology, much time will be devoted to investigation, but students desiring to become research men or professional geologists and paleontologists will continue their work at least two years more for the degree of doctor of philosophy.

INSTRUCTION IN GEOLOGY AND PALEONTOLOGY

The elementary geological subjects are given (1) to convey a broad concept of the constitution and structure of the earth, of its origin and history, and of the evolution of life upon it, (2) to afford to engineering students a knowledge of geology required by them in professional practice, and (3) to furnish the basis for advanced work and research in the geological sciences.

Students who complete the Fifth-Year Course in Geology are prepared for geological positions with oil and mining companies and on government and state geological surveys, but further graduate work (leading to the Doctor's degree) is very desirable for those who are preparing themselves for university and museum positions in geology and paleontology and for service as professional geologists.

OPPORTUNITIES FOR RESEARCH IN GEOLOGY AND PALEONTOLOGY

Within convenient reach of Pasadena occurs an almost unrivaled variety of rock types, geologic structures, and physiographic forms. Field studies can be conducted comfortably throughout the entire year, and this constitutes an 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 presence of many productive oil fields, of large Portland cement plants, and of gem-producing districts in Southern California afford exceptional opportunities to students interested in economic geology. Moreover, the gold, silver, quicksilver, and copper de-

posits of the Sierra Nevada and Coast Ranges of California are within comparatively easy reach, and the varied metalliferous deposits of Arizona and Southern Nevada are also available for visit and research.

Excellent opportunities exist for studies in physical and geological seismology. A fully equipped Seismological Research Laboratory is situated on a site west of the Arroyo Seco in Pasadena. The laboratory is devoted to researches conducted both by the Carnegie Institution of Washington and the California Institute of Technology, and graduate students in the Division of Geology and Paleontology will be received in the Laboratory for the purpose of taking part in the researches or of becoming acquainted with seismological methods.

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

TEACHING AND RESEARCH FELLOWSHIPS

Fellowships are available for properly qualified students who desire to pursue advanced work in geology and paleontology, as in other branches of science; see page 121.

BIOLOGICAL SCIENCES

A Department of Biology, rather than the traditional departments of Botany and Zoölogy, has been established, in order to emphasize the unity of the phenomena of living organisms rather than their manifold diversities. That there are many properties common to the two great branches of the living world has become

abundantly manifest in recent years. For example, the same principles of heredity that obtain among flowering plants apply also to human traits, and in their response to light, animals and plants conform to common laws of physics. It is true that, at what may be called the biological level, an immense diversity of form and function manifests itself, but enough insight has already been gained to make evident that this diversity is in large part due to permutations and combinations of relatively few fundamental and common properties. It is in the search for these properties that the zoologist and botanist may profitably pool their interests. In the development of modern physiology the fundamental chemical processes in animals, higher plants, yeasts and bacteria are so similar that discoveries in one field elucidate or suggest interpretations in others. The geneticist who works with animals will know only half his subject if he ignores the work on plants, and both plant and animal geneticists will fail to make the most of their opportunities if they overlook the advances in cytology and embryology. It is, then, with the intention of bringing together in sympathetic union a group of investigators whose interests lie in the fundamental aspects of their subjects, that a department of Biology has been organized.

As in the other departments of the Institute, emphasis is placed primarily on research and graduate study; and, even in these directions, no attempt is made to cover at once the whole science of biology, but rather efforts are concentrated on the development of those of its branches which seem to offer the greatest promise as fields of research. It is proposed to organize groups of investigators in general physiology, biophysics, biochemistry, genetics and developmental mechanics. The choice of these fields of modern research implies that emphasis will be laid on the intimate relations of biology to the physical sciences. That a closer association of these sciences with biology is imperative is becoming more and more apparent as indicated by the development of special institutes for such work.

An experimental farm for plant genetics has been established near the Institute; a special laboratory, equipped for work in plant physiology, has been built; and a marine station at Newport Bay gives an opportunity for work in experimental embryology and biology.

ASTROPHYSICS

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

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

The new observatory will consist of two main features. One of these will be the 200-inch telescope, with its building, dome,

and auxiliary equipment, to be erected on the most favorable high-altitude site that can be found within effective working distance of the associated groups of investigators and their extensive scientific equipment. The other will be an Astrophysical Laboratory located on the Institute campus, which will serve as the headquarters in Pasadena of the Observatory Staff and of the Graduate School of Astrophysics. Its equipment will include instruments and apparatus for the measurement of photographs, the reduction and discussion of observations, and for such astrophysical investigations as can be made there to the best advantage. Its instruments for the interpretation of astrophysical phenomena will be designed to supplement those of the laboratories of the Institute and the Pasadena laboratory of the Mount Wilson Observatory. 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, consisting of four members of the Executive Council of the Institute, has been placed by the trustees in full charge of the design, construction, and operation of the Astrophysical Observatory and Laboratory. With the approval of the Carnegie Institution of Washington, Dr. John A. Anderson, of the Mount Wilson Observatory, has been appointed

by the Observatory Council as its Executive Officer, in direct charge of design and construction. An Advisory Committee, including the Director and Assistant Director of the Mount Wilson Observatory and many other prominent astronomers and physicists, aid the Observatory Council in determining matters of policy. The organization of the Observatory Council and the personnel of its Advisory Committee are shown on page 52 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. A new form of Pyrex glass has been chosen as the best available material, after much experimental work, and it is hoped that the rough disk for the 200-inch mirror will be cast and annealed in 1934.

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 the Warner & Swasey Company, Dr. Frank E. Ross, the Bausch & Lomb Optical Company, Sir Herbert Jackson, Sir Charles Parsons, the Philips Lamp Works, Professor Joel Stebbins, and others. The Research Laboratory of the Eastman Kodak Company has generously agreed to deal with many of the special photographic problems. A Zeiss recording microphotometer has been obtained, and is being used in a comparative study of various forms of this instrument. The radiometer recently used very successfully by Dr. C. G. Abbot, of the Smithsonian Institution, in measuring the distribution of energy in the spectra of stars of several types has been materially improved and Dr. Sinclair Smith has completed an exhaustive investigation of radiometers of the most sensitive type. The spectrograph objective devised by Rayton has greatly increased the range of the 100-inch telescope and made possible the recent researches of Hubble and Humason on the expanding universe. The new photo-electric amplifier will also extend very greatly the range of the 100-inch

and 200-inch telescopes for other classes of work. A comparative study of possible sites for the 200-inch telescope has been made by Dr. J. A. Anderson, aided by a dozen trained observers.

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

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.

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 engineering, the professional studies monopolize nearly all the available time and money, leaving the humanities to take what is left, which usually turns out to be very little.

This has been particularly unfortunate. It has recruited into the engineering profession large numbers of young men with inadequate cultural backgrounds, lacking in social sympathy, in breadth of outlook, and in their acquaintance with those imponderable forces which even engineers have to take into account. It has crowded into the lower ranks of the engineering vocation too many unimaginative routineers who get no farther than the drafting-room. That should not be the case, for there

is no good reason why engineers should be more limited in their intellectual versatility, or in the range of their human interests, than men of any other profession. Many of them are not. On the contrary, there are those who have shown, time and again, that scientific erudition can be illuminated by humanism, and technical skill vivified by imagination. It is to men of this type that the world must continue to look for leadership in all branches of science, and it is to the training of such men that the energies of the California Institute are primarily directed.

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

One of the largest and most attractive buildings on the Institute campus is devoted to the work in Literature, Languages, Philosophy, Economics, History, and Government. This Hall of the Humanities, erected in 1928, was given by Mr. and Mrs. Joseph B. Dabney, of Los Angeles. In connection with the ac-

ceptance of this gift, a special endowment fund of $400,000 was raised for the support of instruction in the humanistic fields, this amount being subscribed by several friends of the Institute.

In addition to the regular staff of the Institute, several scholars from other institutions are giving instruction in the Division of the Humanities during the current year. Among these are Professor A. O. Craven, of the University of Chicago, Professor Godfrey Davies, formerly of the same institution, Professor Louis B. Wright, formerly of the University of North Carolina, and Professor Hardin Craig 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.

Information and Regulations
for the Guidance of Graduate Students

A. GENERAL REGULATIONS

I. REQUIREMENTS FOR ADMISSION TO GRADUATE STANDING

1. The Institute offers graduate work leading to two higher degrees, the degree of Master of Science, and the degree of Doctor of Philosophy. To be admitted to graduate standing at the Institute an applicant must in general have received a Bachelor's degree representing the completion of an undergraduate course in science or engineering substantially equivalent to one of those courses offered by the Institute. He must, moreover, have attained such a scholastic record and, if from another institution, must present such recommendations as indicate that he is fitted to pursue with distinction advanced study and research.

2. Application for admission to graduate standing at the Institute for work toward either the Master's or the Doctor's degree should be made upon a form which can be obtained from the Registrar. The applicant should state the degree for which he wishes to work. If the applicant's preliminary training in science, mathematics, and engineering has not been substantially that given by the four-year undergraduate courses at the Institute, he must pursue such undergraduate subjects as may be assigned. Since admission to graduate work will be granted to only a limited number of students of superior ability, applications should be made as long as possible before the opening of the school year, preferably by the first of March. Students applying for assistantships or fellowships need not make separate application for admission to graduate standing. See Section D I.

3. Admission to graduate standing does not of itself admit to candidacy for the degree of Master of Science or Doctor of Philosophy. As to this, see pages 107, 109, 116-121.

II. TUITION FEES

In the school year 1934-35 and thereafter the tuition fee for graduate students pursuing courses of more than 32 units will be $300 a year, payable in three equal installments of $100 at the beginning of each term.* Graduate students who continue their researches during the summer are not required to pay tuition fees therefor.

No other fees are required of graduate students; but charges may be made for breakage and supplies. Students working in the chemical laboratories are required to make a deposit of $15 at the beginning of the school year to cover these charges. No degrees are awarded until all bills due the Institute have been paid.

In regard to fellowships and assistantships, see page 121 of this Catalogue. In addition there are available for students with high scholastic attainments *graduate scholarships* covering one-half or the whole of the tuition fee. For such students *loans* also may be arranged, for which application should be made to the Student-Aid Committee.

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

I. GENERAL REQUIREMENTS

To receive the degree of Master of Science, the student must complete in a satisfactory way the work indicated in the schedule of one of the Fifth-Year Courses, as well as in the schedule of the Four-Year Course in Science or in Engineering (see pages 128-145), 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.

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*Except that the tuition fees of students who began their graduate work at the Institute prior to September, 1933, and have since been continuously in residence will be at the rates described in last year's Catalogue.

Senior students at the Institute desiring to return for a fifth year will file an application with the representative of the department in which they expect to do their major work, and such application will be passed upon by the Engineering or the Science Course Committee. Such students will be expected to present satisfactory scholarship qualifications, and to have demonstrated a capacity for doing advanced work.

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

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

II. REGISTRATION

1. The regulations governing registration and student responsibilities as given for undergraduate students on page 81 of the Catalogue apply also to Fifth-Year students.

2. Before registering, the graduate student should consult with members of the department in which he is taking his work

to determine the studies which he can pursue to the best advantage.

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

4. Applications for registration in excess of the prescribed number of units must be approved by the Committee on Courses in Science or by the Committee on Courses in Engineering and will be conditioned upon the quality of work done in the preceding term.

III. SCHOLASTIC REQUIREMENTS

1. Scholastic Requirements given on page 82 of the Catalogue for undergraduate students, with the exception of paragraphs 5 and 6, also apply to Fifth-Year students.

2. In the case of a student registered for a Master's Degree and holding an Assistantship or Teaching Fellowship, the actual number of hours per week required by the teaching shall be deducted from the total number of units for which the student may register.

IV. THESIS

In the Division of Geology and Paleontology, a complete first draft of theses presented in partial fulfillment of the requirements for the degree of Master of Science must be submitted to the supervising instructor by the first of May. Two final copies of theses must be filed with the Division by the first of June.

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

I. GENERAL REGULATIONS

The degree of Doctor of Philosophy is conferred by the Institute 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 term 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 for special requirements for the Doctor's degree in Mathematics, Physics and Electrical Engineering, Section VII for special requirements in Chemistry, and Section VIII for special requirements in Geology.

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.

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 car-

rying 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 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.

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.

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 shall, after consultation with the chairman of the division, arrange otherwise. No student taking a course for credit shall be exempt from these examinations when held.

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

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

V. 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 minor subjects, and must involve not less than 45 units of advanced study.

2. *Residence:* At least three years of work in residence subsequent to a baccalaureate degree equivalent to that given by the

Institute are required for the Doctor's degree. Of this at least one year must be in residence at the Institute. It should be understood that these are minimum requirements, and students must usually count on spending a somewhat longer time in residence.

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

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

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 the removal of conditions, 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.

Special examinations, or the final examinations in specified courses, are required by certain departments for admission to candidacy for the Doctor's degree. (See Sections VI, VII, VIII and IX.)

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 chairman of the Committee on Graduate Study after consultation with the division chairman.

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

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.

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

Before submitting his thesis to the Chairman of the Committee

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

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 1st of the year in which the degree is to be conferred.

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

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

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

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

Modern Algebra, Ma. 101 a, b, c, including the Galois Theory; Relativity, Ma. 205; or Modern Analysis, Ma. 201, Modern Differential Geometry, Ma. 256, Introduction to Higher Geometry, Ma. 102, and any one of the courses, other than the purely mathematical, listed under 1, b, preferably Ph. 101 a, b, c, or Ph. 103 a, b, c.

b. To be recommended for candidacy for the Doctor's degree

in Physics the applicant must pass the following courses with a grade of 2 or better: Electricity and Magnetism, Ph. 101 a, b, c, Analytical Mechanics, Ph. 103 a, b, c, Optics, Ph. 105 a, b, and Atomic Physics, Ph. 107 a, b, c. In case the applicant's minor is in Mathematics he must also pass with a grade of 2 or better one of the following courses: Advanced Calculus, Ma. 8 a, b, c, Differential Equations, Ma. 10 a, b, c, and Mathematical Analysis, Ma. 201, first term, plus two terms in any of the courses Ma. 106-109 (second and third terms), 111, 113 a, b, c. In case the applicant's minor is in Chemistry he must also pass with a grade of 2 or better: Chemical Principles, Ch. 21 a, b, c.

c. To be recommended for candidacy for the Doctor's degree in Electrical Engineering the applicant must pass the following courses with a grade of 2 or better: Analytical Mechanics, Ph. 103 a, b, c, or Applied Mechanics, AM. 1 a, b, and Strength of Materials, AM. 1 c; Electricity and Magnetism, Ph. 101 a, b, c; Advanced Calculus, Ma. 8 a, b, and Differential Equations, Ma. 11, or Introduction to Mathematical Physics, Ph. 5 a, b, c; Alternating Current Analysis, EE. 120; Advanced Alternating Current Machinery, EE. 122; Transmission Lines, EE. 144; Dielectrics, EE. 152.

2. An applicant may also satisfy the requirement by taking an examination in the subject with the instructor in charge.

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

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

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

A student in Electrical Engineering will, in general, be ex-

pected to have had six months or more of practical work in manufacturing, operating, or engineering research, in addition to the time required for college residence.

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

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

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

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

3. Applicants must also show by examination or otherwise that they are reasonably proficient in mathematics and physics. The requirement in these subjects includes a thorough working knowledge of all the topics covered in the first two years of the Institute Undergraduate Courses.

4. With his application for admission to candidacy the applicant must also submit a carefully prepared complete report on the progress of his research up to the date of his application. By this report and his laboratory work the applicant must have given evidence of his industry and ability in research, and of his

power to present his results in clear, forceful language and with discrimination as to what is essential in scientific papers.

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

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

7. 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 in Mechanical Engineering.

VIII. SPECIAL REGULATIONS RELATING TO CANDIDACY FOR THE DOCTOR'S DEGREE FOR STUDENTS MAJORING IN THE DIVISION OF GEOLOGY AND PALEONTOLOGY

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

1. To be admitted to candidacy for the Doctor's Degree in the Division of Geology and Paleontology the applicant must have shown more than average ability in mastering the previous geological and paleontological 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. Students who have not been admitted to candidacy before the end of their second year of graduate study at the Institute will not be permitted to register for further work.

4. 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).

5. 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 Ph.D. thesis and a test of the candidate's knowledge in the specialized fields of his major and minor subjects.

6. A first draft of the Ph.D. thesis with data, maps, and illustrations complete must be submitted to the professor in charge not later than February 1st. Two copies of the final, revised thesis must be filed by April 20th 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.

IX. SPECIAL REGULATIONS RELATING TO CANDIDACY FOR THE DOCTOR'S DEGREE FOR STUDENTS MAJORING IN AERO-NAUTICS, CIVIL AND MECHANICAL ENGINEERING

In agreement with the general requirements for higher degrees adopted by the Committee on Graduate Study, as stated in Section V, the Division of Civil and Mechanical Engineering has adopted the following supplementary regulations:

1. To be recommended for candidacy for the Doctor's degree in the respective departments the applicant must pass the following courses with a grade of 2 or better, or satisfy the requirements by passing special examinations.

a. *Aeronautics:* Introduction to Mathematical Analysis, Ma. 109 a, b, c, or Engineering Mathematical Physics, EE. 226 a, b, c; Aerodynamics of the Airplane, AE. 251 a, b, c; Theoretical Aerodynamics I, AE. 266 a, b; Airplane Design, AE. 252

a, b, c, or Analytical Mechanics, Ph. 103 a, b, c, or Elasticity Applied to Aerodynamics I, AE. 270.

b. *Civil Engineering:* Statically Indeterminate Structures, CE. 23, Structural and Civil Engineering Design, CE. 21 a, b, c; Irrigation and Water Supply, CE. 15; Sewerage, CE. 17; Masonry Structures, CE. 16; Differential Equations, Ma. 11, or Introduction to Mathematical Physics, Ph. 5 a, b, c, or Advanced Calculus, Ma. 8 a, b, c.

c. *Mechanical Engineering:* Two of the following: Thermodynamics, ME. 120; Advanced Machine Design, ME. 101 a, b; Theoretical Aerodynamics I and II, AE. 266 a, b, AE. 267; Science of Metals, ME. 110 a, b, c; and Introduction to Mathematical Physics, Ph. 5 a, b, c, or Engineering Mathematical Physics, EE. 226 a, b, c, and Advanced Calculus, Ma. 8, or Differential Equations, Ma. 11, or Vector Analysis, Ma. 14.

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. 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 free tuition ($300) with or without an additional grant.

Most of the major grants consist in providing, for a continuous period of ten months, board in the Athenæum (see pages 66 and 123) and lodging in the Athenæum loggia, the dormitory, or student houses. The purpose of this plan is to enable the Fellows and Assistants of the various Divisions to live together under attractive and healthful conditions, and thus secure the great educational and social advantages that result from intimate

contacts with one another, with members of the professorial staff of the Institute, and with others using the Athenæum.

In the award of graduate scholarships and fellowships preferred consideration will be given to students who have been accepted as candidates for the Ph.D. degree.

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 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 chairman of the Committee on Graduate Study. When possible, these applications should reach the Institute before March 1st, and notices of awards will be mailed to successful applicants on March 20th. Appointments to Fellowships and Assistantships are for one year only; and a new application must be filed before March 1st of each year by all who desire appointments for the following year, regardless of whether they are already holders of such appointments or not.

II. RESEARCH FELLOWSHIPS

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 additional research work.

2. The National Research 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. The American Petroleum Institute is supporting the work of several Research Fellows at the California Institute. The researches of these Fellows relate to fundamental properties of petroleum and natural gas.

4. The Inspiration Consolidated Copper Company has provided a fund for research on certain phases of the copper leaching process.

III. INSTITUTE GUESTS

Members of the faculties of other educational institutions and Research Fellows who have already received their Doctor's degree and desire to carry on special investigations may be granted the privileges of the facilities of the Institute, without payment of fees. Arrangement should be made in advance with the Chairman of the 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 66) affords opportunity for contact between the Associates of the Institute, distinguished foreign visitors, and members of the staffs and graduate students at the three adjacent institutions, the Mount Wilson Observatory, the Huntington Library, and the California Institute. It also provides living quarters for a limited number of men associated with the foregoing institutions, including specially economical sleeping quarters for about a dozen graduate students.

Description of the Undergraduate and Fifth-Year Courses

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 coordinated with it so as to constitute a harmonious, unified, five-year period of study, with no sharp breaks between the undergraduate and graduate periods, will afford the more intensive training required by the engineer who is to do creative work in his field.

The four-year Course in Engineering includes an unusually thorough training in physics and mathematics, and instruction in chemistry and geology; also extended courses, continuing throughout the four years, in humanistic studies, including English writing and speaking, literature, evolutionary science, history of civilization, current social and political problems, and economics; and, finally, those engineering subjects common to all branches of engineering, such as surveying, mechanism, descriptive geometry, machine drawing, applied mechanics, en-

gineering materials, hydraulics, and preliminary courses in Civil, Mechanical, and Electrical Engineering.

The fifth-year Courses in Civil, Mechanical, Electrical, and Aeronautical Engineering consist mainly of the engineering subjects that are fundamental in these separate branches of engineering. Thus the Civil Engineering Course deals largely with the analysis, design and construction of 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 Aeronautical Engineering Course with the principles of aerodynamics, the design and construction of airplanes, their engines and instruments. Of all these Courses, engineering research or design forms an important part.

THE COURSES IN SCIENCE

The Courses in Science prepare for those scientific and engineering professions in which an intensive training in the basic sciences and in research is of more importance than a knowledge of the principles and practice of engineering. Accordingly, the four-year Course in Science, while including the same historical, literary and economic subjects as the Course in Engineering, requires much more extended study of the three sciences of chemistry, physics, and mathematics; also two years' study of scientific German and French. In its junior and senior years there are offered a series of Options which, when supplemented by the corresponding fifth-year Courses, afford definite preparation for various scientific professions, as outlined in the following statement.

The Option in Chemistry and the Option in Physics and the fifth-year Courses in Chemistry and Physics prepare students, on the chemical and physical sides respectively, for research and

teaching in universities, colleges, and high schools, and for re-search positions in government laboratories and especially in the research and development departments of the larger chemical, metallurgical, and electrical companies.

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

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

The Biology Option and the Graduate Course in Biology 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 take Assembly (1 unit) and Physical Education (3 units) 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 146-224. The abbreviations denote the various branches of instruction as follows:

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

BOTH COURSES

FIRST YEAR, ALL THREE TERMS

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

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

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

***Students with a recommended high school credit of ½ unit or more in mechanical drawing, and all science students, take D 1; others take D 4. All freshmen are required to take D 12a and D 12b the second and third terms, respectively.

COURSE IN ENGINEERING

	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		....
Ch 6	Engineering Chemistry (4-0-7)	....	....	11
D 6	Machine Drawing (0-6-0)		6 or 6	
D 9	Structural Drawing (0-6-0)	6 or 6		....
D 12c	Descriptive Geometry (0-3-0)	3 or 3		....
D 12d	Descriptive Geometry (0-3-0)	....	3 or 3	

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

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

**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

FIRST AND SECOND YEARS
See pages 128 and 129

	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
Ge 1a	Geology (3-3-3)	9	....	....
Ec 17	Accounting (3-0-6)	9	....	....
EE 2	Direct Currents (3-0-6)	....	9	....
EE 3	Direct Current Laboratory (0-3-3)	....	6	....
EE 4	Alternating Currents (3-0-6)	....	....	9
EE 5	Alternating Current Laboratory (0-3-3)	....	....	6
A: Ma 11	Differential Equations (3-0-6)	9	....	....
Me 15	Heat Engineering (3-3-6)	....	12	....
Hy 1	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)	....	6	6
EE 7	Electrical Engineering Laboratory (0-3-3)...	....	....	6
EE 12 } or	Electric Circuits (3-0-6)	9	....	....
EE 163 }	Radio (3-0-6)	9	....	....
EE 70 abc	Engineering Conferences	2	2	2
AM 3	Testing Materials (0-3-3)	....	....	6
Ph 7 abc	Electricity and Magnetism (2-0-4)..........	6	6	6
Ph 9 ab	Electrical Measurements (0-3-1)	4	4	....
A: CE 9	Structures (3-3-6)	....	....	12
Hy 2	Hydraulics Laboratory (0-3-3)	6	....	....
ME 25	Heat Engineering Laboratory (0-3-3)	6	....	....
ME 18	Heat Engineering (3-0-7)	....	10	....
B: EE 162	Vacuum Tubes (4-0-8)	....	....	12
ME 15	Heat Engineering (3-3-6)	....	12	....
Hy 1	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 (Untereiner)
    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).

COURSE IN ENGINEERING

CIVIL ENGINEERING OPTION

FIRST AND SECOND YEARS
See pages 128 and 129

	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	....	....
Ge 1a	Geology (3-3-3)	9	....	....
Ec 25	Business Law (3-0-3)	6	....	....
Hy 1	Hydraulics (3-3-6)	....	12	....
Ec 17	Accounting (3-0-6)	....	9	....
CE 4	Highway Engineering (3-0-3)	....	6	....
ME 15	Heat Engineering (3-3-6)	....	....	12
Ec 2	Economics (4-0-6)	....	....	10
Hy 2	Hydraulics 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
CE 14 abc	Engineering Conferences	2	2	2
AM 3	Testing Materials (0-3-3)	....	6	....
CE 8 abc	Railway Engineering	6	6	6
CE 10 abc	Theory of Structures	12	12	9
CE 12	Reinforced Concrete (3-3-6)	....	....	12
EE 8	Direct Currents (3-0-4)	7	....	....
EE 9	Direct Current Laboratory (0-3-2)	5	....	....
Hy 3	Hydraulic Problems (0-6-0)	6	....	....
EE 10	Alternating Currents (3-0-4)...............	....	7	....
EE 11	Alternating Currents Laboratory (0-3-2).....	....	5	....
	Elective	....	....	9

*See first footnote on page 130.

COURSE IN ENGINEERING

MECHANICAL ENGINEERING OPTION

FIRST AND SECOND YEARS
See pages 128 and 129

	THIRD YEAR	Units per Term		
		1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
AM 1 abc	Applied Mechanics (4-3-7)	14	14	14
Hy 1	Hydraulics (3-3-6)	12	....	....
Ge 1a	Geology (3-3-3)	9	....	....
Ec 25	Business Law (3-0-3)	6	....	....
ME 15	Heat Engineering (3-3-6)	....	12	....
Ec 2	Economics (4-0-6)	....	10	....
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	Heat Engineering Laboratory (0-3-3)	....	....	6

FOURTH YEAR

		1st	2nd	3rd
	Humanities Electives* (3-0-6)	9	9	9
H 5 ab	Current Topics (1-0-1)	2	2	....
H 10	U. S. Constitution (1-0-1)	....	....	2
ME 50	Engineering Conferences (1-0-1)	2	2	2
AM 3	Testing Materials (0-3-3)	6	....	....
CE 9	Structures (3-3-6)	....	12	....
ME 5a	Machine Design (2-3-4)	9	....	....
ME 5b	Machine Design (3-3-6)	....	12	....
ME 5c	Machine Design (0-9-0)	....	....	9
ME 10	Metallurgy (2-0-4)	....	....	6
ME 17	Heat Engineering (3-0-6)	9	....	....
ME 26	Heat Engineering Laboratory (0-3-3)	....	6	....
EE 8	Direct Currents (3-0-4)	7	....	....
EE 9	Direct Currents Laboratory (0-3-2)	5	....	....
EE 10	Alternating Currents (3-0-4)	....	....	7
EE 11	Alternating Currents Laboratory (0-3-2)....	....	5 or	5
	Elective†	....	6	9

*See first footnote on page 130.
†Ma 11—Differential Equations advised for all who expect to take fifth year.

COURSE IN ENGINEERING
AERONAUTICS OPTION

THIRD YEAR

		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	Hydraulics (3-3-6)	12	....	....
Ge 1a	Geology (3-3-3)	9	....	....
Ec 25	Business Law (3-0-3)	6	....	....
ME 15	Heat Engineering (3-3-6)	....	12	....
Ec 2	Economics (4-0-6)	....	10	....
Hy 2	Hydraulics Laboratory (0-3-3)	....	6	....
Ec 17	Accounting (3-0-6)	....	....	9
ME 25	Heat Engineering Laboratory (0-3-3)	....	....	6
EE 8	Direct Currents (3-0-4)	....	....	7
EE 9	Direct Currents Laboratory (0-3-2)	....	....	5

FOURTH YEAR

		1st	2nd	3rd
	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
Ma 8 abc	Advanced Calculus (3-0-6)	9	9	9
Ma 11	Differential Equations (3-0-6)	9	....	....
ME 8	Machine Design (3-3-6)	12	....	....
ME 10	Metallurgy (2-0-4)	6	....	....
AM 3	Testing Materials Laboratory (0-3-3)	....	6	....
AE 1	Aeronautics (3-0-6)	....	9	....
CE 11 ab	Structures (3-0-6)	....	9	9
EE 10	Alternating Currents (3-0-4)	....	....	7
EE 11	Alternating Currents Laboratory (0-3-2)	....	....	5
	Elective	....	5	8

PERMISSIBLE ELECTIVES IN THE FOURTH YEAR

		1st	2nd	3rd
Ma 8 abc	Advanced Calculus	12 or 9	12 or 9	12 or 9
Ma 11	Differential Equations	9	or	9
Ma 14	Vector Analysis	....	....	12
Bi 1, 2	Biology	....	9	9
Ge 1b	Paleontology	....	....	9
CE 12	Reinforced Concrete	....	....	12
AE 1	Aeronautics	....	9	....
ME 10	Metallurgy	6	or	6
Ec 18	Industrial Accounting	....	6 or	6
Ec 19	Industrial Statistics	....	....	9
AE 257	Laboratory Methods in Aeronautics	6	....	....
Ec 20	Financial Organization	8	....	....
	Special Problems or Research (Units to be arranged)			

*See first footnote on page 130.

COURSE IN SCIENCE

FIRST YEAR
See page 128

	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)	10	10	....
Ge 1a	Geology (3-3-3)	9	....	....
Bi 1	Biology (3-3-3)	....	9	....
Ge 1b	Paleontology (4-1-4) or ⎤			
Bi 2	Biology (3-4-2) or ⎬	....	....	9
Ay 1	Astronomy (3-1-5) ⎦			
	Options as below	....	....	10

OPTIONS

CHEMISTRY AND APPLIED CHEMISTRY
Ch 12c	Analytical Chemistry and Chemistry Review** (2-6-2)	....	....	10

PHYSICS OR APPLIED PHYSICS
Ch 43	Organic Chemistry (2-6-2)	....	....	10

BIOLOGY
A: Ch 43	Organic Chemistry (2-6-2)	....	....	10
B: Ch 12c	Analytical Chemistry and Chemistry Review (2-6-2)	....	....	10

MATHEMATICS OR PHYSICS
Ma 3	Theory of Equations (3-0-7)	....	....	10

GEOLOGY***
CE 1	Surveying (3-4-4)	....	....	11
D 14	Descriptive Geometry (0-3-0)	....	....	3
Ge 3a	Crystallography (1-3-2)	....	....	6

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*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.

**To be admitted to the options in Chemistry and Applied Chemistry in the third year students must satisfactorily pass the subject, Ch 12c.

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

COURSE IN SCIENCE

PHYSICS OR ASTRONOMY OPTION

FIRST AND SECOND YEARS

See pages 128 and 129

	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 21a Ch 23 ab	Chemical Principles (4-0-6)	10	10	10
Ph 5 abc	Introduction to Mathematical Physics (4-0-8)	12	12	12
Ma 10 abc	Differential Equations (3-0-6)	9	9	9

FOURTH YEAR

		1st	2nd	3rd
	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 5 ab	Economics (3-0-3) and (2-0-4)	....	6	6
L 35a	German (4-0-6)	10	....	....
L 1 ab	French (4-0-6)	....	10	10
Ma 8 abc	Advanced Calculus (3-0-6)	9	9	9
Ma 12	Probability and Least Squares (2-0-4).......	6	....	....

PHYSICS OPTION

		1st	2nd	3rd
Ph 101 abc	Electricity and Magnetism (3-0-6)	9	9	9
Ph 9 abc	Electrical Measurements (0-3-1)	4	4	4

*See first footnote on page 130.

COURSE IN SCIENCE

APPLIED PHYSICS OPTION

FIRST AND SECOND YEARS
See pages 128 and 129

	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 21a Ch 23 ab	Chemical Principles (4-0-6)	10	10	10
Ph 5 abc	Introduction to Mathematical Physics (4-0-8)	12	12	12
Ph 7 abc	Electricity and Magnetism (2-0-4)	6	6	6
Ph 9 abc	Electrical Measurements (0-3-1)	4	4	4

FOURTH YEAR

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

*See first footnote on page 130.

**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

MATHEMATICS OPTION

FIRST AND SECOND YEARS

See pages 128 and 129

	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 21a	Chemical Principles (4-0-6)	10	....	....
Ma 4 ab	Analytic Geometry (3-0-7)	....	10	10
Ma 8 abc	Advanced Calculus (4-0-8)	12	12	12
Ma 10 abc	Differential Equations (3-0-6)	9	9	9

FOURTH YEAR

		1st	2nd	3rd
	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 5 ab	Economics (3-0-3 or 2-0-4)	....	6	6
L 35a	German (4-0-6)	10	....	....
L 1 ab	French (4-0-6)	....	10	10
Ma 106	Introduction to Theory of Functions of Real Variables	....	....	15
Ma 107	Conformal Representation	....	9	....
Ma 101 abc	Modern Algebra (3 lectures a week).........	6	6	6
Ma 102 ab	Higher Geometry (3-0-6)**	9	9	....
Ma 201 a	Modern Analysis	15	....	....

*See first footnote on page 130.
**See note, page 156.

COURSE IN SCIENCE
CHEMISTRY OPTION

| THIRD YEAR | | Units per Term | | |
		1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ch 21 abc	Chemical Principles (4-0-6).................	10	10	10
Ch 26 ab	Physico-Chemical Laboratory (0-6-2 or 0-3-1)	....	8	4
Ch 41 abc	Organic Chemistry (3-0-5 or 2-0-4)	8	8	6
Ch 46 ab	Organic Chemistry Laboratory (0-12-0; 0-6-0)	12	6	....
Ch 13 a	Inorganic Chemistry (2-0-2)	....	....	4
Ch 14 a	Inorganic Chemistry Lab. (0-8-0)...........	....	....	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 5 ab	Economics (4-0-6)	....	10	....
L 35 abc	German (4-0-6 or 3-0-3)	10	6**	6**
Ch 22 ab	Thermodynamic Chemistry (2-0-4)	6	6	....
Ch 61 abc	Industrial Chemistry (2-0-4 or 2-0-2)........	6	4	6
Ch 16	Instrumental Analysis (0-6-2)	8	....	....
Ch 70-73	Chemical Research (0-5-0 or 0-19-0)........	....	5	19
Ch 29	Surface and Colloid Chemistry (3-0-5).......	....	....	8
A: Ch 13 b	Inorganic Chemistry (2-0-2)...............	4	....	....
Ch 14 bc	Inorganic Chemistry Lab. (0-5-0 or 0-8-0)...	5	8	....
B: Ph 5 ab	Introduction to Math. Physics (4-0-8).......	12	12	....

*See first footnote on page 130.

**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.

†Class of 1934 will continue the course as outlined in the previous catalogue.

COURSE IN SCIENCE
APPLIED CHEMISTRY OPTION

FIRST AND SECOND YEARS

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

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

*See first footnote on page 130.

**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

GEOLOGY OPTION*

FIRST AND SECOND YEARS

See pages 128 and 129

	THIRD YEAR	1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ch 21a Ch 23a	Chemical Principles (4-0-6)	10	10	....
CE 3	Plane Table Surveying (1-6-1)	....	....	8
Ge 3 bc	Mineralogy (1-6-1 or 2-6-2)	8	10	....
D 15, 16	Drawing (0-6-0)	6	....	6
Ge 4 ab	Petrology (2-6-2 or 1-6-1)	....	10	8
Ge 7a	Field Geology	....	....	10
Ge 1c	Historical Geology (3-1-4)	8	....	....

	FOURTH YEAR	1st	2nd	3rd
	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 5 ab	Economics (3-0-3 or 2-0-4)	....	6	6
L 35 abc	German (4-0-6 or 3-0-3)	10	6***	6***
Ge 7b	Field Geology	....	....	8
Ge 9	Structural Geology (4-0-6)	10	....	....
Ge 11 ab	Invertebrate Paleontology‡	8	10	....
Ge 12 ab	Vertebrate Paleontology (2-6-2 or 1-6-1)‡	....	10	8
Ge 5	Optical Mineralogy (2-6-2)‡	10	....	....
Ge 6 ab	Petrography‡	....	10	10
Ge 21, 22	Thesis	8‡	6	8‡

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

**See first footnote on page 130.

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

‡Students desiring to specialize in physical geology may take Ge 5 and Ge 6 in conjunction with one paleontology course. Those desiring to specialize in paleontology may take both Ge 11 and Ge 12, omitting Ge 5 and Ge 6. In either case the course not taken in the fourth year will be taken in the fifth. First or last term thesis load, Ge 21 or 22, omitted depending on choice.

COURSE IN SCIENCE

BIOLOGY OPTION

FIRST AND SECOND YEARS
See pages 128 and 129

	THIRD YEAR	Units per Term 1st	2nd	3rd
En 7 abc	English (3-0-5)	8	8	8
L 32 abc	German (4-0-6)	10	10	10
Ec 5 ab	Economics (3-0-3 or 2-0-4)	....	6	6
Bi 4	General Zoology (3-6-5)	14	....	....
Bi 3	General Botany (3-6-3)	....	12	....
Bi 5	Plant Physiology (2-6-2)	....	....	10
A: Ma 12	Probability and Least Squares (2-0-4)......	6	....	....
Ch 21a } Ch 23 ab }	Chemical Principles (4-0-6)	10	10	10
Ch 26	Physical Chemistry Laboratory (0-3-1)	....	4	4
B: Ch 41	Organic Chemistry (3-0-5 or 2-0-4)	8	8	6
Ch 46a	Organic Chemistry Laboratory (0-9-0)	9	....	....
Bi 7	Biochemistry	....	5	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 35a	German (4-0-6)	10	....	....
L 1 ab	French (4-0-6)	....	10	10
Bi 10	Bacteriology (2-5-1)	8	....	....
Bi 6	Embryology (2-8-4)	....	14	....
Bi 9	Physiology (3-4-3)	10	....	....
A: Bi 7	Biochemistry	....	5	....
Bi 8	Advanced Genetics (3-5-2)	10	....	....
Ch 29	Surface and Colloid Chemistry (3-0-5)	....	....	8
Bi 11	Entomology (2-4-2)	....	....	8
Bi 12	Histology (1-6-2)	....	9	....
Bi 22	Research	....	8	12
B: Ch 21a } Ch 23a }	Chemical Principles (4-0-6)...............	10	10	....
Ch 26	Physical Chemistry Laboratory (0-3-1).....	....	4	4
Bi 22	Research	....	....	14

*See first footnote on page 130.

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Schedules of Courses for the Degree of Master of Science

SUBJECTS COMMON TO ALL COURSES

		1st	2nd	3rd
H 100	Seminar in American History and Government ⎫			
En 100	or English Literature ⎬	9	9	9
Pl 100	or Philosophy ⎭			
	Engineering or Research Seminars	2	2	2
	Professional Subjects	42	42	42
		53	53	53

ELECTRICAL ENGINEERING

		1st	2nd	3rd
	Subjects common to all courses	11	11	11
EE 120	Alternating Current Analysis	12	....	....
EE 122	Advanced Alternating Current Machinery	....	12	....
EE 144	Transmission Lines	....	....	12
EE 121 abc	Alternating Current Laboratory	6	6	6
EE 148	Specifications and Design	6	....	....
EE 160	Electric Transients	....	6	....
EE 152	Dielectrics	....	....	6
	Research or Thesis	12	12	12
	Electives, as below	6	6	6

ELECTIVES

		1st	2nd	3rd
EE 162	Vacuum Tubes	....	....	12
EE 128	Electric Traction	....	6	....
EE 156	Electrical Communication	6	....	....
EE 130	Light and Power Distribution	....	....	6

CIVIL ENGINEERING

		1st	2nd	3rd
	Subjects common to all courses	11	11	11
CE 23	Statically Indeterminate Structures	15	....	....
CE 16	Masonry Structures	....	9	....
Ma 11	Differential Equations	9	....	....
CE 15	Irrigation and Water Supply	....	12	....
CE 21 abc	Structural and Civil Engineering Design	9	9	12
CE 17	Sewerage	....	....	9
	Research or Other Thesis	9	12	12
	Electives or Research	....	....	9

SUPPLEMENTARY SUBJECTS

		1st	2nd	3rd
CE 101 ab	Water Power Plant Design	10	10	....
CE 103 ab	Arched Dams	5	5	....
CE 105 bc	Statically Indeterminate Structures	....	15	15
CE 107 abc	Geodesy and Precise Surveying	6	6	6
CE 108	Highway Problems	....	....	....
CE 110 bc	Sewage Treatment Plant Design	....	10	10
CE 114	Earthquake Effects upon Structures	....	....	....
AM 105	Soil Mechanics	9	9	9
Bi 10	Bacteriology	8	....	....

MECHANICAL ENGINEERING

		Units per Term		
		1st	2nd	3rd
	Subjects common to all courses (page 142)...	11	11	11
ME 120	Thermodynamics	15	....	....
ME 121, 122	Power Plant Engineering	....	12	12
ME 130	Heat Engineering Laboratory	15	....	....
ME 100	Research or Thesis	....	18	18
ME 110 abc	Science of Metals or	12 }	12	12
ME 101 ab	Advance Machine Design	.... }		

PHYSICS OR APPLIED PHYSICS

	Subjects common to all courses (page 142)...	11	11	11

ELECTIVES

Ph 110 ab	Kinetic Theory	12	12	....
Ph 107 abc	Atomic Physics	9	9	9
Ph 108	Spectroscopy Laboratory	....	3	....
Ph 103 abc	Analytical Mechanics	12	12	12
Ph 105 ab	Optics	9	9	....
Ph 106 ab	Optics Laboratory	3	3	....
EE 162	Vacuum Tubes	....	....	12
Ma 109 abc	Mathematical Analysis	15	15	15
	Research	15	15	15

MATHEMATICS

	Subjects common to all courses (page 142)...	11	11	11

Courses open to graduates in Mathematics Curriculum
Research 6   6   6
Subjects in fifth-year Physics Course

CHEMISTRY OR CHEMICAL ENGINEERING

		Units per Term		
		1st	2nd	3rd
	Subjects common to all courses (page 142)...	11	11	11

ELECTIVES

Ch 151 abc	Chemical Principles, Advanced	8	8	8
Ch 153	Thermodynamic Chemistry	6	6	....
Ch 158	Photochemistry	6	....	....
Ch 177 abc	Crystal Structure	2	2	2
Ch 161	Organic Chemical Analysis	....	....	9
Ch 162 ab	Organic Chemistry (special topics)..........	6	6	....
Ch 166 abc	Chemical Engineering*	12	12	12
ME 25	Heat Engineering Laboratory	6 or	6 or	6
	Research 12-18	12-18	12-18	

GEOLOGY AND PALEONTOLOGY

	Subjects common to all courses (page 142)...	11	11	11
Ge 195	Ore Deposits	....	10	....
Ge 196	Non-Metalliferous Deposits	....	....	10
Ge 186	Geomorphology† or.......................	10	....	....
Ge 183	Seismology†	....	6	....
Ge 5	Optical Mineralogy**	10	....	....
Ge 6 ab	Petrography**	....	10	10
Ge 11 ab	Invertebrate Paleontology**	8	10	....
Ge 12 ab	Vertebrate Paleontology**	....	10	8

ELECTIVES AS FOLLOWS

Ge 200 ab	Mineragraphy	9	9	....
Ge 201 ab	Geomorphology	....	6	10
Ge 207‡, 205†				
206‡	Applied Geophysics	5	5	5
Ge 203	Physics of the Earth†.....................	6	....	....
Ge 189a	Structural Geology (Seminar)	5	....	....
Ge 189b	Physical Geology (Seminar)................	....	....	5
Ge 191 ab	Invertebrate Paleontology (Seminar)	5	5	....
Ge 190 ab	Vertebrate Paleontology (Seminar)	....	5	5
Ge 199	Mineralogy (Seminar)	5	....	....
Ge 210	Advanced Petrology	....	5-12	....
Ge 211	Petrology (Seminar)	....	....	5
Ge 198 ab	Economic Geology (Seminar)	....	5	5
Ge 208 ab	Geophysics (Seminar)	5	....	5
Ge 188	Advanced Study	....	....	....
Ge 187	Research	....	....	....

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*Candidates for the Master's degree in Chemical Engineering are required to take the subject Chemical Engineering. They must also have taken or take in this year the engineering subjects included in the Applied Chemistry Option of the Four-Year Course in Science. Their research must be in the fields of Applied Chemistry or Chemical Engineering.

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

†Odd-numbered years.

‡Even-numbered years.

AERONAUTICS

AERONAUTICAL ENGINEERING

FIFTH YEAR

		Units per Term		
		1st	2nd	3rd
	Subjects common to all courses (page 142)...	11	11	11
AE 251 abc	Aerodynamics of the Airplane...............	9	9	9
AE 252 abc	Airplane Design	11	15	20
Ma 109 ab	Mathematical Analysis	15	15	....
or				
EE 226	Engineering Math. Physics	15	15	....
Ma 14	Vector Analysis	....	....	12
AE 257	Laboratory Methods in Aeronautics..........	6	....	....
	Research and Electives	....	....	....

SIXTH YEAR

AE 253 abc	Advanced Problems in Airplane Design......	9	9	9
AE 266 ab	Theoretical Aerodynamics I.................	....	15	6
AE 267	Theoretical Aerodynamics II................	....	....	12
AE 256	Aeronautical Power Plants	....	6	....
AE 270, 271	Elasticity Applied to Aeronautics I, II	12	....	12
	Research and Electives	....	....	....

METEOROLOGY

	Subjects common to all courses (page 142)...	11	11	11
AE 271	Structure of the Atmosphere...............	3	....	....
AE 272 ab	Dynamic Meteorology	9	9	....
AE 273 abc	Synoptic Meteorology	12	12	12
AE 274 abc	Meteorological Laboratory	15	15	15
AE 291 abc	Meteorological Seminar	3	3	3
	Research and Electives.....................	....	....	....

Subjects of Instruction

DIVISION OF PHYSICS, MATHEMATICS, AND ELECTRICAL ENGINEERING

PHYSICS

PROFESSORS: ROBERT A. MILLIKAN, HARRY BATEMAN, IRA S. BOWEN, PAUL S. EPSTEIN, WILLIAM V. HOUSTON, RICHARD C. TOLMAN, EARNEST C. WATSON

ASSOCIATE PROFESSORS: ALEXANDER GOETZ, CHARLES C. LAURITSEN, FRITZ ZWICKY

ASSISTANT PROFESSORS: CARL D. ANDERSON, FREDERICK C. LINDVALL, J. ROBERT OPPENHEIMER, WILLIAM R. SMYTHE

INSTRUCTOR: H. VICTOR NEHER

UNDERGRADUATE SUBJECTS

Ph. 1 a, b, c. MECHANICS, MOLECULAR PHYSICS, AND HEAT. 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, Alexander, Crumrine, Haynes, Herring, Kinsler, Neher, Wooldridge.

Ph. 2 a, b, c. ELECTRICITY, SOUND, AND LIGHT. 12 units (3-3-6), first and second terms; 8 units, third term.

Prerequisites: A high school course, or its equivalent, and trigonometry.

Continuation of Ph. 1 a, b, c, to form a well-rounded two-year course in general physics.

Text: Electricity, Sound, and Light, Millikan and Mills.

Instructors: Anderson, Alcock, Cady, DeVore, Dunnington, Jacobs, Lauritsen.

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.

Instructor: Houston.

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: Electrodynamics for Engineers, Bennett and Crothers.
Instructor: Lindvall.

Ph. 9 a, b, c. ELECTRICAL MEASUREMENTS. 4 units (0-3-1).
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, Bender, Brunner, Read.

UNDERGRADUATE OR GRADUATE SUBJECTS

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

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

A problem course in the mathematical theory of electricity and magnetism, intended primarily as a preparation for graduate work in science. Ph. 9 a, b, c (Electrical Measurements) should accompany or precede this course.

Text: Electricity and Magnetism, Jeans.

Instructor: Smythe.

Ph. 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, reading knowledge of French.

A study of the fundamental principles of theoretical mechanics; force and the laws of motion; statics of systems of particles; the principle of virtual work, potential energy, stable and unstable equilibrium; motion of particles, systems of particles and rigid bodies; generalized coordinates, Hamilton's principle and the principle of least action; elementary hydrodynamics and elasticity.

Text: Dynamics, Webster.

Instructor: Zwicky.

Ph. 105 a, b. Optics. 9 units (3-0-6); first and second terms.

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

A problem course dealing with the fundamental principles of geometrical optics, of diffraction, interference, the electromagnetic theory of light, etc., and their experimental verification. Ph. 106 a, b (Optics Laboratory), should accompany this course.

Text: Theory of Optics, Drude.

Instructor: Bowen.

Ph. 106 a, b. Optics Laboratory. 3 units (0-3-0); first and second terms.

Advanced laboratory work in light, consisting of accurate measurements in diffraction, dispersion, interference, polarization, spectrophotometry.

Text: Manual of Advanced Optics, Taylor.

Instructors: Bowen and Raitt.

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 the elementary principles of quantum mechanics.

Instructors: Millikan, Bowen, Houston.

Ph. 108. SPECTROSCOPY LABORATORY. 3 units; second term.

A laboratory course in the measurement and classification of spectral lines to accompany Ph. 107 b.

Instructor: Bowen.

Ph. 110 a, b. KINETIC THEORY OF MATTER. 12 units; first and second terms.

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

Presents the modern aspects of the kinetic theory of gases, liquids and solids largely from the experimental point of view, covering in gases the Clausius equations, Maxwell distribution law, viscosities, specific heats, mean free paths, molecular magnitudes, high vacuum phenomena, etc.; in liquids, critical states, Brownian movements, diffusion, osmotic pressure; in solids, the interpretation of specific heats. Some thermionic and photoelectric problems will also be treated, and an occasional demonstration lecture will be given.

Instructor: Goetz.

Ph. 142. RESEARCH IN PHYSICS. Units in accordance with the work accomplished.

GRADUATE SUBJECTS

Ph. 211. THERMODYNAMICS. 12 units; first term.

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

The two fundamental laws of thermodynamics. Entropy and the thermodynamical potentials. Equations of reciprocity. Application to gases, perfect and imperfect, and to dilute solutions. Phase rule and chemical equilibrium. Nernst's theorem.

Instructor: 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 1933-1934.)

Instructor: Bateman.

Ph. 222. THEORY OF ELECTRICITY AND MAGNETISM. 12 units; first term.

Prerequisites: Ph. 101 a, b, c; Ma. 8 a, b, c, 10 a, b, c.

Electrostatics, magnetostatics, ferromagnetism, electromagnetic field of stationary currents, electromagnetic induction, phenomena in moving bodies, Maxwell's equations, ponderomotive forces of an electromagnetic field, introduction to the theory of electrons.

(Not given in 1933-1934.)

Instructor: Epstein.

Ph. 223. THEORY OF ELECTROMAGNETIC WAVES. 12 units; second term.

Prerequisites: Ph. 101 a, b, c; Ma. 8 a, b, c, 10 a, b, c.

Mathematical study of Maxwell's equations, propagation of waves, absorption and reflection, approximate and rigorous treatment of diffraction, theory of dispersion, electro- and magneto-optics.

(Not given in 1933-1934.)

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 1933-1934.)

Instructor: Bateman.

Ph. 225. THEORY OF ELECTRONS. 12 units; second term.

Prerequisites: Ph. 101 a, b, c, 222; Ma. 8 a, b, c, 10 a, b, c.

Retarded potentials. Radiation of a point charge. Theory of dielectrics. Electron theory of dia-, para- and ferro-magnetism. Phenomena in moving bodies and experimental foundations of the theory of relativity.

(Not given in 1933-1934.)

Instructor: Epstein.

Ph. 226. HEAT RADIATION AND QUANTUM THEORY. 12 units; second term.

Prerequisites: Ph. 101 a, b, c, 103 a, b, c, 211; Ma. 8 a, b, c, 10 a, b, c.

Historical treatment of the development of the mathematical theory of heat radiation and of the application of the theory of quanta to the phenomena of specific heats of solid and gaseous bodies, photoelectricity, photochemistry, chemical constants, etc.

Instructor: Epstein.

Ph. 228. MODERN ASPECTS OF THE QUANTUM THEORY. 12 units; third term.

Prerequisites: Ph. 103 a, b, c, 107 a, b, c, 229; Ma. 8 a, b, c, 10 a, b, c.

The course is devoted to a review of recent developments in the quantum theory, especially in the fields of the theory of radiation and of the electron theory of metals. The subject matter varies from year to year.

Instructor: Epstein.

Ph. 229. INTRODUCTION TO QUANTUM MECHANICS. 12 units; third term.

Prerequisites: Ph. 101 a, b, c, 103 a, b, c, 107 a, b, c; Ma. 8 a, b, c, 10 a, b, c.

Matrices and tensors. Schroedinger's partial differential equation. Dirac's transformation theory. Applications to the structure of atoms and theory of spectral lines.

Instructor: Epstein.

Ph. 230. STATISTICAL MECHANICS. 9 units, third term.

The statistical interpretation of entropy; the methods of Boltzmann, the H-theorem, the paradoxes and their resolution. Gibbs' reformulation of statistical mechanics; ensembles and thermodynamic analogies; application to specific problems of the methods of Gibbs and Darwin-Fowler; the statistics of quantum mechanical systems; configuration space and hyperquantization; the H-theorem for quantum mechanical systems.

Instructor: Oppenheimer.

Ph. 234 a, b. QUANTUM THEORY. 9 units (3-0-6); second and third terms.

Prerequisites: Ph. 101 a, b, c, 103 a, b, c, 107 a, b, c; Ma. 8 a, b, c, 10 a, b, c.

This course is designed as an introduction to the quantum mechanics; and it will follow fairly closely the historical development of the theory. The following subjects will be treated in detail; the quantization of the electromagnetic field; the photoelectric effect and the Compton effect; stationary states and the quantization of the first integrals of dynamical systems; the Bohr theory of hydrogen-like atoms; the electron spin and the exclusion principle; the correspondence principle; radiation and dispersion; the transition to matrix mechanics; the transformation theory; the wave equation and the undulatory properties of matter; the uncertainty principle; applications of the quantum mechanics.

Instructor: Oppenheimer.

Ph. 235. THE QUANTUM THEORY OF RADIATION. 9 units. (3-0-6); first term.

Prerequisites: Ph. 101 a, b, c, 103 a, b, c, 107 a, b, c; Ma. 8 a, b, c, 10 a, b, c.

This course will deal in a systematic way with the quantum theoretical methods for studying the emission, absorption and scattering of radiation by matter, and with the properties of the electromagnetic field, and will give an account of the present state of the theory on which these methods are based.

Instructor: Oppenheimer.

Ph. 236 a, b, c, d. INTRODUCTION TO THE THEORY OF RELATIVITY. 6 units; first, second and third terms, and first term of following year.

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.

Recommended Texts: First term, Tolman, The Theory of the Relativity of Motion. Second term, Eddington, The Mathematical Theory of Relativity.

Instructor: Tolman.

Ph. 237. ASTROPHYSICS. 6 units (2-0-4); first and second terms.

Prerequisites: The fundamental courses in physics.

Mechanics and thermodynamics of stellar bodies, constitution of stars, stellar atmospheres and their spectra, evolution of the planetary system and of stellar systems, time scales, characteristics of extragalactic nebulæ and their apparent velocities of recession, evolution of the universe, etc.

(Not given in 1933-1934.)

Instructor: Zwicky.

Ph. 238. SEMINAR ON THEORETICAL PHYSICS. 4 units; first, second and third terms.

Recent developments in theoretical physics for specialists in mathematical physics.

Instructor: Epstein.

Ph. 239. SEMINAR ON THE PHYSICS OF SOLIDS. 2 units.

This seminar discusses the current literature on the physics of solids, together with the problems that turn up in the research at the Institute

in this field. Only advanced students working in experimental and theoretical research in the physics of solids should register for this seminar.

Instructors: Goetz and Houston.

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. "X-Rays" by de Broglie is 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 in the field of X-Rays and on fundamental classical work.

Instructor: DuMond.

Ph. 241. RESEARCH CONFERENCES IN PHYSICS. 4 units; first, second and third terms.

Meets twice a week for report and discussion of the work appearing in the literature and that in progress in the laboratory. All advanced students in physics and members of the physics staff are expected to take part.

Instructors: Millikan, Bateman, Epstein, Tolman, Watson.

Ph. 242. RESEARCH IN PHYSICS. Units in accordance with the work accomplished.

Ph. 243 a, b, c. SEMINAR ON RADIATION AND NUCLEAR PHYSICS. 4 units; first, second and third terms.

Meets once each week and is intended primarily for the men working in the radiation laboratory. The problems in progress in the radiation laboratory are discussed and current literature relating to these problems are presented.

Text: Radiation from Radioactive Substances, Rutherford, Chadwick and Ellis.

Instructor: Lauritsen.

ASTRONOMY AND PHYSICS CLUB.

The club, consisting of physicists of the Institute and of the Mount Wilson Observatory, a group of from fifty to one hundred, meets every week either at the Institute or the Observatory Laboratory for the discussion of researches carried on by its members as well as those appearing in the physical journals.

MATHEMATICS

PROFESSORS: HARRY BATEMAN, ERIC T. BELL, HARRY C. VAN BUSKIRK
ASSOCIATE PROFESSORS: ARISTOTLE D. MICHAL, LUTHER E. WEAR
ASSISTANT PROFESSORS: WILLIAM N. BIRCHBY, MORGAN WARD, CLYDE
    WOLFE

UNDERGRADUATE SUBJECTS

NOTE: Students intending to take the mathematics option must indicate their choice by the end of the second term of their sophomore year.

Ma. 1 a, b, c. FRESHMAN MATHEMATICS. 12 units (4-0-8); first, second and third terms.

Including the fundamentals of analytical geometry, certain topics in college algebra, and some of the principles of the differential and integral calculus.

Text: Elementary Calculus, Revised Edition, Woods and Bailey.

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

Prerequisite: Ma. 1 a, b, c.

Includes additional topics in analytical geometry, and completes the usual subjects of the calculus, begun in the freshman year.

Texts: Analytical Geometry, Harding and Mullins; Differential and Integral Calculus, Granville, Smith, and Longley.

Ma. 2 d. MATHEMATICS REVIEW. 4 units (4-0-8).

A comprehensive review of freshman and sophomore mathematics during the last three weeks of the sophomore year.

Courses Ma. 1 a, b, c, and 2 a, b, c, d, form a continuous two-year course in analytical geometry, college algebra, and the differential and integral calculus.

Ma. 3. THEORY OF EQUATIONS. 10 units (3-0-7); third term.

Includes the elementary theorems in the roots of an equation, solution of numerical equations, determinants, symmetric functions, resultants and discriminants.

Instructor: Wear.

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

Will include selected topics in analytic geometry, both of the plane as well as of space.

Instructor: Birchby.

Ma. 8 a, b, c. ADVANCED CALCULUS. 9 or 12 units (3-0-6 or 4-0-8); first, second and third terms.

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

Planned to extend the knowledge gained from the previous studies in calculus and analytic geometry and to lay a better foundation for advanced work in mathematics and science.

Text: Advanced Calculus, Woods.

Instructor: Birchby.

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, Bateman.

Instructor: Bateman.

Ma. 11. DIFFERENTIAL EQUATIONS. 9 units (3-0-6); first and third terms.

Prerequisite: Ma. 2 a, b, c, d.

An abridged course in Differential Equations for students in Electrical Engineering.

Text: Differential Equations, Revised Edition, Cohen.

Instructor: Taylor.

Ma. 12. PROBABILITY AND LEAST SQUARES. 6 units (2-0-4); first term.

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

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: Wolfe.

Ma. 14. VECTOR ANALYSIS. 12 units (4-0-8); third term.

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

Elementary vector operations (addition, multiplication) and their application to problems of geometry and physics are treated.

Instructors: Klein, Ward.

UNDERGRADUATE OR GRADUATE SUBJECTS

NOTE: Those of the following courses for which there is a demand will be given periodically.

Ma. 101 a, b, c. MODERN ALGEBRA. 6 or 9 units; first, second and third terms.

Prerequisite: Ma. 8, reading knowledge of German.

Instructor: Bell.

Ma. 102 a, b, c. INTRODUCTION TO HIGHER GEOMETRY. 9 units; first, second and third terms.

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

A course in the modern methods of analytic geometry.

NOTE: If all three terms are not included in the undergraduate course, graduate students in mathematics must complete this subject in the fifth year.

Instructor: Wear.

Ma. 104. ALIGNMENT CHARTS AND MATHEMATICAL INSTRUMENTS. 6 units; one term.

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

Methods of constructing alignment charts and other types of charts for facilitating computation. Use of the planimeter and integraph. Calculating machines and machines for drawing curves.

Texts: Brodetsky, Nomography; Horsburgh, Modern Instruments of Calculation.

Instructor: Wolfe.

Ma. 106. INTRODUCTION TO THEORY OF FUNCTIONS OF REAL VARIABLES. 15 units; third term. Required for graduation (B.S.) in mathematics.

Postulational treatment of real number system, descriptive properties of point sets, continuous and discontinuance functions, derivatives and differentials. Riemann integration, functions of several real variables, implicit functions.

Instructors: Michal, Ward.

Ma. 107. CONFORMAL REPRESENTATION. 9 units (3-0-6), second term.

Prerequisites: Ma. 8, 10.

Riemann's problem, work of Schwarz and Christoffel. Applications to physical problems. Associated variation problems.

Instructor: Ward.

Ma. 109 a, b, c. INTRODUCTION TO MATHEMATICAL ANALYSIS. 9 units; first, second and third terms.
Prerequisites: Ma. 8, 10.
Primarily for experimental physicists and engineers.
Instructor: Bell.

Ma. 110 a, b, c. INTRODUCTION TO THEORY OF NUMBERS. 6 units; first, second, and third terms.
Prerequisite (third term): Reading knowledge of German.
This course will cover selected topics in elementary number theory.
Texts: Dickson's Introduction to Theory of Numbers; Landau's Vorlesungen.
Instructor: Ward.

Ma. 111. ELEMENTARY THEORY OF TENSORS. 9 units.
Prerequisites: Ma. 8, 10.
Fundamental properties of tensors, differential forms, covariant differentiation, geodesic coordinates, Riemannian differential geometries.
Instructor: Michal.

Ma. 113 a, b, c. GEOMETRY. 12 units; first, second, and third terms.
Prerequisite: Ma. 2 a, b, c, d.
Algebraic geometry; projective geometry; differential geometry; tensor analysis and its applications to numerous geometrical problems; non-Euclidean geometry; Riemannian differential geometry; geometry of dynamics; hyperspace; elementary group theory and its geometrical applications.
Texts: McConnell, Applications of the Absolute Differential Calculus; Eisenhart, Riemannian Geometry; collateral reading.
Instructor: Michal.

GRADUATE SUBJECTS

NOTE: For all courses numbered above 200, except 201a, a reading knowledge of French and German is required.

Ma. 201 a, b, c. MODERN ANALYSIS. 15 units; first, second, and third terms.
Prerequisites: Ma. 8, 10.
Theory of convergence, integration and residues, expansions of functions in infinite series, asymptotic and divergent series. Fourier series. Differential equations and function theory, integral equations, the gamma function and the zeta function, the hypergeometric function and related

functions of mathematical physics, elliptic functions, ellipsoidal harmonics.

NOTE: The first term will satisfy the requirement in Complex Variable for those taking a minor in mathematics.

Instructor: Bateman.

Ma. 202 a, b, c. MODERN THEORY OF DIFFERENTIAL EQUATIONS. 12 units; first, second, and third terms.

Prerequisites: Ma. 10, 107, and reading knowledge of German.

Expansion of functions in series, asymptotic expansions. Linear differential equations in complex domain. Elementary methods of integration. General theory of linear differential equations and their solution by definite integrals and contour integrals. Classification of linear differential equations of the second order.

Instructor: Ward.

Ma. 204 a, b, c. GEOMETRICAL TRANSFORMATIONS AND INVARIANTS. 15 units; first, second, and third terms.

Prerequisite: Graduate standing.

Linear and bilinear transformations of one variable. Simple algebraic invariants. General theory of linear transformations and their invariants. Conformal transformations. Birational transformations. Contact transformations.

Instructor: Bateman.

Ma. 205 a, b, c. THEORY OF FUNCTIONS. 15 units; first, second and third terms.

Theory of convergence and infinite processes, properties of continuous and discontinuous functions, functions of limited variation, selected topics on analytic functions, point sets, measure of point sets, Stieltje's integrals, Lebesgue integrals, Fourier series and integrals, orthogonal functions, convergence in the mean, geometry of Hilbert space.

Text: Titchmarsh, The Theory of Functions.

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; Stieltje's and Lebesgue integrals; abstract spaces.

Instructor: Michal.

Ma. 251 a. SEMINAR (I) IN ALGEBRA AND THE THEORY OF NUMBERS. 9 units, third term.

Prerequisite: Graduate standing.

Ma. 251 b. THEORY OF ALGEBRAIC NUMBERS. 9 units; third term. Alternates with Ma. 251a.

Prerequisite: Graduate standing. (A course in elliptic functions desirable.)

Instructor: Bell.

Ma. 251 c, d. MATHEMATICAL LOGIC. 15 units; first and second terms.

Instructor: Bell.

Ma. 252 a, b, c. SEMINAR IN CONTINUOUS GROUPS. 9 units; first, second, and third terms.

Prerequisite: Graduate standing in Mathematics.

Lie's theory of r-parameter groups; differential geometry of the group manifold. Groups of functional transformations; invariant functionals; differential geometries of function spaces.

Instructor: Michal.

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.

Instructor: Michal.

Ma. 255 a, b, c. METHODS OF MATHEMATICAL PHYSICS. 15 units; first, second and third terms.

Prerequisites: Ma. 8, 10.

Integral equations in which the kernel is a Green's function, Fourier series and integrals, Sturm-Liouville functions. Methods of Volterra, Fredholm and Hilbert for dealing with integral equations, Laplace's type of equation and the Heaviside calculus, calculus of variations, matrices and bilinear forms. Partial differential equations and the related simple solutions. Expansions in series of orthogonal functions.

Instructor: Bateman or Ward.

Ma. 256 a, b, c. MODERN DIFFERENTIAL GEOMETRY. 9 units; first, second, and third terms.

Prerequisite: Graduate standing.

Riemannian and Non-Riemannian geometries. Theory of parallel displacement of tensors. Affine differential geometry. Projective differential geometry. Continuous groups and their applications to geometry. Contemporary researches in differential geometry.

Instructor: Michal.

Ma. 257 a, b, c. SEMINAR IN ABSTRACT SPACES. 6 units; first, second and third terms.

Prerequisite: Graduate standing.

Metric spaces, linear vector spaces; 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.

Instructor: 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.

ELECTRICAL ENGINEERING

PROFESSOR: ROYAL W. SORENSEN
ASSOCIATE PROFESSOR: S. STUART MACKEOWN
ASSISTANT PROFESSORS: FREDERICK C. LINDVALL, FRANCIS W. MAXSTADT

UNDERGRADUATE SUBJECTS

EE. 2. DIRECT CURRENTS. 9 units (3-0-6); second term.

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

Theory and practice of direct current motors and generators. Fundamental to courses in operation and design of electrical apparatus. Numerous problems are solved.

Text: Principles of Direct Current Machines, Langsdorf.

Instructors: Maxstadt, Cobine.

EE. 3. DIRECT CURRENT LABORATORY. 6 units (0-3-3); second term.

Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d; and registration for EE. 2.

Uses of measuring instruments, operation of direct current motors and generators, and determination of their characteristics.

Text: Laboratory notes.

Instructors: Maxstadt, Browne, Hawley, and Hobson.

EE. 4. ALTERNATING CURRENTS. 9 units (3-0-6); third term.

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

Elementary study of alternating currents by analytical and graphical methods; alternating current machinery. The effect of inductance, capacitance, and resistance loads. Numerous problems are worked dealing with reactive circuits; resonance; coils in series and multiple; single and polyphase alternators; single and polyphase systems; synchronous motors; transformers; induction and single phase motors.

Text: Alternating Currents, Magnusson.

Instructors: Maxstadt, Cobine.

EE. 5. ALTERNATING CURRENT LABORATORY. 6 units (0-3-3); third term.

Prerequisites: Ma. 2 a, b, c, d; Ph. 2 a, b, c, d; EE. 2, 3, and registration for EE. 4.

Uses of alternating current indicating instruments and oscillograph operation of alternators, induction and synchronous motors and transformers; determination of characteristics of these machines.

Text: Laboratory Notes.

Instructors: Maxstadt, Griest, McRae.

EE. 6 a, b. ELECTRICAL MACHINERY. 6 units (2-0-4); second and third terms.

Prerequisites: EE. 2, 3, 4, and 5.

Further study of direct current and alternating current machinery with particular emphasis on commutation, the rotary converter, the synchronous motor and the induction motor; short transmission lines; short circuit currents; protective devices.

Texts: Principles of Direct Current Machines, Langsdorf; Alternating Currents, Magnusson; Problems in Electrical Engineering, Lyon.

Instructor: Lindvall.

EE. 7. ELECTRICAL LABORATORY. 6 units (0-3-3); third term.

Prerequisites: EE. 2, 3, 4, 5, 6; Ph. 7.

A continuation of EE. 3 and 5. Efficiency tests of direct and alternating current machinery, operation of generators in parallel, investigation of magnetic distribution in direct current machines. Graphic analysis of alternator performance; complete tests of transformers.

Text: Laboratory Notes.

Instructors: Maxstadt, Hawley, Gainder.

EE. 8. DIRECT CURRENTS. 7 units (3-0-4); first term.

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

An abridged course for other than Electrical Engineering students.

Text: Principles of Electrical Engineering, Blalock.

Instructors: Browne, McRae.

EE. 9. DIRECT CURRENT LABORATORY. 5 units (0-3-2); first term.

An abridged course 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, Cobine, Gainder, Hawley, Hobson.

EE. 10. ALTERNATING CURRENTS. 7 units (3-0-4); second or third term.

Prerequisites: EE. 8 and 9.

An abridged course for science students.

Text: Principles of Electrical Engineering, Blalock.

Instructors: Maxstadt, Browne, McRae.

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 course for science students.

Text: Laboratory notes.

Instructors: Maxstadt, Gainder, Hobson.

EE. 12. ELECTRIC CIRCUITS. 9 units (3-0-6); first term.

Prerequisites: EE. 2, 3, 4, 5.

A course of study involving the calculation by the symbolic or complex method of voltage, current and power in electrical circuits.

Text: Alternating Current Circuits, Weinbach.

Instructor: Sorensen.

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

Prerequisites: EE. 2, 3, 4, 5

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

Instructors: Sorensen, Mackeown.

FIFTH-YEAR SUBJECTS

EE. 120. ALTERNATING CURRENT ANALYSIS. 12 units (5-0-7); first term.

Prerequisites: EE. 7 and preceding courses.

Advanced study of magnetic and electric circuits. Solution of problems involving the symbolic method and complex notation; symmetrical components; analysis of electromotive force and current, nonsinusoidal wave forms; analysis of oscillograms.

Texts: Alternating Current Phenomena, Steinmetz; Problems in Electrical Engineering, Lyon.

Instructor: Sorensen.

EE. 121 a, b, c. ALTERNATING CURRENT LABORATORY. 6 units (0-3-3); first, second and third terms.

Prerequisites: EE. 7 and preceding courses.

Complete tests of the induction motor; the operation of transformers in parallel; study of polyphase connections; rotary converter tests; photometric measurements; use of the oscillograph; testing of magnetic materials; calibration of watt-hour meters and other instruments.

Text: Advanced Laboratory Notes.

Instructor: Vaile.

EE. 122. ADVANCED ALTERNATING CURRENT MACHINERY. 12 units
Prerequisites: EE. 120 and preceding courses.
(5-0-7); second term.

An advanced study of the alternator, the induction motor and the
stationary transformer, with particular emphasis on problems involving
polyphase polarity, together with single and polyphase multiple circuit.

Texts: Principles of Alternating Current Machinery, Lawrence;
Problems in Alternating Current Machinery, Lyon.

Instructor: Sorensen.

EE. 128. ELECTRIC TRACTION. 6 units (2-0-4); second term.
Prerequisites: EE. 2, 4, 6.

The electric railway, traffic studies and schedules, selection of equip-
ment in rolling stock, location and equipment of sub-stations, comparison
of systems and power requirements for operation of electric cars and
trams.

Text: Railway Engineering, Harding.
Instructor: Maxstadt.

EE. 130. ELECTRIC LIGHTING AND POWER DISTRIBUTION. 6 units
(2-0-4); third term.
Prerequisites: EE. 2, 4, 6.

Electric distribution and wiring; calculation of simple alternating
current circuits; installation and operation costs and selling price of
electric power.

Text: Electrical Equipment, Lloyd.
Instructor: Maxstadt.

EE. 144. TRANSMISSION LINES. 12 units (4-0-8); third term.
Prerequisites: EE. 122 and preceding courses.

Determination of economic voltage for transmission lines; line pro-
tection; elementary transient phenomena; corona; use of hyperbolic
functions in line calculations.

Instructor: Lindvall.

EE. 148. SPECIFICATIONS AND DESIGN OF ELECTRICAL MACHINERY. 6
units (4-0-2); first term.
Prerequisites: EE. 7 and preceding courses.

Preparation of specifications and design calculations for alternating
and direct current machinery.

Text: Electrical Machine Design, Gray.
Instructor: Sorensen.

EE. 152. Dielectrics. 6 units (2-0-4); third term.
Prerequisites: EE. 122 and preceding courses.
A study of electric fields in insulations, particularly air, and the effects on sparking voltage of the sparking distance, atmospheric pressure and humidity; corona phenomena; high frequency voltages; characteristics of commercial insulations.
Text: Dielectric Phenomena in High Voltage Engineering, Peek.
Instructors: Sorensen, Hobson.

EE. 156. Electrical Communication. 6 units (2-0-4); first term.
Prerequisites: EE. 2, 3, 4, 5.
A study of modern means of communication with special emphasis on recent developments.
Instructor: Mackeown.

EE. 160. Electric Transients. 6 units (2-0-4); second term.
Prerequisites: EE. 120 and preceding courses.
A detailed study of circuits, including advanced work in wave propagation and transient phenomena in electric conductors; with special emphasis on the use of differential equations for solving circuit problems.
Instructor: Mackeown.

EE. 162. Vacuum Tubes. 12 units (4-0-8); third term.
Prerequisites: EE. 6 and preceding courses.
Fundamental theory, and uses as detectors, amplifiers, and oscillators. Special uses of vacuum tubes in both radio and line communication.
Instructor: Mackeown.

EE. 163. Radio. 9 units (3-0-6); first term.
Elementary course dealing with fundamentals of Radio Transmission.
Text: Radio Engineering, Terman.
Instructor: Mackeown.

ADVANCED SUBJECTS

EE. 200. Advanced Work in Electrical Engineering.
Special problems relating to electrical engineering will be arranged to meet the needs of students wishing to do advanced work in the field of electricity. The Institute is equipped to an unusual degree for the following lines of work: Theory of Electrical Machine Design, Electric Transients, and High Voltage Engineering Problems, under the direction of Professors R. W. Sorensen and F. C. Lindvall; Electrical Engineering Problems using vacuum tubes under the direction of Professor

S. S. Mackeown; Electrical Engineering Problems relating to the distribution and uses of electric power for lighting and industrial uses under the direction of Dr. 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. All advanced students in Electrical Engineering and members of the Electrical Engineering staff are expected to take part.

Instructors: Sorensen, Mackeown, Maxstadt, and Lindvall.

EE. 221. TRANSMISSION LINE PROBLEMS. 15 units.

A study of transmission line transient problems, inductive interference, power limit analysis, etc.

Instructor: Sorensen.

EE. 223 a, b. ELECTRIC STRENGTH OF DIELECTRICS. 15 units.

A study of the effect of high potentials applied to dielectrics.

Text: Theory of Dielectrics, Schwagen-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.

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: BS. in Engineering, Electrical Engineering Option, EE. 20, 21 a, b, c, 22, 60.

This course is designed to develop the correlation of mathematics and physics with problems in engineering design and application. The following subjects will be treated in detail: mechanical vibrations, oscillations in electro-mechanical systems, short circuit forces, power system transients, electric motors applied to variable or pulsating loads, heat

transfer and transient heat flow. The principle of constant flux linkage in electrical transient analysis; solution of mechanical problems by electrical methods; application of Heaviside operational calculus to mechanical and thermal problems.

Instructor: Lindvall.

EE. 227. OPERATIONAL CIRCUIT ANALYSIS. 6 units (2-0-4); third term.

An introduction to the solution of circuit problems by the operational method.

Instructor: Mackeown.

EE. 228. CONDUCTION OF ELECTRICITY IN GASES, units to be arranged. Selected topics in glow arcs and spark discharges.

Instructor: Mackeown.

DIVISION OF
CHEMISTRY AND CHEMICAL ENGINEERING

CHEMISTRY

PROFESSORS: ARTHUR A. NOYES, STUART J. BATES, JAMES E. BELL, WIL-
LIAM N. LACEY, LINUS C. PAULING, RICHARD C. TOLMAN
ASSOCIATE PROFESSORS: ROSCOE G. DICKINSON, HOWARD J. LUCAS
RESEARCH ASSOCIATE: JOSEPH B. KOEPFLI
ASSISTANT PROFESSORS: RICHARD MCLEAN BADGER, ARNOLD O. BECKMAN,
ERNEST H. SWIFT, DON M. YOST

UNDERGRADUATE SUBJECTS

Ch. 1 a, b, c. CHEMISTRY. 12 units (3-6-3); first, second, and third terms.

Lectures, recitations and laboratory practice. The class and laboratory work in the first term deals with volumetric analysis, solubility effects, the ionic theory, and equilibria in solutions, and in the second term with qualitative analysis; and in the third term the laboratory work consists of selected inorganic preparations and the lectures and classroom exercises of a survey of descriptive inorganic chemistry.

Texts: Noyes, Chemistry of Solutions; A. A. Noyes, Qualitative Analysis; Holmes, Chemistry.

Instructors: Bell, Beckman, and Teaching Fellows.

Ch. 6. ENGINEERING CHEMISTRY. 11 units (4-0-7); second or third term.

Prerequisite: Ch. 1 a, b, c.

Conferences, lectures, and problems, dealing with the application of chemical principles to engineering problems and the relations of engineering to the chemical industries.

Text: Leighou, Chemistry of Engineering Materials.

Instructor: Lacey.

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

Prerequisite: Ch. 1 c.

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

Text: Willard-Furman, Quantitative Analysis.

Instructor: Swift.

Ch. 12 c. ANALYTICAL CHEMISTRY AND CHEMISTRY REVIEW. 10 units (2-6-2), third term.

Prerequisite: Ch. 12 b.

A study of special methods of chemical analysis, including electrometric methods and analyses of selected alloys and minerals. Students are 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. To be admitted in the junior year to the Option in Chemistry or in Applied Chemistry students must pass this subject satisfactorily.

Instructor: Swift.

Ch. 13 a, b. INORGANIC CHEMISTRY. 4 units (2-0-2); third and first terms.

Prerequisite: Ch. 12 b, 21 a, b.

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

Instructor: Yost.

Ch. 14 a, b, c. INORGANIC CHEMISTRY LABORATORY. 8 units (0-8-0), third term; 5 units (0-5-0), first term; 8 units (0-8-0), second term.

Prerequisite: Ch. 12 c, 21 a, b.

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

Instructors: Swift, Yost.

Ch. 16. INSTRUMENTAL ANALYSIS. 8 units (0-6-2); first term.

Prerequisite: Ch. 12 c.

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

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

Ch. 21 a, b, c. CHEMICAL PRINCIPLES. 10 units (4-0-6); first, second and third terms.

Prerequisites: Ch. 12 b; Ph. 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: Noyes and Sherrill, Chemical Principles.
Instructors: Bates, Dickinson.

Ch. 22 a, b. THERMODYNAMIC CHEMISTRY. 6 units (2-0-4); first and second terms.

A continuation of subject Ch. 21, given in much the same way. The topics considered include reaction rate and a further study of electro-chemistry and thermodynamic chemistry. Practice is given in the computation of free energies, activities and entropies of typical substances.

Text: Noyes and Sherrill, Chemical Principles, and mimeographs.
Instructor: Bates.

Ch. 23 a, b. CHEMICAL PRINCIPLES. 10 units (4-0-6); second and third terms.

Prerequisite: Ch. 21 a.

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

Text: Noyes and Sherrill, Chemical Principles, and mimeographs.
Instructor: Dickinson.

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.

Laboratory exercises to accompany Ch. 21.

Text: Sherrill, Laboratory Experiments on Physico-Chemical Principles.

Instructor: Bates.

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 surface tension, adsorption, contact catalysis, and the general principles relating to disperse systems with particular reference to the colloidal state. Supplementary laboratory work can be provided if desired.

Text: Kruyt, Colloids, and mimeographed notes.

Instructor: Badger.

Ch. 41 a, b, c. ORGANIC CHEMISTRY. 8 units (3-0-5), first and second terms; 6 units (2-0-4), third term.

Prerequisite: Ch. 12 c.

Lectures and recitations treating of the classification of carbon compounds, the development of the fundamental theories, and the characteristic properties of the principal classes including hydrocarbons, alkyl halides, alcohols, acids, ethers, esters, amines, carbohydrates, aromatics.

Text: Lucas, Mimeographed Notes.

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: Porter, The Carbon Compounds.

Instructor: Wheland.

Ch. 46 a, b. ORGANIC CHEMISTRY LABORATORY. 9 units (0-9-0) or 12 units (0-12-0), first term; 6 units (0-6-0) or 9 units (0-9-0), second term.

Prerequisite: Ch. 12.

Laboratory exercises to accompany Ch. 41, a, b. The preparation and purification of carbon compounds and the study of their characteristic properties. Qualified students may pursue research work.

Text: Lucas, Mimeographed Notes.

Instructor: Lucas.

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: Badger and Baker, Inorganic Chemical Technology.

Instructor: Lacey.

Ch. 63 a, b. CHEMICAL ENGINEERING THERMODYNAMICS. 6 units (2-0-4); second and third terms.

Prerequisite: Ch. 21 a.

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

Instructor: Lacey.

Ch. 70-73. CHEMICAL RESEARCH.

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

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FIFTH-YEAR AND ADVANCED SUBJECTS

Ch. 151 a, b, c. CHEMICAL PRINCIPLES, ADVANCED (Seminar). 8 units (2-0-6), first, second, and third terms.

This subject is given in the form of a seminar, meeting twice a week. It is arranged especially for graduate students coming to the Institute from other colleges as an aid to them in preparing for candidacy for the Ph.D. degree in chemistry as a major, or in meeting the requirements for a minor in chemistry for Ph.D. students majoring in other sciences or for an M.S. degree in chemistry itself. The subject consists of a study and discussion, in a way more fundamental than is usual in undergraduate courses in physical chemistry, of the basic laws and theories of that subject. The work consists largely in outside study of the newly printed parts of the revised edition of Noyes and Sherrill's "Chemical Principles" relating mainly to general thermodynamics, kinetic theory, and the molecular and ionic theories of solution, and of the mimeographed notes prepared on the rates of chemical reaction, and the free energy and entropy of substances. Atomic structure in some of its important chem-

ical relations is also studied. Examinations are held at the middle and at the end of the year (about Feb. 15 and June 1); and students who pass these examinations satisfactorily are considered to have satisfied the requirements in physical chemistry for candidacy for the Ph.D. degree in chemistry.

Students for the Ph.D. degree majoring in chemistry who do not attend this seminar (because they have already had correspondingly thorough courses in the subject) may take these examinations for admission to Ph.D. candidacy; and such students are expected to do so provided they are applicants for fellowships or graduate scholarships during the following school year.

Instructor: Dickinson.

Ch. 152. SURFACE AND COLLOID CHEMISTRY. 8 units; third term.

Lectures and classroom discussions with outside reading and problems, devoted to the general principles relating to surface-tension, absorption, contact catalysis, and to disperse systems and the colloidal state.

Text: Mimeographed Notes.

Instructor: Badger.

Ch. 153 a, b. THERMODYNAMIC CHEMISTRY. 6 units; first and second terms.

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

Text: Chemical Principles, Noyes and Sherrill, and mimeographs.

Instructor: Bates.

Ch. 154 a, b. STATISTICAL MECHANICS (Seminar). 6 units; first and second terms.

A discussion of statistical mechanics and its applications to physics and chemistry. The topics treated will include a sufficient exposition of classical and quantum theory mechanics to serve as a foundation for statistical mechanics; applications to specific heats, chemical equilibria, absorption and emission of radiation, collisions of the first and second kinds, and the rates of physical chemical processes; and a discussion of Boltzmann's H-theorem and the relations between statistical mechanics and thermodynamics.

Text: Statistical Mechanics with Applications to Physics and Chemistry, Tolman.

Instructor: Tolman.

Ch. 156 a, b, c. INTRODUCTION TO WAVE 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, and this is followed by a discussion of the development and significance of the new quantum mechanics. Then a thorough treatment of the Schrödinger wave equation is given, 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 Heisenberg-Dirac resonance phenomenon, the structure of many-electron atoms and of simple molecules, the nature of the covelant chemical bond, the structure of aromatic molecules, and other recent chemical applications.

Instructor: Pauling.

Ch. 157. THE STRUCTURE OF CRYSTALS. 6 units; second term or third term.

This topic is divided into two parts.

A. Methods of determining the structures of crystals with X-rays and electron waves; introduction to the theory of space groups; the various structures occurring in nature, and their relation to the phenomena of isomorphism, solid solution formation, cleavage, etc.

B. The Born lattice theory; electrostatic theory of ionic crystals, with discussion of the crystal energy, heat capacity, and other properties; ionic and atomic radii and their relation to the physical and chemical properties of crystals; the structure of complex crystals, etc.

Instructors: Pauling, Sturdivant.

Ch. 158. PHOTOCHEMISTRY. 6 units; first term.

Lectures and discussions on photochemical processes, especially in their relations to quantum phenomena. The following topics will be included: the photochemical absorption law; the processes—excitation, dissociation, ionization—accompanying the absorption of radiation; subsequent processes including fluorescence and collisions of the second kind; photosensitization; quantum yield and its relation to photochemical mechanism; catalysis and inhibition; temperature coefficients of photochemical reactions.

Instructor: Dickinson.

Ch. 160. INORGANIC CHEMISTRY (Seminar). 6 units; second term.

Selected groups of inorganic compounds (e.g., the various compounds of nitrogen with hydrogen and with oxygen) will be considered from modern physico-chemical view-points; thus with reference to their physical properties, their thermodynamic constants (their heat-contents, free-

energies, and entropies); their rates of conversion into one another (including effects of catalysis and energy radiations), the ionization of those that are weak acids or bases, and their electron structure and valence relations.

Instructors: Noyes, Yost.

Ch. 161. ORGANIC CHEMICAL ANALYSIS. 9 units; third term.

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

Instructor: Lucas.

Ch. 162 a, b. ORGANIC CHEMISTRY (Special Topics). 6 units; first and second terms.

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

Instructor: Lucas.

Ch. 166 a, b, c. CHEMICAL ENGINEERING. 12 units (4-0-8); first, second and third terms.

Prerequisites: Ch. 61; ME. 15; or Ch. 63 a, b.

Problems and discussions designed to bring the student in touch with the problems involved in efficiently carrying out chemical reactions on a commercial scale. The basic operations of chemical industry (such as heat production, heat transfer, mixing, filtration, distillation) are studied both as to principle and practice.

Text: Walker, Lewis and McAdams, Principles of Chemical Engineering.

Instructor: Lacey.

Ch. 169. RESEARCH MANIPULATIONS. 3 units; first term.

Laboratory exercises in glass-blowing and machine shop operations for research students. Class-room discussions on topics of general interest for research in physical chemistry, such as high-vacuum technique, electrical apparatus including applications of vacuum tube circuits, and the measurement of pressure, temperature and radiant energy.

Students must obtain permission from the instructor before registering for this course as the enrollment is necessarily limited.

Instructor: Beckman.

Ch. 170-173. CHEMICAL RESEARCH.

Opportunities for research are offered to graduate students in all the main branches of chemistry, namely, in analytical or inorganic chemistry

(170), physical chemistry (171), organic chemistry (172), and applied chemistry (173).

The main lines of research now in progress are:

Ionized substances in relation to the ion attraction theory.
Free-energies, equilibria, and electrode-potentials of reactions.
Study of crystal structure and molecular structure by diffraction of X-rays and electron waves.
Determination of the distribution of electrons in crystals.
Rates of chemical reactions in relation to the quantum theory.
Application of quantum mechanics to chemical problems.
Mechanism of homogeneous reactions.
Chemical reactions produced by atoms and molecules excited by radiations.
Band spectra in their chemical relations.
Isomerism in the ethylene series.
Hydration of unsaturated compounds.
Substitution in the benzene series.
Rates of Adsorption of gases by liquids.
Solubility of gases in liquids at high pressures.
Equilibria in saturated salt solutions.
Electrolysis of copper leaching solutions.
Researches on Portland Cement.

For a fuller survey of the researches in progress, see Publications of the Gates Chemical Laboratory.

Ch. 174-179. CHEMICAL RESEARCH CONFERENCES.

Each 2 units; given all three terms, unless otherwise noted.

Ch. 174. INORGANIC AND PHYSICAL CHEMISTRY.

Ch. 175. ORGANIC CHEMISTRY.

Ch. 176. PHOTOCHEMISTRY.

Ch. 177. CRYSTAL AND MOLECULAR STRUCTURE.

Ch. 178. BAND SPECTRA AND MOLECULAR STRUCTURE. (First and second terms.)

Ch. 179. 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.

DIVISION OF
CIVIL AND MECHANICAL ENGINEERING*

CIVIL ENGINEERING

PROFESSORS: FRANKLIN THOMAS, ROMEO R. MARTEL
ASSOCIATE PROFESSOR: WILLIAM W. MICHAEL
ASSISTANT PROFESSOR: FRED J. CONVERSE

UNDERGRADUATE SUBJECTS

CE. 1. SURVEYING. 11 units (3-4-4); first or second term.
A study of the elementary operations employed in making surveys for engineering work, including the use, care, and adjustment of instruments, linear measurements, angle measurements, note keeping, stadia surveys, calculation and balancing of traverses, topographic mapping and field methods.
Text: Surveying, Breed and Hosmer.
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, Breed and Hosmer.
Instructor: Michael.

CE. 3. PLANE TABLE SURVEYING. 8 units (1-6-1); third term.
A course offered primarily for students in geology but may be elected by arrangement with the department. Theory and use of the plane table as applied to geological surveys. The class devotes one entire day a week to field surveys over typical terrain completing a topographic map of the region covered.
Text: Surveying, Breed and Hosmer.
Instructor: Michael.

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*See Division of Physics, Mathematics and Electrical Engineering pages 161-167, for subjects in Electrical Engineering.

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: Construction of Roads and Pavements, Agg.

Instructor: Michael.

CE. 8 a. RAILWAY ENGINEERING. 6 units (3-0-3); first term.
Prerequisites: CE. 1, 2.

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

Text: Elements of Railroad Engineering, Raymond.

Instructor: Thomas.

CE. 8 b. RAILWAY SURVEYING. 6 units (2-0-4); second term.
Prerequisite: CE. 1.

The theory of railway, highway and ditch location and surveys; problems relating to curves, grades, earthwork and track layout, including a study of the mass diagram as applied to railway and highway earthwork.

Text: Railway Curves and Earthwork, Allen.

Instructor: Michael.

CE. 8 c. RAILWAY SURVEYING. 6 units (0-6-0); third term.
Prerequisite: CE. 8 b.

The class devotes one entire day a week to field surveys of a railroad location, applying the principles as outlined under course CE. 8 b.

Text: Railway Curves and Earthwork, Allen.

Instructor: Michael.

CE. 9. ELEMENTS OF STRUCTURES. 12 units (3-3-6); second term for Mechanical Engineering students; third term for students in Electrical Engineering.

Prerequisite: AM. 1 c.

An abridged course in design of simple structures of timber, steel, masonry, and reinforced concrete. Emphasis is placed upon methods and computations in numerous typical examples.

Text: Structural Design, Thomas.

Instructors: Thomas, Michael.

CE. 10 a. THEORY OF STRUCTURES. 12 units (3-3-6); first term.
Prerequisite: AM. 1 c.
Methods used in the calculation of stresses in and proportioning of beams, girders, and columns of timber, steel and concrete; study of the effects of moving load systems; graphic statics applied to roofs and bridges.
Text: Structural Theory, Sutherland and Bowman.
Instructor: Martel.

CE. 10 b, c. THEORY OF STRUCTURES. 12 units (3-3-6), second term, and 9 units (3-0-6) third term.
Prerequisite: CE. 10 a.
A continuation of CE. 10 a, covering the computation of stresses in truss members, the design of structural parts, connections, portals, and bracing; a study of arch, cantilever, and continuous bridges; and deflection of trusses.
Text: Design of Steel Structures, Urquhart and O'Rourke.
Instructor: Martel.

CE. 11 a, b. STRUCTURES. 9 units, second and third term.
Prerequisite: AM. 1 c.
A brief course adapted for aeronautical engineering students in the analysis of forces by analytical and graphical methods and the calculation of stresses in beams, girders, columns and simple trusses of timber, steel, and light alloys. The third term is devoted to a study of continuous beams and trusses, trusses with redundant members, effect of flexure and direct stress, deflections in beams and trusses.
Text: Airplane Structures, Niles and Newell.
Instructor: Donnell.

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: Principles of Reinforced Concrete Construction, Turneaure and Maurer.
Instructor: Martel.

CE. 14 a, b, c. ENGINEERING CONFERENCES. 2 units (1-0-1); first, second and third terms.
Conferences participated in by faculty and seniors of the Civil Engineering department. The discussions cover current developments and advancements within the field of civil engineering and related sciences.

The technique of effective oral presentation of reports is emphasized through criticisms of the reports from the standpoint of public speaking by a member of the Department of English.

Instructors: Michael, Eagleson.

FIFTH-YEAR SUBJECTS

CE. 15. IRRIGATION AND WATER SUPPLY. 12 units (5-0-7); second term.

Prerequisite: Hy. 1.

A study of modern practice of the collection, storage and distribution of water for municipal, domestic and irrigation uses; design, construction and operation of systems; consideration of the conditions adapted to irrigation developments, dams, reservoirs, canals; laws pertaining to irrigation; the economic aspects of projects.

Text: Water Supply and Utilization, Baker and Conkling.

Instructor: Thomas.

CE. 16. MASONRY STRUCTURES. 9 units (2-3-4); second term.

Prerequisite: CE. 12.

Theory of design and methods of construction of masonry structures; foundations, dams, retaining walls, and arches.

Text: Design of Masonry Structures, Williams.

Instructor: Martel.

CE. 17. SEWERAGE. 9 units (3-0-6); third term.

Prerequisite: Hy. 1.

Systems for the collection and disposal of sewage; the design of sewers and storm drains; inspection of local sewage disposal plants; the drainage of land; cost assessments.

Text: Sewerage and Sewage Disposal, Metcalf and Eddy.

Instructor: Thomas.

CE. 21 a. STRUCTURAL DESIGN. 9 units (0-9-0); first term.

Prerequisites: CE. 10 a, b, c.

The design of a plate girder bridge and a truss bridge or a steel frame building; stress sheets and general drawings are made. Designing office practice is followed as affecting both computations and drawings.

Instructor: Thomas.

CE. 21 b. STRUCTURAL DESIGN. 9 units (0-9-0); second term.

Prerequisites: CE. 10 a, 12.

The design of a reinforced concrete building in accordance with a selected building ordinance, with computations and drawings.

Instructors: Thomas, Martel.

CE. 21 c. CIVIL ENGINEERING DESIGN. 12 units (0-12-0); third term. Prerequisites: CE. 15, 21 a, b.

Special problems including preliminary investigations of irrigation or water power projects; study of stream flow data, the effect of reservoir storage upon distributed flow, determination of size and type of economic development.

Instructor: Thomas.

CE. 23. STATICALLY INDETERMINATE STRUCTURES. 15 units, first term.

A study of such structures as continuous spans, rigid frames and arches by the methods of least work or slope-deflections; analysis of secondary stresses.

Text: Continuous Frames of Reinforced Concrete, Cross and Morgan.

Instructor: Martel.

CE. 30. ENGINEERING SEMINAR. 2 units (1-0-1); first, second and third terms.

Conferences participated in by faculty and graduate students of the Civil Engineering department. The discussions cover current developments and advancements within the field of civil engineering and related sciences, with special consideration given to the progress of research being conducted at the Institute.

ADVANCED SUBJECTS

Special problems in the various fields of civil engineering will be arranged to meet the needs of students wishing to do advanced work in this department. The following lines of work are possible. Stream Regulation and Utilization for Power, Irrigation, and Water Supply under the direction of Prof. Franklin Thomas; Advanced Structures under the direction of Prof. Martel; Sanitation and Sewerage under the direction of Profs. Thomas and Martel; Highways and Geodesy under the direction of Prof. Michael; Analysis of Earthquake Effects upon Structures under the direction of Professor Martel.

CE. 101 a, b. WATER POWER PLANT DESIGN. 10 units; first and second terms.

A design of a power plant in conformity with the conditions of head, flow, and load fluctuations at a particular site. Includes selection of number and type of units, design of water passages, and general structural features.

Instructor: Thomas.

CE. 103 a, b. ARCHED DAMS. 5 units; first and second terms.

A study of the distribution of stresses in arched dams. Design and investigation of the stresses in an arched dam for a given site.

Instructor: Martel.

CE. 105 b, c. STATICALLY INDETERMINATE STRUCTURES. 15 units; second and third terms.

A continuation of the study of indeterminate structures as begun in CE. 23, with the use of analytical and instrumental methods of solution.

Text: Elastic Energy Theory, Van den Broek.

Instructor: Martel.

CE. 107 a, b, c. GEODESY AND PRECISE SURVEYING. 6 units; first, second and third terms.

Methods of triangulation and surveying over extended areas. The adjustment of triangulation systems, the adjustment of observations by the method of least squares. Map projections, precise leveling determination of a true meridian.

Instructor: Michael.

CE. 108. HIGHWAY PROBLEMS. Units to be based on work done.

Cooperating with the Highway Research Board of the National Research Council, opportunities are offered for advanced studies in highway engineering. Arrangements may be made for special studies on subgrade materials, wearing surfaces, economics of vehicle operation, and allied subjects.

Instructor: Michael.

CE. 110 b, c. SEWAGE TREATMENT PLANT DESIGN. 10 units; second and third terms.

A design of treatment works for a selected community and site involving special conditions of location, volume. and character of disposal. Includes selection of process, arrangement of tanks and equipment, and general design of structures.

Instructor: Thomas.

CE. 111. WATER TREATMENT PLANT DESIGN. Units to be based upon work done; any term.

Preparation of a layout and design of the general features of a plant to effect the purification and softening of water as may be required in specific circumstances. Includes design of typical structural features of the plant.

Instructor: Thomas.

CE. 112. SANITATION RESEARCH. Units to be based upon work done; any term.

Exceptional opportunities in this field are available at the sewage treatment plant of the city of Pasadena, where the activated sludge process is in operation, supplemented by a rotary kiln drier for the reduction of sludge to commercial fertilizer.

Instructor: Thomas.

CE. 113. UNDERGROUND WATER INVESTIGATIONS. Units to be based upon work done; any term.

A study of the relation between rainfall, runoff, percolation, and accumulations of ground water. Investigation of the location, extent, and yield of underground reservoirs.

Instructor: Thomas.

CE. 114. ANALYSIS OF EARTHQUAKE EFFECTS UPON STRUCTURES. Units to be based upon work done; any term.

An experimental study of effects of vibrations in framed models used with a shaking table.

Instructor: Martel.

MECHANICAL ENGINEERING

PROFESSORS: ROBERT L. DAUGHERTY, W. HOWARD CLAPP
ASSISTANT PROFESSOR: ROBERT T. KNAPP
INSTRUCTOR: ERNEST E. SECHLER

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: Mechanism, Clapp and Ogier.

Instructor: Watson.

ME. 3. MATERIALS AND PROCESSES. 11 units. (3-3-5); first or second 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.

Instructors: Clapp and Clark.

ME. 5 a, b, c. MACHINE DESIGN. (2-3-4) first term; (3-3-6) second term; (0-9-0) third term.

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

Applications of mechanics of machinery and mechanics of materials to practical design and construction. Riveting and welding; boilers and plate vessels; bolts and screws; force and shrink fits; hydraulic cylinders; cylinders and cylinder heads for steam and gas engines; stuffing boxes and packing; pistons and piston rings; leaf springs, coil springs; piston pins; connecting rods and cross heads; cranks and crank-shafts; flywheels; spur gears; helical gears; bevel gears; worm gears; spiral gears; 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: Norman, Machine Design; Marks, Mechanical Engineers Handbook.

Instructor: Clapp.

ME. 8. MACHINE DESIGN. 12 units (3-3-6); first term.
Prerequisites: ME. 1; AM. 1 a, b.
An abbreviated course in machine design for aeronautical engineers. The energy and force problem; relations of stress and strain to failure and the determination of proper safety factors; straining actions in machines; stresses with complex loading; screws and screw fastenings; axles, shafting, and couplings; friction and lubrication; journals and bearings.
Text: Machine Design, Kimball and Barr. Lectures and problems.
Instructor: Sechler.

ME. 10. METALLURGY. 6 units (2-0-4); first and third terms.
Prerequisite: Ch. 6.
A study of the principles underlying the manufacture and heat treatment of the ferrous metals and some of the non-ferrous alloys.
Instructors: Clapp, Clark.

ME. 15. HEAT ENGINEERING. 12 units (3-3-6); second or third term.
Prerequisites: Ma. 2 a, b, c, d; ME. 1.
Principles of thermodynamics, and their application to steam engines, steam turbines, and internal combustion engines; types of steam, gas, and oil engines, boilers, and auxiliaries. Inspection of local power plants, elementary tests in the laboratory, and computing or drawing room exercises.
Instructors: Knapp, Binder.

ME. 16. HEAT ENGINEERING. 12 units (4-0-8); third term.

Prerequisite: ME. 15.

Additional work in thermodynamics; properties of gases, saturated and superheated vapors; various cycles of steam and internal combustion engines; flow of gases and vapors through orifices, nozzles, and pipes; air compression.

Instructor: Daugherty.

ME. 17. HEAT ENGINEERING. 9 units (3-0-6); first term.

Prerequisite: ME. 16.

A study of the application of thermodynamics to modern practice in power plants and to refrigeration; heating and ventilating; and other thermal processes.

Instructor: Daugherty.

ME. 18. HEAT ENGINEERING. 10 units (3-0-7); second term.

Prerequisite: ME. 15.

An abridgement of ME. 16 for students in Electrical Engineering.

ME. 25. HEAT ENGINEERING LABORATORY. 6 units (0-3-3); first, second or third term.

Prerequisite: ME. 15.

Tests of steam engine, steam turbine, blower and gas engine, etc., for efficiency and economy.

Text: Power Plant Testing, Moyer.

Instructors: Knapp, Binder.

ME. 26. HEAT ENGINEERING LABORATORY. 6 units (0-3-3); second term.

Prerequisite: ME. 15.

Additional work in the laboratory on air compressors, fuel and oil testing, and special work on steam and internal combustion engines.

Text: Power Plant Testing, Moyer.

Instructors: Knapp, Binder.

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. 12 units, each term.

Prerequisite: ME. 10.

General principles of metallography and of metal science; metallic microscopy; preparation of specimens and photomicrographs; microstructure of the more common metals and alloys; physical properties of metals as a function of structure; constitution diagrams; pyrometry and thermal analysis; grain growth and recrystallization; metallic compounds; solid solutions; structure and properties of aggregates; heat treatment operations; investigation problems. Class and laboratory exercises.

Instructors: Clapp, Clark.

ME. 120. THERMODYNAMICS. 15 units; first term.
Prerequisite: ME. 17.

Advanced work in engineering thermodynamics, with applications to combustion, heat transfer, and similar practical problems.

Instructor: Daugherty.

ME. 121 and 122. POWER PLANT ENGINEERING. 12 units (1-9-2); second and third terms.

Prerequisite: ME. 120.

A study of modern power plant engineering, computation of typical problems, and design and layout for a complete plant. Class room and computing room.

Instructor: Daugherty.

ME. 125. REFRIGERATION PLANTS. Units to be based on work done; any term.

Design of various types of refrigeration plants best adapted to different conditions of service.

Instructors: Daugherty, Knapp.

ME. 130. HEAT ENGINEERING LABORATORY. 15 units (1-9-5); first term.

Prerequisites: ME. 17, 26.

Advanced work on steam turbines, internal combustion engines, lubrication, and similar subjects. Each problem will be studied in enough detail to secure a thorough analysis. Conference hour for progress discussion.

Instructor: Knapp.

ME. 132. ENGINE LABORATORY. 15 units; first, second and third terms.

Use of the dynamometer. Experimental work in engine performance, carburetion, ignition, fuel consumption, etc.

ME. 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.

AERONAUTICS

PROFESSORS: HARRY BATEMAN, THEODOR VON KÁRMÁN

ASSISTANT PROFESSORS: ARTHUR L. KLEIN, CLARK B. MILLIKAN, ARTHUR
E. RAYMOND

INSTRUCTOR: IRVING P. KRICK

UNDERGRADUATE SUBJECTS

AE. 1. GENERAL AERONAUTICS. 9 units (3-0-6); second term.

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

Historical development. Elementary theory of airplane, balloon, and helicopter. Theory of model testing. Control and stability of aircraft. Survey of contemporary design.

Texts: Bedell, The Airplane; Monteith and Carter, Simple Aerodynamics and the Airplane.

See also Courses CE. 11 and ME. 8.

FIFTH-YEAR AND ADVANCED SUBJECTS

AE. 251 a, b, c. AERODYNAMICS OF THE AIRPLANE. 9 units, first, second, and third terms.

Prerequisites: AM. 1 a, b, c, AM. 3, CE. 11.

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

Texts: Stalker, Principles of Flight; Younger and Woods, Dynamics of Airplanes.

Instructor: Millikan.

AE. 252 a, b, c. AIRPLANE DESIGN. 11 units, first term; 15 units, second term; 20 units, third term.

Prerequisites: AM. 1 a, b, c, AM. 3, CE. 11.

Properties of aircraft materials, beams, trusses, columns, and indeterminate structures, design of airplanes, shop and drafting room practice. 252 must be taken concurrently with or subsequently to 251.

Texts: Niles and Newell, Airplane Structures; Boyd, Strength of Materials.

Instructors: Klein, Raymond.

AE. 253 a, b, c. ADVANCED PROBLEMS IN AIRPLANE DESIGN. 9 units; first, second, and third terms.

Prerequisite: AE. 251.

Instructor: Raymond.

AE. 256. AERONAUTICAL POWER PLANTS. 6 units, second term.

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

Survey course in airplane engines, performance, propellers, cooling systems, fuel and oil systems, installations.

Text: Aircraft Power Plants, Jones, Insley, Caldwell, and Kohr.

Instructor: Klein.

AE. 257. LABORATORY METHODS AND INSTRUMENTS. 6 units, first term.

Velocity and pressure measurements, meteorological instruments, recording and reducing of upper air observations, wind-tunnel technique, laws of similarity and scale effect.

Instructor: Klein.

AE. 258 a, b, c. AERONAUTICAL PROBLEMS. 3 units (1-0-2), first, second and third terms.

Open to students in aeronautical engineering.

Instructor: Hoover.

AE. 266 a, b. THEORETICAL AERODYNAMICS I. PERFECT FLUIDS. 15 units, second term; 6 units, third term.

Prerequisite: Ma. 14, 109 a, b.

Hydrodynamics of perfect fluids as applied to aeronautics, potential motion, circulation, laws of vortex motion, elements of conformal transformation, streamline bodies, airfoils, three dimensional wing theory, monoplanes, biplanes, interference.

Texts: Glauert, The Elements of Aerofoil and Airscrew Theory; Prandtl, Applications of Modern Hydrodynamics to Aeronautics.

Instructor: Kármán or Millikan.

AE. 267. THEORETICAL AERODYNAMICS II. REAL FLUIDS. 12 units, third term.

Prerequisite: AE. 266 a.

Hydrodynamics of viscous fluids, laminar motion in pipes and channels, turbulence and Reynolds' criterion, similarity laws, theory of drag, discontinuous flow and vortex streets, theory of skin-friction, boundary layer, general theory of turbulence.

Instructor: Kármán or Millikan.

AE. 268. HYDRODYNAMICS OF A COMPRESSIBLE FLUID. 12 units; one term.

Prerequisites: AE. 266 a, b.

Relation of the equations to the kinetic theory of gases, theory of jets and of the Venturi tube, motion with a velocity exceeding the velocity of sound, shock waves, cavitation.

Instructor: Bateman.

AE. 270. ELASTICITY APPLIED TO AERONAUTICS I. 12 units, first term.

Prerequisites: Ma. 109 a, b, AM. 1 a, b, c, 3.

Analysis of stress and strain. Hookes law. Theory of bending and torsion. Stresses in thin shells. Theory of elastic stability.

Instructors: Kármán, Donnell.

AE. 271. ELASTICITY APPLIED TO AERONAUTICS II. 12 units, third term.

Prerequisites: Ma. 109 a, b, AM. 1 a, b, c, 3.

Theory of elastic vibrations, critical speed with particular reference to airplane engines, wing and tail flutter, strength and vibration of propeller blades.

Instructors: Kármán, Donnell.

AE. 272 a, b. DYNAMIC METEOROLOGY. 9 units, first and second 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.

Instructors: Kármán, Millikan.

AE. 273 a, b, c. SYNOPTIC METEOROLOGY. 12 units; 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 reports, construction of daily weather maps by air mass analysis methods, analysis of weather maps and practice forecasting for selected areas with particular emphasis being placed upon conditions important for the safe operation of aircraft. Practice in obtaining and evaluating upper air data obtained from airplane ascents at a nearby flying field. Construction of meteorological instruments.

Instructor: Krick.

AE. 275. STRUCTURE OF THE ATMOSPHERE. 3 units, first term.

Constituents of the atmosphere and their distribution. Theories underlying the probable structure and temperature of the stratosphere. Optics of the atmosphere and related phenomena.

Instructor: Gutenberg.

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.

AE. 291 a, b, c. METEOROLOGICAL SEMINAR. 3 units; first, second and third terms.

Weekly reviews and discussions of current meteorological literature and problems.

Instructors: Gutenberg, Krick.

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Additional and supplementary courses will be offered as the need arises. Lectures will be given from time to time by visiting scientists and engineers from this country and Europe. Flying is not given officially at the Institute, but there are ample opportunities for a student to learn to fly at one of the neighboring flying fields.

APPLIED MECHANICS

PROFESSOR: FREDERIC W. HINRICHS, JR.
ASSISTANT PROFESSOR: FRED J. CONVERSE

UNDERGRADUATE SUBJECTS

AM. 1 a, b. APPLIED MECHANICS. 14 units (4-3-7); first and second terms.

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

Action of forces on rigid bodies; composition and resolution of forces; equilibrium, couples, framed structures; cords and chains; centroids; displacement; velocity and acceleration; translation, rotation, and plane motion; moments of inertia; inertia forces; kinetic and potential energy; work and energy; impulse and momentum; impact; power; efficiency.

Text: Engineering Mechanics, Brown.

Instructors: Hinrichs, Converse, Rockefeller, Byrne, White.

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: Strength of Materials, Poorman; and Steel Construction, A. I. S. C.

Instructors: Hinrichs, Converse, Rockefeller, Byrne, White.

AM. 2 a, b. APPLIED MECHANICS AND STRENGTH OF MATERIALS. 12 units (4-0-8); first and second terms.

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

An abridged course for students electing the Applied Chemistry Option in the Science Course, condensing in the work of two terms as much as possible of the general field outlined above in AM. 1 a, b, c.

Texts: Engineering Mechanics, Brown; Strength of Materials, Poorman; and Steel Construction, A. I. S. C.

Instructor: Christensen.

AM. 3. TESTING MATERIALS LABORATORY. 6 units (0-3-3); first, second, or third term.

Prerequisite: AM. 1 c.

Tests of the ordinary materials of construction in tension, compression, torsion, and flexure; determination of elastic limit; yield point, ultimate strength, and modulus of elasticity; experimental verification of formulas derived in the theory of strength of materials.

Text: Materials of Construction, J. B. Johnson.

Instructors: Converse and Johnson.

ADVANCED SUBJECTS

AM. 105. SOIL MECHANICS. 9 units (3-0-6); any 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.

ENGINEERING DRAWING

INSTRUCTORS: ERNEST E. SECHLER, NATHANIEL W. WILCOX

D. 1. ELEMENTARY FREEHAND DRAWING. 3 units (0-3-0); first term.

The study of geometrical forms and their representation by means of freehand perspective. Careful observation, accurate draftsmanship and correct proportions will be emphasized.

D. 2. ADVANCED FREEHAND DRAWING. 3 units (0-3-0); elective third term.

Prerequisite: D. 1.

Similar to D. 1, but with advanced subject matter.

D. 4. ELEMENTARY MECHANICAL DRAWING. 3 units (0-3-0); first term.

The study of shape and size, description by means of mechanical drawing, and the care and use of drawing instruments. The study and use of single stroke lettering. Accuracy and precision are required.

Text: Svensen, Drafting for Engineers.

Machine drawing, D. 6 and D. 7, are planned to prepare all engineering students for the drawing required in the professional work of the engineering departments. Accuracy, neatness and good lettering are required.

D. 6. MACHINE DRAWING AND LETTERING. 6 units (0-6-0); second and third terms.

Prerequisite: D. 4, D. 12 a, b.

The study of the general principles of working drawings of machinery. The work covers conventional representations and dimensioning, the making of simple working drawings, the making of dimensioned freehand sketches and complete detail and assembly drawings made from the sketches.

Text: Svensen, Drafting for Engineers.

D. 7. ADVANCED MACHINE DRAWING. 6 units (0-6-0); elective any term.

Prerequisite: D. 6.

The study and execution of design drawings for various mechanisms.

Instructor: Sechler.

Structural Drawing, D. 9 and D. 10, are planned to acquaint students with the technique of structural drawing. Accuracy, neatness, and good lettering are required.

D. 9. STRUCTURAL DRAWING AND LETTERING. 6 units (0-6-0); first and second terms.

Prerequisite: D. 4, D. 12 a, b.

The study of the general principles of working drawings of structural steel and reinforced concrete, covering conventional representations, dimensioning and billing. The work includes the making of simple working drawings of structural steel trusses, members and details.

Texts: Bishop, Structural Drafting; A. I. S. C. Handbook.

D. 10. ADVANCED STRUCTURAL DRAWING. 6 units (0-6-0), elective any term.

Prerequisite: D. 9.

The study and execution of drawings of structural steel or reinforced concrete for structures designed by upper class students in civil engineering.

Descriptive Geometry, D. 12 a, b, c, d and D. 13 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. 12 a. ELEMENTARY 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: Hood, Geometry of Engineering Drawing.

D. 12 b. DESCRIPTIVE GEOMETRY. 3 units (0-3-0); third term.

Prerequisite: D. 12 a.

A continuation of D. 12 a, covering the geometrical relationships of lines and planes.

Text: Hood, Geometry of Engineering Drawing.

D. 12 c. DESCRIPTIVE GEOMETRY. 3 units (0-3-0); first and second terms.

Prerequisite: D. 12 b.

A continuation of D. 12 b, covering problems involving curved lines and the intersection and development of surfaces.

Text: Hood, Geometry of Engineering Drawing.

D. 12 d. DESCRIPTIVE GEOMETRY. 3 units (0-3-0); second and third terms.

Prerequisite: D. 12 c.

A continuation of D. 12 c, covering more complicated problems involving single curved surfaces, warped and double curved surfaces, and mining problems.

Text: Hood, Geometry of Engineering Drawing.

D. 13. ADVANCED DESCRIPTIVE GEOMETRY. 6 units (0-6-0); elective any term.

Prerequisite: D. 12 a, b, c, d.

The study of lineal perspective and the execution of mechanical perspective drawings of machines, bridges, and other structures.

D. 14. DESCRIPTIVE GEOMETRY. 3 units (0-3-0); third term.

Prerequisites: D. 12 a, b.

This course is planned primarily for geology students, and includes practical problems in mining and earth structures.

Text: Hood, Geometry of Engineering Drawing.

D. 15. BLOCK DIAGRAMS AND LAND FORMS. 6 units (0-6-0); third term.

The graphical representation of land forms and geological structure by means of pictorial drawings. The work, which will be mainly freehand, includes the drawing of block diagrams of various land forms in perspective, and of "isometric diagrams and problems in structural geology."

Text: Lobeck, Block Diagrams.

Instructor: Ridgway.

D. 16. PHYSIOGRAPHIC SKETCHING. 6 units (0-6-0); first term.

Freehand sketching from landscape forms and details of geological structure. Sketches will be made in both the drawing room and the field, and by means of various mediums. Required of geology students; elective for students of other courses.

Text: Lobeck, Block Diagrams.

Instructor: Ridgway.

HYDRAULICS

PROFESSOR: ROBERT L. DAUGHERTY
ASSISTANT PROFESSOR: ROBERT T. KNAPP

UNDERGRADUATE SUBJECTS

Hy. 1. HYDRAULICS. 12 units (3-3-6); first, second or third term.
Prerequisite: AM. 1 a, b.

Physical properties of water; hydrostatics; flow of water in pipes, nozzles, and channels; theory, construction, and installation of hydraulic turbines, and a study of their characteristics with a view to intelligent selection of the proper type for any given conditions; centrifugal pumps and other hydraulic equipment.

Text: Hydraulics and Hydraulic Turbines, Daugherty.

Instructors: Daugherty, Knapp.

Hy. 2. HYDRAULIC LABORATORY. 6 units (0-3-3); first, second or third term.

Prerequisite: AM. 1 a, b.

Experiments on the flow of water through orifices and nozzles, through pipes and Venturi meters, over weirs; use of Pitot tube; tests of impulse and reaction turbines, centrifugal pumps, and other hydraulic apparatus.

Instructors: Knapp, Wislicenus.

Hy. 3. HYDRAULIC PROBLEMS. 6 units (0-6-0); first 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.

ADVANCED SUBJECTS

Hy. 101. HYDRAULIC MACHINERY. Units to be based on work done; any term.

A study of such machines as the hydraulic turbine and the centrifugal pump and their design to meet specified conditions.

Instructor: Daugherty.

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.

DIVISION OF GEOLOGY AND PALEONTOLOGY

PROFESSORS: JOHN P. BUWALDA, WILLIAM MORRIS DAVIS*, BENO GUTEN-
BERG, F. L. RANSOME, CHESTER STOCK
ASSISTANT PROFESSOR: IAN CAMPBELL
INSTRUCTORS: RENE ENGEL, JOHN H. MAXSON

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 sur-
face. Dynamical and structural geology. Lectures, recitations, labora-
tory and weekly field trips.
Text: Pirsson and Schuchert's Text-book of Geology, Part I.
Instructors: Buwalda, Maxson, Bell, Curry, Smith.

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: Lull, Organic Evolution.
Instructors: Stock, Bode.

Ge. 1 c. HISTORICAL GEOLOGY. 8 units (3-1-4); first term.
Prerequisite: Ge. 1 b.
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: Schuchert and Dunbar, Textbook of Geology: Part II, His-
torical Geology.
Reference: Grabau, Textbook of Geology, Part II, Historical Geology.
Instructor: Maxson.

Ge. 3 a. CRYSTALLOGRAPHY. 6 units (1-3-2); third term.
Prerequisites: Ch. 1 a-c; Ph. 1 and 2.
A study of crystal systems and forms, not only from the classical
geometric view-point, but also in light of the modern atomic conceptions

*First and third terms, 1933-1934.

of crystal structure; also, the physical properties characteristic of crystals.

Text: Dana's Text-book of Mineralogy.

Instructor: Campbell.

Ge. 3 b. c. MINERALOGY. 8 units (1-6-1), first term; 10 units (2-6-2), second term.

Prerequisite: Ge. 3 a.

Lectures and laboratory work devoted to the study of the physical and chemical properties of minerals, of their associations and modes of occurrence, and to their identification.

Text: Dana's Text-book of Mineralogy.

Instructors: Engel, Peterson.

Ge. 4 a. PETROLOGY. 10 units (2-6-2), second term.

Prerequisites: Ge. 3 a, b, c.

The origin, properties, and megascopic identification of the common igneous rocks.

Text: Rocks and Rock Minerals, Pirsson-Knopf.

Instructors: Engel, Donnelly.

Ge. 4 b. PETROLOGY. 8 units (1-6-1), third term.

Prerequisite: Ge. 4 a.

Study and identification of the common sedimentary and metamorphic rocks.

Instructors: Campbell, Smith.

Ge. 5. OPTICAL MINERALOGY. 10 units (2-6-2), first term.

Prerequisites: Ge. 1, 3, 4.

Study of optical mineralogy and use of the petrographic microscope in the identification of minerals.

Text: Winchel, Elements of Optical Mineralogy, Part I.

Instructors: Engel, Donnelly.

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

Prerequisites: Ge. 1, 3, 4, 5.

Application of optical mineralogy to the study of mineral aggregates. The study of the petrographic characteristics of certain important types of rocks.

Instructors: Campbell, Rice.

Ge. 7 a, b. FIELD GEOLOGY. 10 units (1-7-2), third term, third year; 8 units (1-6-1), third term, fourth year.

Prerequisites: Ge. 1 a-c; 3 a, b; 4 a, b.

During the first term students acquire a knowledge of technical field methods of mapping the distribution of rocks, determining structure, and deciphering the geological history of a region. A representative Coast Range area is mapped in detail and a report is prepared on its stratigraphy, structure and history. The field work and selected text-book assignments are discussed in weekly class meetings.

The second half of the course consists of brief studies of several different localities in the Southwest exemplifying a wide range of geological formations and structures. The trips vary from one to three days in length; often an expedition of about one week is arranged for the spring vacation. Indoor exercises relate to the interpretation of map data in the solution of geologic problems.

Students will be called upon to expend small sums for traveling expenses.

Text: Field Geology, Lahee.

Instructors: Buwalda, Maxson.

Ge. 9. STRUCTURAL GEOLOGY. 10 units (4-0-6); first term.

Prerequisite: Ge. 7 a.

A consideration of the structural features of the Earth's crust; folds, faults, joints, foliation. Computation of thicknesses and depths. Determination of the nature and amount of displacements on faults by use of descriptive geometry.

Instructor: Buwalda.

Ge. 11 a, b. INVERTEBRATE PALEONTOLOGY. 8 units (1-6-1), first term; 10 units (2-6-2), second term.

Prerequisites: Ge. 1 a, b, c.

Morphology and geologic history of the common groups of fossil invertebrates, with emphasis on progressive changes in structures and their significance in evolution and in adaptive modifications. Laboratory, conferences, lectures, and occasional field trips.

Instructor: Popenoe.

Ge. 12 a, b. VERTEBRATE PALEONTOLOGY. 10 units (2-6-2), second term; 8 units (1-6-1), third term.

Prerequisite: Ge. 1 b.

Osteology, affinities, and history of the principal groups of fossil mammals and reptiles. History of vertebrate life with special reference to the region of western North America.

Instructor: Stock.

Ge. 21. THESIS PROBLEM IN GEOLOGY. 8 units first or third terms, 6 units second term.

Prerequisite: Ge. 7 a.

The student investigates a limited geologic problem, preferably of his own choosing, under direction, in the field or laboratory. Individual initiative is developed, principles of research are acquired, and practice gained in technical methods. The student prepares a thesis setting forth the results of the research and their meaning. Last date for acceptance of thesis, May 25.

Ge. 22. THESIS PROBLEM IN PALEONTOLOGY. 8 units first or third terms, 6 units second term.

Prerequisites: Ge. 11 a, b, or Ge. 12 a, b; may be taken concurrently.

Special investigations in either invertebrate or vertebrate paleontology. Research on a limited problem involving either field relationships of fossil assemblages or consideration in the laboratory of the structural characters and relations of fossil forms. Preparation of a thesis.

Ge. 23. SUMMER FIELD GEOLOGY. 12 units.

Intensive 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 even-numbered years and in the Great Basin in odd-numbered years. As an occasional alternative in odd-numbered years 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 course 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 and Paleontology course. Tuition, $15.

Instructors: Buwalda, Maxson.

FIFTH-YEAR AND ADVANCED SUBJECTS

Ge. 183. SEISMOLOGY. 6 units (2-0-4); second term of odd-numbered years.

Study and conferences on the principles of physical and geological seismology.

Text: Gutenberg, Grundlagen der Erdbebenkunde.

Instructor: Gutenberg.

Ge. 184. LABORATORY STUDIES IN SEISMOLOGY. First, second or third term.

Laboratory practice in the measurement and interpretation of instrumental earthquake records; investigation of specific seismologic problems.

Instructor: Gutenberg.

Ge. 186. GEOMORPHOLOGY. 10 units; first term of odd-numbered years.

Prerequisite: Ge. 9.

Nature and origin of the physiographic features of the earth. Geologic processes involved in their development. Use of physiography in elucidating the later geologic history of regions.

Instructor: Buwalda.

Ge. 187. RESEARCH.

Original investigation, designed to give training in methods of research, to serve as theses for higher degrees, and to yield contributions to scientific knowledge. These may be carried on in the following fields: (m) mineralogy, (n) general areal geology, (o) stratigraphic geology, (p) structural geology, (q) physiography, (r) petrology, (s) vertebrate paleontology, (t) invertebrate paleontology, (u) seismology, (v) economic geology, (w) geophysics, (x) geophysical prospecting, (y) meteorology and climatology, (z) geochemistry.

Ge. 188. ADVANCED STUDY.

Students may register for not to exceed 8 units of advanced study in fields listed under Ge. 187. Occasional conferences; final examination.

Ge. 189 a. PHYSICAL GEOLOGY (SEMINAR). 5 units; first term.

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

Instructor: Buwalda.

Ge. 189 b. PHYSICAL GEOLOGY (SEMINAR). 5 units; third term.

Study and critical discussion of current contributions to geologic knowledge.

Instructor: Buwalda.

Ge. 190 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.

Instructor: Stock.

Ge. 191 a, b. INVERTEBRATE PALEONTOLOGY (SEMINAR). 5 units; first and second terms.

Conferences on research in invertebrate paleontology and reviews of literature. Discussions of particular aspects of invertebrate paleontology with special reference to the Pacific Coast.

Instructors: Popenoe, Findlay.

Ge. 195. ORE DEPOSITS. 10 units (3-0-7); second term.

Prerequisites: Ge. 1, 3, 4, 5, 6, 7.

A study of metalliferous deposits with particular reference to their geological relations and origins. Lectures, recitations, and field trips.

Text: Not prescribed, but either Tarr's Introductory Economic Geology or Emmons' Principles of Economic Geology is suggested, with Lindgren's Mineral Deposits as collateral reading.

Instructor: Ransome.

Ge. 196. NON-METALLIFEROUS DEPOSITS. 10 units (3-0-7); third term.

Prerequisites: Ge. 1, 3, 4, 5, 6, 7.

Modes of occurrence, distribution, and origin of the principal non-metallic mineral products, including mineral fuels, building materials, etc.

Text: Not prescribed, but Ries' Economic Geology or an equivalent text will be found useful.

Instructor: Ransome.

Ge. 197 a, b. ADVANCED ECONOMIC GEOLOGY. 8 units (2-0-6); second and third terms.

Prerequisites: Ge. 195, 196.

A more thorough and comprehensive study of some of the important mineral deposits of the world than is practicable in courses 195 and 196. Particular attention will be given to deposits in the western United States, Mexico, and Africa.

Instructor: Ransome.

Ge. 198 a, b. ECONOMIC GEOLOGY (SEMINAR). 5 units; second and third terms.

Prerequisites: Ge. 195, 196, or equivalents.

Discussion of current literature and special problems. The seminar work may be varied by occasional lectures.

Instructor: Ransome.

Ge. 199. MINERALOGY AND GEOCHEMISTRY (SEMINAR). 5 units; first term.

Prerequisite: Ge. 3, 4, 5, 6.

Discussion of current literature and recent advances in this field.

Instructor: Engel.

Ge. 200 a, b. MINERAGRAPHY. 9 units (1-6-2); first and second terms.

Prerequisites: Ge. 3, 4, 5, 6, 195.

Investigation of ores in polished surfaces by microscopic and other laboratory methods.

(Not given, 1933-1934.)

Ge. 201 a, b. GEOMORPHOLOGY. 6-10 units; first and third terms (1933-1934).

First term, systematic geomorphology. Third term, special problems in geomorphology. Seminar, reports and conferences.

Instructor: Davis.

Ge. 203. PHYSICS OF THE EARTH. 6 units; first term of odd-numbered years.

Structure of the earth; gravity and isostasy; tides; movement of the poles; elastic properties, temperature; density.

Instructor: Gutenberg.

Ge. 205. APPLIED GEOPHYSICS I. Measurements of gravity and earth magnetism applied to geological problems and prospecting. 5 units; first term of odd-numbered years.

Instructor: Soske.

Ge. 206. APPLIED GEOPHYSICS II. Methods of seismology applied to geological problems and prospecting. 5 units; second term of even-numbered years.

Instructor: Gutenberg.

Ge. 207. APPLIED GEOPHYSICS III. Electricity and heat measurements applied to geological problems and prospecting. 5 units; third term of even-numbered years.

Instructor: Soske.

Ge. 208 a, b. GEOPHYSICS (Seminar). 5 units; first and third terms.

Structure of the earth; gravity and isostasy; tides; movement of the poles; elastic properties; temperature; density; changes in the earth's crust; earthquakes; applied geophysics.

Instructors: Gutenberg, Buwalda.

Ge. 210. ADVANCED PETROLOGY. 5-12 units; second term.

Devoted to class and laboratory study of the sedimentary rocks during odd-numbered years, and to metamorphic and igneous rocks during even-numbered years.

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.

Instructor: Campbell.

DIVISION OF BIOLOGY

PROFESSORS: THOMAS HUNT MORGAN, ALFRED H. STURTEVANT

ASSOCIATE PROFESSOR: ERNEST G. ANDERSON

ASSISTANT PROFESSORS: HENRY BORSOOK, THEODOSIUS DOBZHANSKY, ROB-
ERT EMERSON, STERLING H. EMERSON, HUGH M. HUFFMAN, GEORGE E.
MACGINITIE, FRITS W. WENT

INSTRUCTORS: KENNETH V. THIMANN, ALBERT TYLER

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

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

UNDERGRADUATE SUBJECTS

Bi. 1. ELEMENTARY BIOLOGY. 9 units (3-3-3); second term.

An introductory course intended to give the student of general science some information about the fundamental properties of living things.

Instructors: Morgan, Borsook, Beadle.

Bi. 2. GENETICS. 9 units (3-4-2); third term.

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

Instructor: Dobzhansky.

Bi. 3. GENERAL BOTANY. 12 units (3-6-3); second term.

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

Instructor: S. Emerson.

Bi. 4. GENERAL ZOOLOGY. 14 units (3-6-5); first term.

A general survey of some of the main groups of animals, including examination of representative living types, especially marine forms.

Instructor: MacGinitie.

Bi. 5. PLANT PHYSIOLOGY. 10 units (2-6-2); third term.

A general study of water relations, growth, tropisms, and the chemical reactions occurring in plants.

Instructor: Went.

Bi. 6. EMBRYOLOGY. 14 units (2-8-4); second term.

A course in descriptive and experimental embryology. As far as possible some of the work will be done at the Marine Laboratory, Corona del Mar.

Instructor: Tyler.

Bi. 7 a, b. BIOCHEMISTRY. 5 units second term; 10 units third term.

Second term: Lecture course on the chemical constitution of living matter, and on the chemical changes in animal physiology.

Third term: Laboratory course illustrating principles and methods in current use in biochemistry.

Instructors: Borsook and Huffman.

Bi. 8. ADVANCED GENETICS. 10 units (3-5-2); first term.

A more advanced course dealing with special problems of genetics.

Instructors: Sturtevant and Anderson.

Bi. 9. PHYSIOLOGY. 10 units (3-4-3); first term.

Fundamental characteristics of photosynthesis, respiration, and fermentation in unicellular organisms. The mechanism of response to light in various organisms, with a consideration of the light-sensitive system in the human eye. With the instructor's consent, this course may be taken by students pursuing the Physics option.

Instructor: R. Emerson.

Bi. 10. BACTERIOLOGY. 8 units (2-5-1); first term.

The principal reactions carried out by bacteria, and the main groups of micro-organisms responsible for these reactions.

Instructor: Thimann.

Bi. 11. ENTOMOLOGY. 8 units (2-4-2); third term.

A general survey of the structure and life histories of the class Insecta, emphasizing the groups presenting favorable material for experimental work.

Instructors: Dobzhansky and Sturtevant.

Bi. 12. HISTOLOGY. 9 units (1-6-2); second term.

A course in technique and in the microscopic structure of animal tissues.

Instructor: Tyler.

Bi. 22. RESEARCH. 12 or 14 units; third term.

An opportunity will be given to follow special lines of research under direction.

ADVANCED COURSES

Instruction will be given by lectures and seminars; and research will be forwarded by intimate contact between students and instructors in the laboratories. In view of the great expense of modern research along physiological lines, the department will make careful selections of students of exceptional ability and aptitude in order to avoid the formal instruction that large numbers entail.

Bi. 100. A seminar in genetics is held twice monthly for graduate students specializing in heredity and related subjects.

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

Bi. 101. A Journal club is conducted twice monthly for reports on current biological literature.

Bi. 102. BIOCHEMISTRY SEMINARS. Two seminars are held throughout the academic year, one on special, selected topics; the other on recent advances reported in the current literature.

Bi. 103. A seminar in plant physiology, twice monthly.

Bi. 110. BIOCHEMISTRY: Courses in biochemistry are offered to graduate students who have completed work in General and Organic Chemistry.

Instructor: Borsook.

Bi. 120. DEVELOPMENTAL MECHANICS: A short course in Descriptive Embryology including laboratory work will precede a general course of lectures and seminar work on the Mechanics of Development.

Instructors: Morgan and Tyler.

Bi. 130. BIOLOGICAL PROBLEMS.

A course of lectures and reading, including the more general topics of biology, such as sex-determination; the role of the hormones; secondary sexual characters; parthenogenesis; regeneration and grafting; and migration of animals, will be given to graduate students at the beginning of their graduate work.

Instructor: Morgan.

Bi. 160. ADVANCED PHYSIOLOGY. It is expected to offer graduate courses in general physiology to students prepared to carry on research work.

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.

DIVISION OF ASTROPHYSICS

RESEARCH ASSOCIATE: JOHN A. ANDERSON

UNDERGRADUATE SUBJECTS

Ay. 1. INTRODUCTORY COURSE IN ASTRONOMY. 9 units (3-1-5); third term.

This course 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, Moulton.

Instructor: Anderson.

DIVISION OF THE HUMANITIES

ENGLISH

PROFESSOR: CLINTON K. JUDY
ASSOCIATES: HARDIN CRAIG, LOUIS B. WRIGHT
ASSOCIATE PROFESSOR: GEORGE R. MacMINN
ASSISTANT PROFESSORS: HARVEY EAGLESON, WILLIAM HUSE, JR.,
    ROGER STANTON
INSTRUCTOR: L. WINCHESTER JONES

A course in English composition is prescribed for all students in the Freshman year, and a course in the survey of English literature is prescribed for all students in the Junior year. In the Senior year the students are offered a number of options in English, American, and European literature.

The instruction in composition is intended to give a thorough training in both written and spoken English. The instruction in literature is intended to provide an appreciative acquaintance with the chief works of 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 courses in English do not exhaust the attention given at the Institute to the student's use of the language; all writing, in whatever department of study, is subject to correction with regard to English composition.

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 course is designed to give the student a thorough review of the principles of composition, with much practice in writing and speaking, and a broad introduction to good reading. The student is offered every

inducement to self-cultivation, and is allowed ample opportunity for the exercise of special talents or the pursuit of special intellectual interests.

The work of the honor section is directed toward the stimulation of intellectual initiative. 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: Thought in English Prose, Dent; These United States, Jones, Huse 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 beginnings to the end of the 19th century, focused on the most distinguished works of the greater writers in poetry, drama, the novel, and the essay. Special attention is given to the social background of the works assigned for reading, and to the chief cultural movements of the modern world. In the first term the emphasis is placed on Shakespeare and the English Renaissance; in the second term on the life and literature of the 18th century; in the third on the Victorian Era.

Texts: The Oxford Shakespeare; British Poetry and Prose, Lieder, Lovett and Root.

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. Wide reading is required.

Text: Tradition and Experiment in Present-day Literature.

Instructors: Eagleson, Judy.

En. 9. CONTEMPORARY AMERICAN LITERATURE. 9 units (3-0-6); first, second or third 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. Spe-

cial attention is given to the reflection of national characteristics in the novel, the short story, drama, and poetry.

Texts: Recent American Literature, Foerster; Contempory Trends, Nelson.

Instructor: MacMinn.

En. 10. MODERN DRAMA. 9 units (3-0-6); first, second or third term.
Prerequisite: En. 7 a, b, c.

A study of the leading European and British dramatists, from Ibsen to the writers of the present time. Special attention may be given to new movements in the theatre, to stage decoration and production. Wide reading of plays is required.

Text: Twenty-five Modern Plays, Tucker.

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.

(Not offered in 1933-1934).

Text: The Modern Reader's Bible, Moulton.

Instructor: MacMinn.

En. 12 a, b, c. DEBATING. 4 units (2-0-2).

Elective, with the approval of the Registration Committee, for upper classmen in the first and second terms. Study of the principles of argumentation; systematic practice in debating; preparation for inter-collegiate debates.

Elective, with the approval of the Freshman Registration Committee, for Freshmen, 2 units (1-0-1) in the second term, and 4 units (2-0-2) in the third term. Lectures on the principles of formal logic and the theory of argumentation and debate.

Instructor: Untereiner.

En. 13 a, b, c. READING IN ENGLISH. Units to be determined for the individual by the Department.

Elective, with the approval of the Registration Committee, in any term.

Collateral reading in literature and related subjects, done in connection with regular courses in English, or independently of any course, but under the direction of members of the department.

En. 14. SPECIAL COMPOSITION. 2 units (1-0-1); any term.

This course may be prescribed for any student whose work in composition, general or technical, is unsatisfactory.

En. 15 a, b, c. JOURNALISM. 3 units (1-0-2).

Elective, with the approval of the Registration Committee.

A study of the principles and practice of newspaper writing, editing, and publishing, especially as applied to student publications at the Institute.

Instructor: MacMinn.

En. 16. SPELLING. No credit.

This course may be prescribed for any student whose spelling is unsatisfactory.

En. 20. SUMMER READING. Maximum, 16 credits.

Credits are allowed to the maximum number of 16 for vacation reading from a selected list of books in various subjects, and written report thereon.

FIFTH-YEAR AND ADVANCED SUBJECTS

En. 100. LITERATURE. 9 units; first, second and third terms.

A study of some selected period, or type, or author, or group of authors in American, English or European literature, with an introduction to the methods of research and criticism applicable thereto.

Instructors: Craig, Eagleson, Judy, Wright.

LANGUAGES

Professor: John R. Macarthur

The courses in this department are arranged primarily to meet the needs of scientific students who find it necessary to read books, treatises, and articles in French, German, and Italian. In these languages correct pronunciation and the elements of grammar are taught, but the emphasis is laid upon the ability to translate from them into English. An elective course in Greek is offered to students interested in that language.

UNDERGRADUATE SUBJECTS

L. 1 a, b. Elementary French. 10 units (4-0-6); second and third terms.

A course in grammar, pronunciation, and reading that will provide the student with a vocabulary of extent and with a knowledge of grammatical structure sufficient to enable him to read at sight French scientific prose of average difficulty. Accuracy and facility will be insisted upon in the final tests of proficiency in this subject.

Texts: An Introduction to the Study of French, Bond; Technical and Scientific French, Williams.

Instructor: Macarthur.

L. 11. Elementary Italian. 9 units (3-0-6); one term, as required.

A course designed to give the student who has already some acquaintance with Latin or with another Romance language sufficient knowledge of the forms and vocabulary of Italian to enable him to read scientific Italian, especially in the field of Mathematics.

Text: Elementary Italian, Marinoni and Passarelli.

Instructor: Macarthur.

L. 32 a, b, c. Elementary German. 10 units (4-0-6); first, second and third terms.

This subject is presented in the same manner as the Elementary French.

Texts: First German Course for Science Students, Fiedler and Sandbach; Technical and Scientific German, Greenfield.

Instructors: Macarthur and Gregory.

L. 35 a, b, c. Scientific German. 10 units (4-0-6) first term; 6 units (3-0-3) 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.

Texts: Aus der Werkstatt grosser Forscher, Danneman; Die Radioaktivitat, Fajans.

Instructors: Macarthur and Gregory.

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.

Text: German Literature, Thomas.

Instructor: Macarthur.

L. 51 a, b, c. Greek. 6 units (3-0-3).

This is a course in the elements of the classical Greek language. Special reference is made to scientific nomenclature. Outside reading upon topics drawn from Greek literature, art, philosophy, and science is reported on in term papers. The course is elective.

Texts: Alpha, Frost; Xenophon's Anabasis; The Study of Greek Words in English, Including Scientific Terms, Hoffman.

Instructor: Macarthur.

HISTORY AND GOVERNMENT

PROFESSORS: JOHN R. MACARTHUR, WILLIAM B. MUNRO
ASSOCIATES: AVERY O. CRAVEN, GODFREY DAVIES
ASSISTANT PROFESSOR: RAY E. UNTEREINER
INSTRUCTOR: WILLIAM BEARD

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.

Texts: Ancient Times, Breasted; History of Medieval Europe, Thorndike.

Instructors: Eagleson, Huse, Jones, Judy, Macarthur, MacMinn, Stanton.

H. 2 a, b, c. MODERN EUROPEAN HISTORY. 6 units (2-0-4); first, second and third terms.

Prerequisite: H. 1 a, b, c.

The general political and social history of Europe from 1500 to 1926, presented as the background and development of movements underlying present conditions.

Instructors: Munro, Untereiner.

H. 5 a, b. CURRENT TOPICS. 2 units (1-0-1); first and second terms.

This course is given collaterally with senior humanities electives, and is articulated with a selected weekly journal of general information and opinion.

H. 10. THE CONSTITUTION OF THE UNITED STATES. 2 units (1-0-1); third term.

A study of the principles and provisions of the national constitution in the light of present-day interpretation by the courts. Required of all seniors.

Instructor: Munro.

FIFTH-YEAR AND ADVANCED SUBJECTS

H. 100. SEMINAR IN AMERICAN 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.

Instructor: Davies.

Second term: American History.

Instructor: Craven.

Third term: American Government.

Instructor: Munro.

H. 101. TECHNOLOGY AND GOVERNMENT. 9 units (3-0-6); second and third terms.

Open only to fifth-year students and a limited number of seniors whose qualifications are approved by the instructor.

Instructor: William Beard.

ECONOMICS

PROFESSOR: GRAHAM A. LAING
ASSOCIATE PROFESSOR: HORACE N. GILBERT
ASSISTANT PROFESSORS: PHILIP S. FOGG, RAY E. UNTEREINER, CLYDE WOLFE
INSTRUCTOR: HERBERT HOOVER, JR.

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

UNDERGRADUATE SUBJECTS

Ec. 2. GENERAL ECONOMICS AND ECONOMIC PROBLEMS. 10 units (4-0-6), second or third term.

The purpose of this course is to describe in as great detail as possible the economic life of the community. It includes a study of production, distribution, and exchange of goods, the nature of money and credit, the development of economic institutions, and an analysis of a number of pressing economic problems. The course is given in the second and again in the third term.

Instructors: Laing (lectures), Gilbert, Untereiner, Fogg.

Ec. 5 a, b. GENERAL ECONOMICS. 6 units (3-0-3) second term, and (2-0-4) third term. Same material as in Ec. 2, but in more detail.

Instructors: Laing (lectures), Gilbert, Untereiner, Fogg.

Ec. 10. MATHEMATICS OF FINANCE. 4 units (1-0-3); third term.

The mathematical theory underlying compound interest, annuities, and mathematical expectation, with application to such subjects as the accumulation of reserves, the amortization of debts, evaluation of bonds, partial payments, capitalized costs, and insurance.

Text: Mathematics of Investment, Hart.
Instructor: Wolfe.

Ec. 11. STATISTICS. 3 units (1-0-2); second term.

Statistical methods and the graphic portrayal of results, with their application to concrete business problems.

Text: Mathematical Part of Elementary Statistics, Camp.
Instructor: Wolfe.

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 course 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: Introduction to Accounting, Prickett and Mikesell.

Instructor: Fogg.

Ec. 18. INDUSTRIAL ACCOUNTING. 6 units, second or third term. Prerequisite: Ec. 17.

Open only to third, fourth, and fifth year engineering students. The course covers the essential principles of cost accounting as applied to industrial enterprises. The theoretical background of cost accumulation and distribution is supplemented by case studies of actual industrial accounting experience.

Text: Industrial Accounting, Saunders.

Instructor: Fogg.

Ec. 19. INDUSTRIAL STATISTICS. 9 units, third term.

Open only to fourth and fifth year engineering students. The object of this course is to introduce students who contemplate going into the administrative side of industry to the essentials of statistical method, especially as it is applied to, and utilized by, business. Consideration is given both to statistical devices for internal control of operations and to methods of analyzing external business conditions

Text: Economic Statistics, Crum and Patton.

Instructor: Fogg.

Ec. 20. FINANCIAL ORGANIZATION. 8 units (3-0-5); first term. Prerequisites: Ec. 2 or 5.

A general study of the financial organization of society. The course includes a study of the following topics: Principles of money; nature and functions of credit; the varieties of credit instruments; the marketing of low and high grade securities; the functions of the corporation and the stock exchange as capital-raising devices; the development of the banking system and the general principles of banking, including studies

of commercial banking, the national banking system, and the Federal Reserve system.

Instructor: Laing.

Ec. 25. Business Law. 6 units (3-0-3); 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.

Text: Principles of Business Law, Dilbrou and Howard.

Instructor: Untereiner.

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); second and third terms.

This course consists in weekly lectures and discussions of the development of economic and social organization from a broad standpoint, and includes consideration of such subjects as primitive economic and political groupings and methods, development of gild and feudal systems, evolution of the competitive and quasi-competitive systems in economic life and democratic organization in political life. A considerable amount of outside reading is required from each student. The class meets once a week for two hours, the first being devoted to lecture and the second to discussion of the problems treated in the lecture. The number of students is limited and the seminar is open to juniors and seniors. The seminar meets on Thursday evenings at the home of Professor Laing.

Instructor: Laing.

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 course 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 course 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 course.

Text: An Introduction to Business, Gilbert and Gragg.
Instructor: Gilbert.

Ec. 106 a, b, c. BUSINESS ECONOMICS SEMINAR. Units to be arranged; first, second, and third terms. Open to graduate students.

Special studies of current economic problems are presented by the instructor, after which an open discussion is held. Emphasis is placed on the materials of economic science, i.e., statistics of production, consumption, prices, banking and finance, etc. These quantitative studies are accompanied, where advisable, by reference to economic doctrine.

Instructor: Gilbert.

PHILOSOPHY, ETHICS AND SOCIOLOGY

PROFESSORS: THEODORE G. SOARES, GRAHAM A. LAING

UNDERGRADUATE SUBJECTS

Pl. 1. INTRODUCTION TO PHILOSOPHY. 9 units (3-0-6); second term.
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.
Text: Major, An Introduction to Philosophy.
Instructor: Soares.

Pl. 4. ETHICS. 9 units (3-0-6); first and third terms.
The fundamental ethical concepts and theories that have emerged in
the process of human thought. The major social problems of modern life.
Texts: Barrett, Ethics; Clark and Smith, Readings in Ethics.
Instructor: Soares.

Pl. 5. SOCIOLOGY. 9 units (3-0-6); first term.
The development of races, with a study of biological selection, physi-
cal adaptation, and the influence of climatic and geographical conditions.
The genesis and evolution of the social organism, and the influence of
the economic, religious, intellectual and political interests. A course in
principles, with theses assigned for the application of these principles to
specific social problems.
Instructor: Laing.

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.

DIVISION OF PHYSICAL EDUCATION

PHYSICAL DIRECTOR: WILLIAM L. STANTON
INSTRUCTOR AND MANAGER OF ATHLETICS: HAROLD Z. MUSSELMAN
CONSULTING PHYSICIAN: DR. E. D. KREMERS
PHYSICIAN TO ATHLETES: DR. FLOYD L. HANES

PE. 1, 2, 3, 4. PHYSICAL EDUCATION. 3 units; first, second and third terms.

All students during all four undergraduate years are required to participate either in the intramural or intercollegiate sports on which the physical education programme is based. The intramural sports comprise competition between student houses, classes, clubs, in all sports, including football, cross-country running, track and field events, baseball, basketball, swimming, boxing, wrestling, tennis, handball, etc., and is required of all students not taking part in intercollegiate sports. The intercollegiate sports comprise competition with other members of the Southern California Intercollegiate Conference, of which the Institute is a member. Representative freshmen and varsity teams, trained by experienced coaches, in the major sports are developed. Fair-spirited and clean-cut athletic competition is encouraged for its social and physical values, and as a foundation for genuine college spirit. During the freshman and sophomore years, all students are given physical strength and skill tests in the first and third terms. These tests are used as a basis of comparison with other men of the same weight and height. Corrective or special exercises are prescribed throughout the four years for those who cannot compete in intramural or intercollegiate sports.

Degrees Conferred, June 9, 1933

DOCTOR OF PHILOSOPHY

RAYMOND WELLINGTON AGER, B.S., California Institute of Technology.
ALFRED BERNARD C. ANDERSON, A.B., University of California at Los
    Angeles.
GEORGE HAROLD ANDERSON, A.B. and A.M., Stanford University.
ROBERT C. BARTON, B.S. and M.S., Carnegie Institute of Technology.
STERLING BECKWITH, A.B., Stanford University; M.S., University of
    Pittsburgh.
JAMES LAWRENCE BOTSFORD, B.A., University of Washington.
LAWRENCE OLIN BROCKWAY, B.S. and M.S., University of Nebraska.
ALFRED HOBLITZELLE CLIFFORD, A.B., Yale University.
EVERETT FRANKLIN COX, A.B., Miami University.
EVERETT CARLYLE EDWARDS, A.B. and A.M., University of Wisconsin.
RENE ENGEL, B.S. and M.S., University of Paris.
CHARLES EDWARD HABLUTZEL, JR., A.B. and A.M., Stanford University.
GEORGE THOMAS HARNESS, B.S., California Institute of Technology.
MAURICE FRED HASLER, B.S. and M.S., California Institute of Technology.
GERALD L. HASSLER, B.A. and M.S., Washington University.
RALPH RAYMOND HULTGREN, B.S., University of California; M.S., Uni-
    versity of Utah.
ARNOLD MARTIN KUETHE, Ph.B., Ripon College.
CHARLTON MINER LEWIS, B.A., Yale University.
WILLIAM BRADLEY LEWIS, B.A., Williams College; M.S., California Insti-
    tute of Technology.
JOHN McMORRIS, A.B., College of Emporia.
GEORGE CLARKSON MUNRO, A.B., University of California at Los Angeles.
DWIGHT OLCOTT NORTH, B.S., Wesleyan University.
JOHN GIBSON PLEASANTS, B.S., University of Southern California; M.S.,
    California Institute of Technology.
ROBERT SELDEN ROSE, A.B., Harvard University.
HERMAN FRANZ SCHOTT, B.S., California Institute of Technology.
MAPLE DELOS SHAPPELL, B.S., University of Arizona.
SELBY MILLMORE SKINNER, B.S., University of Washington.
DANIEL DWIGHT TAYLOR, A.B., Colorado College.
GEORGE FREDERIC TAYLOR, B.S. and M.S., California Institute of Tech-
    nology.
JOSEPH WINCHESTER URMSTON, B.A., University of California at Los
    Angeles; M.S., California Institute of Technology.
FRANK LESLIE WATTENDORF, B.A., Harvard University; M.S., Massachu-
    setts Institute of Technology.
SIDNEY WEINBAUM, B.S., California Institute of Technology.
DAVID HAROLD WEINSTEIN, A.B., University of California.
EDGAR BRIGHT WILSON, JR., B.S. and M.A., Princeton University.
ALEXANDER WOLF, B.S., University of Pennsylvania.
CARLETON RUSSELL WORTH, A.B., Southwest Missouri Teachers College;
    S.M., University of Chicago.

MASTER OF SCIENCE IN ENGINEERING

ELECTRICAL ENGINEERING

LINDSAY MORITZ APPLEGATE, B.S., University of Washington.
ALBERT WILLIAM ATWOOD, JR., B.S., California Institute of Technology.
WILLIAM LADHU BERRY, B.S., California Institute of Technology.
FREDERICK WILLIAM BOWDEN, B.S., California Institute of Technology.
WILLIAM MORRIS EVANS, B.S., University of Southern California.
RAYMOND HOWARD GRIEST, B.S., California Institute of Technology.
PAUL FREDERICK HAWLEY, B.S., University of Arizona.
MILLS SCHUYLER HODGE, B.S., California Institute of Technology.
SAMUEL ERIC HOWSE, B.S., California Institute of Technology.
CHUEN CHANG HSU, B.S., Georgia School of Technology.
WILLIAM LAWRENCE NEWMEYER, JR., B.S., Case School of Applied Science.
WILLIAM MORLEY PICKLES, JR., B.S., Missouri School of Mines.
ARTHUR HERMAN SCHLECHTER, B.S., University of Oklahoma.
HYMAN ZALMON SOLOMON, B.S., California Institute of Technology.
ROBERT LESLIE SUGGS, B.S., Agricultural and Mechanical College of Texas.
RUBIN WIDESS, B.S., California Institute of Technology.

MECHANICAL ENGINEERING

AMMON S. ANDES, B.S., Montana State College.
THOMAS WILLIAM BELL, B.S., California Institute of Technology.
RAYMOND CHARLES BINDER, B.S., California Institute of Technology.
MILTON EUGENE CZAMANSKE, M.E., Marquette University.
EDWIN NATHAN DAVIS, B.S., University of Wyoming.
ROBERT BRAMAN FREEMAN, B.S., California Institute of Technology.
BENARTHUR CASTLE HAYNES, B.S., California Institute of Technology.
KANAME KITUSDA, B.S., Tri-State College.
CLARENCE R. DE LAUBENFELS, B.S. (ME); B.S. (EE), Iowa State College.
JOHN LESLIE MAGDEN, B.S., University of California.
EDWIN BARTHOLOMEW MICHAL, B.S., University of Nevada.
KEITH MURDOCK, B.S., University of Utah.
LEONARD EUGENE ROOT, B.A., College of the Pacific.
KENNETH HAYES SWART, B.S., California Institute of Technology.

CIVIL ENGINEERING

FRED BERKELEY BOWMAN, B.S., The State College of Washington.
CLIFFORD COMER CAWLEY, B.S., California Institute of Technology.
ALBERT ARTHUR KOCH, B.S., Armour Institute of Technology.
WILLIAM ARTHUR LARSEN, B.S., University of Utah.
HARALD OMSTED, Graduate of Norway Institute of Technology.
WORRELL FRANZONI PRUDEN, B.S., California Institute of Technology.
HAROLD ROACH, B.S., California Institute of Technology.
JOSEPH SHEFFET, B.S., California Institute of Technology.
HOWARD GARDNER SMITS, B.S., California Institute of Technology.
DAVID YUE-KWONG WONG, B.A., University of Redlands; B.S., California
        Institute of Technology.

AERONAUTICAL ENGINEERING

PAUL HANES KEMMER, Graduate U. S. A. Air Corps Engineering School.

MASTER OF SCIENCE IN SCIENCE

PHYSICS

EDWARD DAY ALCOCK, A.B., University of California at Los Angeles.
ROBERT COMBS KENDALL, B.A., De Pauw University.
WILLIAM HAYWARD PICKERING, B.S., California Institute of Technology.
JOHN TOWNSEND SINNETTE, JR., B.S., California Institute of Technology.
CARL LESLIE THIELE, B.S., California Institute of Technology.

ASTROPHYSICS

BRIAN ORVILLE SPARKS, B.S., California Institute of Technology.

CHEMISTRY

ERNEST HERBERT LYONS, JR., B.S., Massachusetts Institute of Technology.
ARTHUR NICHOLS PRATER, A.B., University of California at Los Angeles.
CHESTER EUGENE WILSON, B.S., California Institute of Technology.

CHEMICAL ENGINEERING

CHARLES EDMUND KIRCHER, JR., B.S., California Institute of Technology.

GEOLOGY AND PALEONTOLOGY

FRANK WAGNER BELL, B.S., California Institute of Technology.
WILLIAM MAURICE COGEN, B.S., California Institute of Technology.
MAURICE GHIRARR DONNELLY, E.M., Colorado School of Mines.
DAVID BARNARD ERICSON, B.S., Massachusetts Institute of Technology.
ELBERT NELSON HARSHMAN, B.S., California Institute of Technology.
BENJAMIN HOLZMAN, B.S., California Institute of Technology.
LOUIS EMMETT KEMNITZER, A.B., Stanford University.
WILLIS PARKISON POPENOE, B.S., George Washington University.

METEOROLOGY

IRVING PARKHURST KRICK, A.B., University of California.

BACHELOR OF SCIENCE

(Stars indicate graduation with honor)

Science

*Harrison Stout Backus
David Fulmer Bender
Ygnacio Bonillas
*Eugene Mittell Brunner
Lee Thurston Carleton
Raymond Avolon Cromley
Russell Nimtz Doescher
Nathan Eisen
Victor Elconin
Elmer Sherwood Franklin
*Rubin Harold Frieman
Gregory Kemenyi Hartman
Francis Robert Hunter
Kedric Vincent Keeley
E. Russell Kennedy

Delmar Herman Larsen
*L. Jackson Laslett
Wyatt Hunter Lewis
Douglas George Marlow
*William A. Mersman
Hunter Nicholson, Jr.
Earl Mortimer Olds
Donald Keith Olson
Charles Dillon Perrine, Jr.
Donald Frederick Poulson
Christian Henry Prior
Hyman Zalmon Solomon
William Ellis Stone
Henry Bruno Suhr
Arnold Philip Wilking

Engineering

Willard Andrew Ashton
John Kimball Ayers
Sidney Francis Bamberger
Earl Edgar Barnett
George Merrill Berkeley
Evan George Bower
*Ralph Edward Byrne, Jr.
David Lewis Clark, Jr.
Phillip Henry Craig
Edgar Grenfelle Crawford
Ray Hayward Cripps
Bruce M. Dack
Trent Raysbrook Dames
Madison Thenton Davis, III.
Joseph DeMilita
Frederick Henry Detmers
Phillip Charles Efromson
Kenneth Stuart Fitch
Robert Dawson Fletcher

Louis Harold Goss
Laurence Keeney Gould
Robert Brown Grossman
Edward A. Hayes
Robert George Herlin
James Warren Hill
Oliver Dimmitt Hofmann
Robert Charles Hogan
James Stanley Johnson
Samuel Yorks Johnson
Arthur Edward Lamel
Alexander Feller Libby
*Ernest Ray Lockhart
Robert George Macdonald
Arthur Adelbert Mathewson, Jr.
Edward Jean Matson
Walter Lyde McCleery, Jr.
Robert Rufus Mead
*John Dale Mendenhall

John Edward Meskell
Theodore Samuel Mitchell
John Chester Monning, Jr.
William Wallace Moore
Wendell Alton Morgan
Bernhard Nelson Palm
Durward Harry Palmer
William Charles Pauly
George Henry Pickett
*John Robinson Pierce
*Louis Albert Pipes
Dick August Plank
Winston Randolph Rice
Willard Clement Robinette
Richard Lord Russell
Dean Frederick Saurenman

Walter Scholtz
Grover Marion Secord
Nikolai Nikolaevich Skaredoff
Robert Leslie Smallman
Alvin Joseph Smith
Warren Howard Smith
James Clifton Spade
Jack Norman Sparling
Charles Bryson Spicer
Ferdinand Edward Strauss
Thomas Starr Terrill
*Charles Emil Tillman
John Spencer Warfel
William Thornton Wheeler
*Moses Barak Widess

Honors, 1933

JUNIOR SCHOLARS: WILLIAM GORDON COX, THOMAS JAY DEAHL, CHARLES JAMES GIBBS, EMERSON WARD GREEN, RICHARD HENRY JAHNS, WALLACE J. S. JOHNSON, ROBERT LINCOLN KRAMER, HENRI ARTHUR LEVY, JOHN LISOL, WILLIAM BURDETTE MCLEAN, RICHARD B. NELSON, KENNETH SANBORN PITZER

SOPHOMORE SCHOLARS: DANA R. BEAL, CLARENCE FRANCIS GOODHEART, ROBERT GEORGE HEITZ, BRUCE LATHAN HICKS, ALEXANDER IVAN KOSSIAKOFF, TOM LAURITSEN, HARRY GLENN LEWIS, ROBERT ALFRED MCINTYRE, MAURICE SKLAR, CARL MAYN SMITH, TYLER F. THOMSON, THEODORE VERMEULEN, KENICHI WATANABE, EUCLID V. WATTS, DONALD LAURENCE YOUNG

DRAKE SOPHOMORE SCHOLAR:
ROBERT LEE JANES

BLACKER FRESHMAN SCHOLARS:
DANIEL LAUDER GERLOUGH, Palo Alto High School
LEVAN GRIFFIS, Los Angeles High School
JAMES ARNOLD HURST, Hinsdale Township High School, Illinois
WENDELL BOWER MILLER, Hollywood High School
DAVID PRESSMAN, Los Angeles High School
EDWARD THOMAS PRICE, Webb School, Claremont
FREMONT FISHER RADCLIFFE, San Luis Obispo High School
RICHARD ROSENCRANZ, Benjamin Bosse High School, Evansville, Indiana
ROBERT DAWSON TOWNSEND, Manual Arts High School, Los Angeles
GEORGE ROCKWELL WALLACE, Montesano High School, Washington

DRAKE FRESHMAN SCHOLARS:
WILLARD FARNHAM, Bend High School, Oregon
JOHN CUNNINGHAM LILLY, St. Paul Academy, St. Paul, Minnesota
HARRY HEYBURN MILLER, Bend High School, Oregon

KIRCHER FRESHMAN SCHOLAR:
WILBUR FISHER SNELLING, Placer Union High School, Auburn, California

SANTA BARBARA FRESHMAN SCHOLAR:
VICTOR BORIS ZEZUKEVICH, Russian High School, Harbin, China; and Santa Barbara State Teachers College

SAN DIEGO FRESHMAN SCHOLAR:
DANIEL SCHUMAN, San Diego High School

INSTITUTE FRESHMAN SCHOLARS:

ELLSWORTH WILLIAM CORNWALL, Benson Polytechnic High School, Portland, Oregon

DON CHARLES DEVAULT, Inglewood High School

DON PATTERSON EDWARDS, Franklin High School, Los Angeles

ALAN JOHN GROBECKER, San Diego High School

EDWARD JAMES HORKEY, John Muir High School, Pasadena

WILSON BURDETTE JONES, Alhambra High School

CARL ELMER LARSON, Monrovia-Arcadia-Duarte High School

FREDERIC HOLLWAY MOORE, Fairfax High School, Los Angeles

JOHN PETER SELBERG, Jefferson High School, Portland, Oregon

JOSIAH EDWARDS SMITH, Corona High School

BENJAMIN FREDRICK STEIN, Mt. Carmel High School, Mt. Carmel, Illinois

JAMES EUGENE STONES, Polytechnic High School, Los Angeles

GEORGE YOSHIO TSUBOTA, Polytechnic High School, Riverside

VSEVOLOD VESIE TULAGIN, Hollywood High School

CONGER PEACE PRIZE:

MAX FRANKLIN MILLIKAN, THOMAS STARR TERRILL.

Graduate Students

NAME	MAJOR SUBJECT	HOME ADDRESS
ALCOCK, EDWARD DAY	Ph	Los Angeles

A.B., University of California at Los Angeles, 1930; M.S., California Institute, 1933

ALDEN, LUCAS AVERY (†)	Ph	Montrose

B.S., California Institute, 1931

ALEXANDER, CHARLES K.	Ph	Oberlin, Ohio

A.B., Oberlin College, 1932

BACKUS, HARRISON STOUT	Ch E	Pasadena

B.S., California Institute, 1933

BEACH, JOHN YOUNGS	Ch	Lakeport

B.S., University of California, 1933

BELL, FRANK WAGNER	Ge	Altadena

B.S., California Institute, 1928; M.S., 1933

BENDER, DAVID FULMER	Ph	Spokane, Washington

B.S., California Institute, 1933

BERGREN, WILLIAM RAYMOND	Bi	Pasadena

B.S., California Institute, 1932

BINDER, RAYMOND CHARLES	ME	Chicago, Illinois

B.S., Massachusetts Institute of Technology, 1930; M.S., California Institute, 1933

BLAIR, CHARLES MELVIN (†)	Ch	Vernon, Texas

B.A., The Rice Institute, 1931; M.A., 1932

BODE, FRANCIS DASHWOOD (†)	Ge	Sierra Madre

B.S., California Institute, 1930; M.S., 1931

BOLGER, HENRY JOSEPH, C.S.C.	Ph	Notre Dame, Indiana

A.B., University of Notre Dame, 1924; M.A., Catholic University of America, 1929

BOLLAY, WILLIAM	AE	Evanston, Illinois

B.S., Northwestern University, 1933

BOLLMAN, VERNON LEROY	Ph	Pasadena

B.S., University of Nebraska, 1931; M.S., 1933

BONNER, JAMES FREDERICK (†)	Bi	Salt Lake City, Utah

B.A., University of Utah, 1931

BONNER, LYMAN GAYLORD (†)	Ch	Salt Lake City, Utah

B.A., University of Utah, 1932

BOWDEN, FREDERICK WILLIAM	EE	San Luis Obispo

B.S., California Institute, 1932; M.S., 1933

BREITWIESER, CHARLES JOHN	EE	Grand Forks, North Dakota

B.S., University of North Dakota, 1931

BRICE, RICHARD THEOBOLD	Ph	Atlanta, Georgia

B.S., Emory University, 1931; M.S., 1932

BRIDGET, FRANCIS JOSEPH	AE	Altadena

United States Naval Academy, 1917-1921

BROADWELL, SAMUEL JONATHAN (†)	Ph	Monterey Park

B.S., Throop College of Technology, 1918; M.S., University of Chicago, 1920

BROWN, VINTON AUSTIN (†)	Ph	Mesa, Arizona

B.S., University of Arizona, 1929; M.S., 1931

NAME	MAJOR SUBJECT	HOME ADDRESS

BROWNE, THOMAS EVERETT, JR.   EE Raleigh, North Carolina
   B.S., North Carolina State University, 1928; M.S., University of Pittsburgh, 1933

BRUBAKER, WILSON MARCUS   Ph West Alexandria, Ohio
   A.B., Miami University, 1932

BRUNNER, EUGENE MITTELL   Ph Santa Paula
   B.S., California Institute, 1933

BYRNE, RALPH EDWARD, JR.   CE Kansas City, Missouri
   B.S., California Institute, 1933

CARRICO, JAMES LEON (†)   Ch Aubrey, Texas
   B.A., North Texas State Teachers College, 1927; B.S., 1929; M.A., University of Texas, 1931

CHATTERTON, JAY HEWITT   Ma Portland, Oregon
   B.S., Oregon State College, 1932

CHAWNER, WILLIAM DONALD   Ge Pasadena
   A.B., Occidental College, 1925

CHRISTENSEN, NEPHI ALBERT   CE Provo, Utah
   B.S., Brigham Young University, 1925; B.S.C.E., University of Wisconsin, 1928

CLANCY, CLARENCE WILLIAM   Bi Highland, Illinois
   B.S., University of Illinois, 1930; M.S., 1932

CLARK, DONALD SHERMAN (†)   ME Bakersfield
   B.S., California Institute, 1929; M.S., 1930

CLARKE, LOYAL   Ch Los Gatos
   B.S., Oregon State College, 1927

CLARKE, ROBERT ALMA   Ph American Fork, Utah
   B.S., Brigham Young University, 1932; M.S., 1933

COBINE, JAMES DILLON (†)   EE Madison, Wisconsin
   B.S., University of Wisconsin, 1931; M.S., California Institute, 1932

COGEN, WILLIAM MAURICE (†)   Ge Los Angeles
   B.S., California Institute, 1931; M.S., 1933

CONLEE, ROBERT HENRY   Ma Fairfield, Iowa
   A.B., University of New Mexico, 1926; A.M., University of Southern California, 1933

COOK, DAVID ERVING   EE Flintridge
   B.S., Duke University, 1933

COOKSEY, CHARLTON DOWS   Ge New Haven, Connecticut
   B.S., Yale University, 1932

CRAWLEY, CLYDE BROOKS (†)   Ph Pasadena
   B.A., University of Kentucky, 1930; M.S., 1931

CRUMRINE, KENNETH CARL   Ph Lawrence, Kansas
   A.B., University of Kansas, 1932; A.M., 1933

CURCIO, ANTHONY EUGENE   AE Brooklyn, New York
   United States Military Academy, 1926-1930

CURRY, H. DONALD   Ge Tulare
   B.A., State University of Iowa, 1929; M.S., 1930

DAMES, TRENT RAYSBROOK   CE San Diego
   B.S., California Institute, 1933

DARLINGTON, JOSEPH HUBBARD   Ph La Jolla
   A.B., Bowdoin College, 1928; B.A., Cambridge University, England, 1931

DAVIS, MADISON THENTON, III.   ME Pasadena
   B.S., California Institute, 1933

DELSASSO, LEWIS A.   Ph South Pasadena
   A.B., University of California at Los Angeles, 1930

DESCAMPS, ALPHONSE MAURICE   AE Mons, Belgium
   Ingenieur Civil Electricien et Ingenieur Civil Mecanicien, Mining and Metallurgical School, Mons, Belgium, 1933

DEVORE, HENRY BLYTHE (†)   Ph Monongahela, Pennsylvania
   B.S., Pennsylvania State College, 1926; M.S., 1927

NAME	MAJOR SUBJECT	HOME ADDRESS
DOESCHER, RUSSELL NIMTZ	Ch	Santa Monica
B.S., California Institute, 1933		
DONNELLY, MAURICE GHIRARR (†)	Ge	Johnsonburg, Pennsylvania
E.M., Colorado School of Mines, 1929; M.S., California Institute, 1933		
DUNN, CLARENCE LINCOLN	Ch	Juneau, Alaska
B.S., University of Washington, 1932; M.S., 1933		
DUNSTER, WILLIAM HILL	CE	West Los Angeles
B.S., University of Michigan, 1922		
DUNTLEY, SEIBERT QUIMBY	Ph	Macomb, Illinois
B.S., Massachusetts Institute of Technology, 1933		
DUWEZ, POL EDGARD	AE	Brussells, Belgium
Engineer, School of Mines, Mons, 1932; Doctor in Physical and Mathematical Sciences, Brussels, 1933		
EBERZ, WILLIAM FERDINAND (†)	Ch	Altadena
B.S., California Institute, 1931		
ELLIOTT, NORMAN	Ch	Glendora
A.B., Oberlin College, 1929; A.M., 1930		
ELLIS, EMORY LEON (†)	Bi	Pasadena
B.S., California Institute, 1930; M.S., 1932		
FINDLAY, WILLARD ALEXANDER (†)	Ge	Pasadena
B.S., California Institute, 1929; M.S., 1932		
FLETCHER, ROBERT DAWSON	AE	Huntington Park
B.S., California Institute, 1933		
FOWLER, WILLIAM ALFRED	Ph	Lima, Ohio
B. of Eng.Ph., Ohio State University, 1933		
FRACKER, HENRY EDWARD	Ph	Pasadena
B.S., California Institute, 1930		
FREEMAN, ROBERT BRAMAN	ME	Pasadena
B.S., California Institute, 1932; M.S., 1933		
FRIEMAN, RUBIN HAROLD	Ch	Los Angeles
B.S., California Institute, 1933		
GAINDER, MELVIN EARNEST (†)	EE	San Diego
B.S., California Institute, 1926; M.S., University of Pittsburgh, 1931		
GENACHTE, PAUL FRANK	EE	Brussels, Belgium
Engineer in Electrical and Mechanical Engineering, Brussels University, 1932; M.S.E.E., Massachusetts Institute of Technology, 1933		
GLASSER, JULIAN	Ch	Chicago, Illinois
B.S., University of Illinois, 1933		
GOLDSTEIN, JULIAN RICHARD	AE	Rochester, New York
B.S., University of Rochester, 1932		
GREGORY, CARTER HOLT (†)	Ph	San Marino
B.S., California Institute, 1931		
GRIEST, RAYMOND HOWARD	EE	Hermosa Beach
B.S., California Institute, 1932; M.S., 1933		
GRIMM, GEORGE, JR.	EE	Fort Thomas, Kentucky
B.S., University of Kentucky, 1933		
GROSS, SIEGFRIED THEODORE	Ch	Colorado Springs, Colorado
A.B., Colorado College, 1933		
HARKER, DAVID	Ch	Mill Valley
B.S., University of California, 1928		
HAWLEY, PAUL FREDERICK	EE	Miami, Arizona
B.S., University of Arizona, 1932; M.S., California Institute, 1933		
HAYNES, BENARTHUR CASTLE	ME	Pasadena
B.S., California Institute, 1932; M.S., 1933		
HAYNES, SHERWOOD KIMBALL (†)	Ph	Allston, Massachusetts
A.B., Williams College, 1932		
HEMMENDINGER, ARTHUR	Ph	Bernardsville, New Jersey
B.A., Cornell University, 1933		

NAME	MAJOR SUBJECT	HOME ADDRESS
HERRING, WILLIAM CONYERS	Ph	Parsons, Kansas
A.B., University of Kansas, 1933		
HIGHBERG, IVAR EDMUND	Ma	Spokane, Washington
B.A., Whitman College, 1932; M.A., 1933		
HILL, EARL S.	ME	Tangent, Oregon
B.S., Oregon State College, 1930		
HOBSON, JESSE EDWARD	EE	Marshall, Indiana
B.S.E.E., Purdue University, 1932; M.S.E.E., 1933		
HOLZMAN, BENJAMIN (†)	Ge	Los Angeles
B.S., California Institute, 1931; M.S., 1933		
HOWARD, JOHN BRIGHAM	Ch	Edgewood, Pennsylvania
B.S., Harvard College, 1933		
HUTCHINS, CARLTON BARMORE	AE	Pasadena
United States Naval Academy, 1922-1926		
JACOBS, ROBERT BYRON (†)	Ph	Santa Monica
B.S., California Institute, 1931		
JEROME, CLAYTON C.	AE	Pasadena
United States Naval Academy, 1918-1922, 1932-1933		
JOHNSON, JAMES STANLEY	ME	Pasadena
B.S., California Institute, 1933		
JOHNSON, JOSEF JEROME (†)	Ay	Pasadena
B.S., California Institute, 1930		
JOHNSON, SAMUEL YORKS	CE	Pasadena
B.S., California Institute, 1933		
JORDAN, WALTER HARRISON (†)	Ph	Scappoose, Oregon
A.B., University of Oklahoma, 1930; M.S., 1931		
KANOUSE, EDGAR LAROE	EE	Amarillo, Texas
B.S., Oklahoma University, 1932; B.A., 1933		
KEIGHLEY, GEOFFREY (†)	Bi	Toronto, Canada
B.A., University of Toronto, 1926		
KELCH, MAXWELL	Ph	Hollywood
A.B., University of California at Los Angeles, 1933		
KELLEY, VINCENT COOPER	Ge	South Pasadena
A.B., University of California at Los Angeles, 1931		
KEMNITZER, LUIS EMMETT (†)	Ge	Altadena
A.B., Stanford University, 1925; M.S., California Institute, 1933		
KENDALL, ROBERT COMBS	Ph	Jeffersonville, Indiana
B.A., DePauw University, 1932; M.S., California Institute, 1933		
KENNEDY, E. RUSSELL	Ch	Los Angeles
B.S., California Institute, 1933		
KINSLER, LAWRENCE EDWARD (†)	Ph	Los Angeles
B.S., California Institute, 1931		
KITUSDA, KANAME	AE	Toyko, Japan
B.S., Tri-State College, 1932; M.S., California Institute, 1933		
KNOY, MARION FRANKLIN	ME	Los Angeles
B.S., Texas Christian University, 1927		
KRICK, IRVING PARKHURST (†)	My	Pasadena
A.B., University of California, 1928; M.S., California Institute, 1933		
LIBBY, ALEXANDER FELLER	EE	San Bernardino
B.S., California Institute, 1933		
LIPP, JAMES EVERETT	AE	Los Angeles
B.S., California Institute, 1932		
LIU, YUN-PU (†)	Ch	Gianyen, Taichow, Kiangsu, China
B.S., University of Amoy, China, 1927; M.A., University of Southern California, 1931		
LLOYD, PAUL EUGENE	Ph	Hollywood
A.B., Stanford University, 1929		

NAME	MAJOR SUBJECT	HOME ADDRESS
LOCKHART, ERNEST RAY	ME	El Paso, Texas

B.S., California Institute, 1933

| LYONS, ERNEST HERBERT, JR. | Ch | Kenilworth, Illinois |

B.S., Massachusetts Institute of Technology, 1931; M.S., California Institute, 1933

| MAGDEN, JOHN LESLIE | AE | North Hollywood |

B.S., University of California, 1929; M.S., California Institute, 1933

| MATHEWS, ADIN ERNEST | EE | Peyton, Colorado |

B.S., University of Southern California, 1931

| McCULLOUGH, JAMES DOUGLAS | Ch | Los Angeles |

A.B., University of California at Los Angeles, 1932

| McMILLIN, FITTEN LAMAR | Ph | Yazoo City, Mississippi |

B.A., Mississippi College, 1929; B.S., Mississippi State College, 1930

| McNAUGHTON, DUNCAN ANDERSON | Ge | Vancouver, British Columbia |

A.B., University of Southern California, 1933

| McRAE, JAMES WILSON | EE | Vancouver, British Columbia |

Bachelor of Applied Science, University of British Columbia, 1933

| MEDLIN, WILLIAM VIRGIL (†) | Ch | Tracy |

B.S., University of California, 1932

| MEEHAN, EDWARD JOSEPH | Ch | Berkeley |

B.S., University of California, 1933

| MENG, CHAO YING | Ph | Peiping, China |

B.S., Yenching University, 1928; M.S., 1931

| MERSMAN, WILLIAM ALVIN | Ma | Alhambra |

B.S., California Institute, 1933

| MILES, ERIC JOHNSTONE | EE | Fort Collins, Colorado |

B.S., University of Colorado, 1931; M.S., California Institute, 1932

| MOORE, WILLIAM WALLACE | CE | Pasadena |

B.S., California Institute, 1933

| NEDDERMEYER, SETH HENRY (†) | Ph | San Clemente |

A.B., Stanford University, 1929

| OFFNER, FRANKLIN FALLER | Ch | Three Lakes, Wisconsin |

Bachelor of Chemistry, Cornell University, 1933

| OVERHAGE, CARL F. J. | Ph | Santa Barbara |

B.S., California Institute, 1931

| PETERSEN, FRANK FRED | ME | Fullerton |

B.S., California Institute, 1927; M.A., University of Southern California, 1930

| PETERSON, RAYMOND ALFRED (†) | GE | Denver, Colorado |

B.S., California Institute, 1931

| PICKERING, WILLIAM HAYWARD (†) | Ph | Christchurch, New Zealand |

B.S., California Institute, 1932; M.S., 1933

| PICKETT, GEORGE HENRY | CE | Pasadena |

B.S., California Institute, 1933

| PICKLES, WILLIAM MORLEY, JR. | EE | El Paso, Texas |

B.S., School of Mines and Metallurgy, Missouri, 1932; M.S., California Institute, 1933

| PIERCE, JOHN ROBINSON | EE | Pasadena |

B.S., California Institute, 1933

| PIPES, LOUIS ALBERT | EE | South Pasadena |

B.S., California Institute, 1933

| PITTS, ROBERT GILES | AE | Marion, Alabama |

B.S., Alabama Polytechnic Institute, 1933

| PLESSET, ERNEST H. | Ph | Pittsburgh, Pennsylvania |

B.S., University of Pittsburgh, 1933

| POOLE, ALBERT ROBERTS | Ma | Vancouver, British Columbia |

B.A., University of British Columbia, 1929; M.A., 1931

| POPENOE, WILLIS PARKISON (†) | Ge | Pasadena |

B.S., George Washington University, 1929; M.S., California Institute, 1933

NAME	MAJOR SUBJECT	HOME ADDRESS
PORTER, ARZA FRANCIS	CE	Arroyo Grande
B.S., University of Santa Clara, 1932		
POULSON, DONALD F.	Bi	Idaho Falls, Idaho
B.S., California Institute, 1933		
PRATER, ARTHUR NICOLAS (†)	Ch	Glendale
A.B., University of California at Los Angeles, 1932; M.S., California Institute, 1933		
RAITT, RUSSELL WATSON (†)	Ph	South Pasadena
B.S., California Institute, 1929; M.S., 1932		
RAMO, SIMON	EE	Salt Lake City, Utah
B.S., University of Utah, 1933		
RASSIEUR, WILLIAM THEODORE	AE	Altadena
United States Naval Academy, 1919-1923		
READ, GEORGE WILBUR (†)	EE	Glendale
B.S., California Institute, 1930		
READ, JOHN (†)	Ph	Hertfordshire, England
B.S., London University, 1931		
REED, ALBERT CLARK	AE	Los Angeles
B.S., California Institute, 1929		
RICE, HARINGTON MOLESWORTH ANTHONY (†)	Ge	Duncan, British Columbia
B.A., University of British Columbia, 1923; M.A., 1931		
RIDENOUR, LOUIS NICOT, JR.	Ph	Evanston, Illinois
B.S., University of Chicago, 1932		
ROCKEFELLER, WILLIAM CURTIS	ME	Pasadena
B.S., California Institute, 1932		
ROMER, ALFRED (†)	Ph	Whittier
B.A., Williams College, 1928		
ROOT, LEONARD EUGENE	AE	Stockton
B.A., College of the Pacific, 1932; M.S., California Institute, 1933		
RUCKER, GEORGE FOSTER	EE	Denver, Colorado
B.S. in E.E., Southern Methodist University, 1931		
SAGE, BRUCE HORNBROOK	ME	Pasadena
B.S., New Mexico College of Agriculture and Mechanical Arts, 1929; M.S., California Institute, 1931		
SCHULTZ, JOHN RUSSELL	Ge	Lanark, Illinois
A.B., University of Illinois, 1931; M.S., Northwestern University, 1933		
SCOTT, HOMER JUDKINS	CE	Pasadena
B.S., Iowa State College, 1932		
SERBIN, HYMAN	Ma	Pittsburgh, Pennsylvania
B.A., Carnegie Institute of Technology, 1933		
SERRURIER, MARK USONA	CE	Hollywood
B.S., California Institute, 1926; M.S., University of Illinois, 1928		
SHURTLEFF, DEWEY	Ph	Globe, Arizona
B.S., University of Arizona, 1932; M.S., 1933		
SIMMONS, NORWOOD LEE	Ch	Chapel Hill, North Carolina
B.S., University of North Carolina, 1933		
SKARADOFF, NIKOLAI NIKOLAEVITCH	ME	Yokahama, Japan
B.S., California Institute, 1933		
SKOOG, FOLKE KARL (†)	Bi	Pasadena
B.S., California Institute, 1932		
SLAUGHTER, RICHARD ERVIN	AE	Dallas, Texas
B.S. in M.E., Southern Methodist University, 1933		
SLAWSKY, ISRAEL ZAKA	Ph	Brooklyn, New York
B.S., Rensselaer Polytechnic Institute, 1933		
SLAWSKY, MILTON	Ph	Brooklyn, New York
B.S., Rensselaer Polytechnic Institute, 1933		

NAME	MAJOR SUBJECT	HOME ADDRESS
SMITH, ALVIN JOSEPH	EE	Pasadena
B.S., California Institute, 1933		
SMITH, HAMPTON (†)	Ge	Monrovia
B.S., California Institute, 1928		
SOSKE, JOSHUA LAWRENCE (†)	Ge	Pasadena
G.E., Colorado School of Mines, 1929; M.S., California Institute, 1932		
SPARLING, JACK NORMAN	CE	Glendale
B.S., California Institute, 1933		
STIRTON, ROBERT INGERSOLL (†)	Ch	Rochester, Michigan
B.S., California Institute, 1930		
STITT, FRED BEALS	Ch	Pittsburgh, Pennsylvania
B.S., Carnegie Institute of Technology, 1932; M.S., 1933		
STRONG, THOMAS FOSTER	Ph	Berkeley
B.S., University of Wisconsin, 1922		
TAPLEY, GUSTAVIUS SHEFFIELD	ME	Los Angeles
B.S., University of Southern California, 1924; M.S., 1929		
TAYLOR, ANGUS ELLIS	Ma	Pomona
B.S., Harvard College, 1933		
THAYER, THOMAS P. (†)	Ge	Eugene, Oregon
B.A., University of Oregon, 1929; M.A., Northwestern University, 1931		
THIELE, CARL LESLIE	Ph	Pasadena
B.S., California Institute, 1932; M.S., 1933		
TURNER, JAMES HOWARD	Ch	Colorado Springs, Colorado
A.B., Colorado College, 1933		
VAILE, ROBERT BRAINARD, JR. (†)	EE	Alhambra
B.S., California Institute, 1927		
VANONI, VITO AUGUST (†)	CE	Camarillo
B.S., California Institute, 1926; M.S., 1932		
VOSSELLER, AURELIUS BARTLETT	AE	Pasadena
United States Naval Academy, 1920-1924		
WALL, FREDERICK THEODORE	Ch	Minneapolis, Minnesota
Bachelor of Chemistry, University of Minnesota, 1933		
WATSON, BERNARD BENNETT	Ph	Philadelphia, Pennsylvania
A.B., Temple University, 1932		
WATSON, RALPH MAYHEW	ME	Pasadena
B.S., California Institute, 1927; M.S., 1928		
WAYLAND, JAMES HAROLD (†)	Ph	Boise, Idaho
B.S., University of Idaho, 1931		
WEBB, DONALD LOOMIS	Ma	Tucson, Arizona
B.S., University of Arizona, 1931; M.S., 1933		
WEBER, RALPH CLARENCE	EE	Crestline
B.S., California Institute, 1928		
WEINGARTEN, SAMUEL MARCUS	Ph	Los Angeles
A.B., University of California at Los Angeles, 1930		
WELGE, HENRY JOHN	Ch	Long Beach
B.S., University of Illinois, 1929; M.S., California Institute, 1932		
WENSTROM, WILLIAM HOLMES	My	Pasadena
United States Military Academy, 1919; M.S., Yale University, 1931		
WEST, SAMUEL STEWART (†)	Ph	Los Angeles
B.S., California Institute, 1930; M.S., 1932		
WESTGATE, MARK WHEELER	Ch	Honolulu, Hawaii
B.S., University of Hawaii, 1932; M.S., 1933		
WHITE, MERIT PENNIMAN	CE	Whately, Massachusetts
A.B., Dartmouth College, 1930; C.E., 1931		
WHITE, ROLAND JAMES	AE	San Francisco
B.S., University of California, 1933		
WIDESS, MOSES B.	EE	Pasadena
B.S., California Institute, 1933		

NAME	MAJOR SUBJECT	HOME ADDRESS
WILLARD, KENNETH A.	AE	Evanston, Illinois
B.S., Northwestern University, 1933		
WILSON, CHESTER EUGENE (†)	Ch	North Hollywood
B.S., California Institute, 1932		
WILSON, CLYDE E.	ME	Pasadena
B.S., University of Michigan, 1905; M.S., 1917		
WILSON, OLIN CHADDOCK, JR. (†)	Ay	Pasadena
A.B., University of California, 1929		
WILSON, ROBERT WARREN (†)	Ge	Los Angeles
B.S., California Institute, 1930; M.S., 1932		
WILSON, WARREN ELVIN	CE	Madison, New Jersey
Civil Engineer, Lehigh University, 1928; Master of C.E., Cornell University, 1932		
WISLICENUS, GEORGE FRIEDRICH (†)	ME	Strassburg, Alsace
M.E., State Institute of Technology, Wurzberg, Germany, 1925; M.S., California Institute, 1931		
WOLFE, HALLEY	EE	Porterville
B.S., California Institute, 1932		
WOOD, CARLOS CLAUDE	AE	Stockton
A.B., College of the Pacific, 1933		
WOOLDRIDGE, DEAN EVERETT	Ph	Oklahoma City, Oklahoma
B.A., University of Oklahoma, 1932; M.S., 1933		

Undergraduate Students

Students whose names are starred attained honor standing during the preceding year.

SENIOR CLASS

NAME	COURSE	OPTION	HOME ADDRESS
Anderson, Robert Carron	Eng.	AE	Hollywood
Babcock, Horace Welcome	Eng.	CE	Pasadena
Birdsey, William Canvin	Eng.	ME	Pasadena
Boche, Robert DeVore	Sci.	Bi	Seattle, Washington
Boykin, Robert Owen, Jr.	Eng.	ME	Pasadena
Brown, Robert	Eng.	ME	Los Angeles
Campbell, James Richard	Eng.	ME	Pasadena
Charters, Alexander C.	Sci.	A.Ph	Portland, Oregon
Childers, Milford Carlson	Eng.	AE	Los Angeles
Clauser, Francis Hettinger	Sci.	A.Ph	Pasadena
Clauser, Milton Ure	Sci.	A.Ph	Pasadena
Cleveland, Donald Leroy	Sci.	A.Ch	Wilmar
Cogen, Sol	Eng.	CE	Los Angeles
Core, Edwin John	Eng.	CE	Long Beach
Cortelyou, Jack Taylor	Eng.	CE	Los Angeles
Cox, Herbert Orville	Eng.	EE	Pomona
Craig, Carroll	Eng.	CE	Beverly Hills
Crutchfield, Richard Stanley	Eng.	CE	Pasadena
Dane, Paul Howard	Eng.	AE	Taft
Davis, James Donald	Eng.	ME	Los Angeles
Desmond, Jack Maxwell	Eng.	EE	San Bernardino
Dietrich, Robert Alexander	Sci.	A.Ph	Los Angeles
Doll, Edward Bushnell	Sci.	A.Ph	Los Angeles
Donahue, Willis Ray	Sci.	Bi	Ontario
Douglass, Paul William	Sci.	Ma	Pasadena
Escherich, Roland Herman	Eng.	EE	Altadena
Etter, Lewis Fort	Eng.	ME	Beverly Hills
Everett, Wilhelm Sydow	Sci.	A.Ph	Ventura
Ewing, Gordon Richardson	Eng.	EE	Topeka, Kansas
Felt, Robert Carlen	Sci.	Ch	Gardena
Gordon, Garford Gailord	Sci.	A.Ph	Pasadena
Gregory, James Nathaniel	Eng.	ME	San Marino
Grimes, Joseph Wilbur	Eng.	CE	Glendale
Gulick, Howard East	Sci.	A.Ph	Glendale
Hallanger, Lawrence	Sci.	A.Ch	Alhambra
Halloran, James Joseph	Eng.	EE	Anaconda, Montana
Harshberger, John Daniel	Eng.	EE	Alhambra
Haskins, Ray Watt	Eng.	ME	Los Angeles
Hebel, Francis Frederick	Eng.	EE	Carpinteria
Heinrich, Albert	Eng.	CE	Pasadena
Holman, Rudolph George	Eng.	ME	Pasadena
Holtom, Harold Thomas	Eng.	EE	Pasadena
Howard, Ernest Russell	Eng.	ME	Kodoli, Kolhapur State, India
Howard, Robert Adrian	Sci.	A.Ph	Los Angeles
Howland, Walter Lavern	Eng.	AE	Temple City
Huene, Rudolf von Hoiningen	Eng.	ME	Alhambra

NAME	COURSE	OPTION	HOME ADDRESS
Jaynes, Willis Feighan	Eng.	ME	South Pasadena
Johnson, Norman Stanley	Eng.	CE	Pasadena
Judson, Jack Finlay	Sci.	Ge	Pasadena
Kartzke, Paul Louis	Eng.	CE	Pasadena
Kidd, Raymond Edward	Eng.	EE	Monrovia
Kilpatrick, Paul William	Sci.	A.Ch	Los Angeles
Kurata, Fred	Sci.	Ch	Rialto
Ledyard, Paul Hoyt	Eng.	EE	Pasadena
Lien, Elvin Bernard	Sci.	Ch	Tacoma, Washington
Little, John Robert	Eng.	ME	Xenia, Ohio
Lutes, David Wallace	Eng.	CE	La Mesa
Marmont, George Heineman	Sci.	Ma	Hollywood
Mathewson, Dan Reinert	Eng.	ME	Coronado
McCann, Gilbert Donald	Eng.	EE	Glendale
McClain, Franklin James	Eng.	EE	Los Angeles
McFadden, William Clyde	Eng.	AE	Fullerton
Michener, Harold David	Sci.	Bi	Pasadena
Miller, Guy Oscar	Eng.	EE	San Marino
Moore, Morton Estes	Eng.	EE	Hollywood
Morris, Lee Pierce	Eng.	ME	Los Angeles
Myers, Bryant Elmer	Eng.	ME	Santa Barbara
Naylor, Ralph Arthur	Sci.	Ch	Pasadena
Newcombe, Dennis Arthur	Sci.	Ma	Los Angeles
Newton, Charles Vernon	Eng.	ME	Westwood
Nicolson, Garth Fancher	Eng.	ME	Pasadena
Nies, Nelson Perry	Sci.	Ch	Los Angeles
O'Neil, Hugh Michael	Eng.	CE	Havre, Montana
Parker, Richard Tudor	Eng.	ME	Los Angeles
Patton, Warren Lomax	Eng.	EE	San Diego
Paxson, Edwin Woolman	Sci.	Ma	Sayville, New York
Pearne, John Frederick	Eng.	ME	Los Angeles
Pier, Everett, Harry	Eng.	EE	Monrovia
Radford, James Croxton	Sci.	A.Ch	San Marino
Ritter, John	Eng.	CE	Whittier
Roberts, Paul Clark	Eng.	ME	Crestline
Roeding, Fred Charles	Eng.	EE	Berkeley
Romoli, John Albert	Eng.	ME	Los Angeles
Rooke, Donald R.	Eng.	EE	Pasadena
Schaak, Frank Augustus, Jr.	Eng.	CE	Pasadena
Schiller, Harold	Sci.	A.Ch	Venice
Schneider, Charles Lewis	Sci.	Bi	Tujunga
Schreck, J. Robert	Eng.	EE	Los Angeles
Sexton, Louis Perry	Eng.	EE	Los Angeles
Sharp, Robert Phillip	Sci.	Ge	Oxnard
Sherborne, John Elliott	Sci.	Ch	Long Beach
Shoemaker, Orin Henderson	Eng.	ME	Anaheim
Simmons, Edward Ernest	Eng.	EE	Los Angeles
Skinner, Davis Ayres	Sci.	A.Ch	Altadena
Slavin, Leon	Eng.	CE	Los Angeles
Sluder, Darrell Hayes	Eng.	CE	Alhambra
Smith, George Sidney	Eng.	EE	Oakland

NAME	COURSE	OPTION	HOME ADDRESS
Stevenson, Louis	Eng.	EE	Riverside
Sunderland, Robert Croft	Eng.	EE	Los Angeles
Switzer, Alfred Ivan	Eng.	ME	San Gabriel
Thompson, Alverdo Earnest	Sci.	A.Ch	Beverly Hills
Tracy, Francis Gallatin	Eng.	ME	Carlsbad, New Mexico
Traynor, Raymond William	Eng.	EE	Los Angeles
Ugrin, Nick Thomas	Eng.	ME	Los Angeles
Van Osdol, George William	Eng.	EE	Los Angeles
Weaver, Glenn Wakelin	Eng.	EE	Compton
Wheeler, Edgar James	Eng.	EE	Alhambra
White, Charles Edward	Eng.	EE	El Monte
Wilson, William Wayne	Eng.	ME	Pasadena
Woodward, Glen Everett	Sci.	A.Ch	Upland
Wyatt, Francis William	Sci	A.Ch	Boulder City, Nevada

JUNIOR CLASS

NAME	COURSE	OPTION	HOME ADDRESS
Allardt, Frederick Hamilton	Eng.	AE	Fresno
Ashworth, Joseph Albert	Sci.	Ph	North Arlington, New Jersey
Bakeman, Robert Tate	Sci.	Ge	Los Angeles
Baker, Horace White	Eng.	ME	Glendora
Becker, Leon Sangamon	Sci.	A.Ph	Los Angeles
Beerbower, Alan	Sci.	A.Ch	Warren, Arizona
Beman, Ward Wilson	Sci.	A.Ph	Los Angeles
Binkley, John Thomas, Jr.	Sci.	A.Ph	San Diego
Browder, Lewis Blakely	Sci.	A.Ph	Pasadena
Chamberlain, Donald Newton	Eng.	CE	Glendora
Chivens, Clyde Cuthbertson	Eng.	ME	Burbank
Condon, John	Eng.	AE	Beverly Hills
*Cox, William Gordon	Eng.	EE	Los Angeles
Davenport, Horace Willard	Sci.	Bi	Glendale
Davenport, Lind Burnett	Eng.	EE	Monrovia
Davies, James Allman	Sci.	A.Ch	Pasadena
Davis, Chester Arthur	Eng.	CE	Alhambra
*Deahl, Thomas Jay	Sci.	Ch	Long Beach
Dekker, Albert Orno	Sci.	Ch	Glendale
Dewees, Norman Branson	Eng.	ME	San Gabriel
Douglas, Duncan Howitt	Sci.	A.Ph	Pasadena
Dourson, Robert Henry	Sci.	A.Ch	Redondo Beach
Drummond, Finlay True	Eng.	ME	La Jolla
Dunbar, Oliver Churchill	Eng.	EE	Canton, Massachusetts
Dunn, Louis Gerhardus	Eng.	ME	Transvaal, South Africa
Edwards, Eugene Leroy	Sci.	Ma	Pasadena
Edwards, Jackson	Eng.	EE	Pasadena
Ehrenberg, Gustave, Jr.	Eng.	EE	San Diego
Elmendorf, Charles Halsey	Sci.	Ph	Westwood Hills
Engelder, Arthur Edward	Sci.	Bi	Douglas, Arizona
Estes, Harry De	Sci.	A.Ch	Compton
Evans, Harrison Milton	Sci.	Ge	Los Angeles

Name	Course	Option	Home Address
Ferver, Greer Wilson	Eng.	CE	Long Beach
Fussell, Robert George	Eng.	EE	Winslow, Arizona
Garner, Clifford Symes	Sci.	Ch	Pasadena
Gay, Francis Rowell	Eng.	ME	Redlands
Gelzer, John Roswell	Eng.	EE	St. Louis, Missouri
*Gibbs, Charles James	Eng.	ME	Palos Verdes Estates
Gluckman, Howard Philip	Eng.	EE	Los Angeles
Gordon, Adrian Hugh	Sci.	Ma	Canoga Park
Gravitt, Bruce Benson	Eng.	EE	Lynwood
*Green, Emerson Ward	Sci.	Ch	Pasadena
Green, Nathaniel Baldwin	Eng.	EE	Arcadia
Griffiths, Thomas William	Eng.	CE	Santa Barbara
Hallanger, Robert John	Eng.	ME	Alhambra
Harris, William Richard	Sci.	A.Ph	Los Angeles
Hartzell, Wilbur Gaus	Eng.	ME	Minneapolis, Minnesota
Higley, John Ball	Eng.	EE	Altadena
Holtom, Gordon Francis	Sci.	Ch	Pasadena
Homann, Ralph E., Jr.	Sci.	Bi	Hollywood
Inman, Byron Noll	Sci.	A.Ch	Pasadena
*Jahns, Richard Henry	Sci.	Ch	Seattle, Washington
Jennison, James Henry	Eng.	CE	Pasadena
Johnson, Owen Champlin	Eng.	AE	Denver, Colorado
*Johnson, Wallace John Stockman	Eng.	ME	Fort Dodge, Iowa
Jones, Robert Gardner	Sci.	A.Ch	Altadena
Jones, Robert Parry	Eng.	EE	Inglewood
Joseph, Paul Alton	Eng.	ME	Los Angeles
Jurs, Albert E., Jr.	Eng.	EE	Piedmont
Kelly, Dunford Austermell	Eng.	EE	Los Angeles
Ketchum, Milo Clement	Eng.	CE	Kansas City, Missouri
Keyes, William Forrest	Sci.	A.Ch	Los Angeles
King, Fred Charles, Jr.	Sci.	A.Ch	Berkeley
Koons, Harry Montford	Eng.	CE	Los Angeles
*Kramer, Robert Lincoln	Eng.	ME	Alhambra
Krantz, Channing Henry	Eng.	EE	El Monte
Lanham, Arden Keith	Sci.	Ch	South Pasadena
LaRue, Robert Orville	Sci.	Ph	Beverly Hills
Lehmicke, David John	Sci.	A.Ch	Stillwater, Minnesota
Leppert, Elmer Louis, Jr.	Eng.	ME	Monrovia
*Levy, Henri Arthur	Sci.	Ch	Oxnard
Lindsay, Chester William	Sci.	A.Ch	Los Angeles
Maloney, Fred Vern	Eng.	EE	Los Angeles
Marsh, Robert Henry	Eng.	EE	Kalispell, Montana
*McLean, William Burdette	Sci.	Ph	Santa Barbara
McRae, Robert Alexander	Eng.	CE	Los Angeles
Meneghelli, Hugo Antonio	Eng.	CE	Hollywood
Merralls, Franz Nelson	Eng.	EE	Los Angeles
Miller, Daniel Harrison	Eng.	EE	Los Angeles
Miller, Eugene Clair	Eng.	CE	Glendora
Miller, Mark Trevellick	Eng.	ME	Greenville
Mosteller, William Carter	Eng.	EE	Pasadena

NAME	COURSE	OPTION	HOME ADDRESS
*Nelson, Richard Burton	Sci.	A.Ph	Powell, Wyoming
Nichols, Robert Maurice	Eng.	EE	Glendale
Obatake, Tanemi	Sci.	EE	Los Angeles
Ohashi, George Yoshio	Eng.	EE	Los Angeles
Patrick, Charles	Sci.	Ch	Huntington Beach
Patterson, Leonard Searles	Sci.	A.Ph	Hollywood
Pehoushek, Frederick	Eng.	EE	San Fernando
*Pitzer, Kenneth Sanborn	Sci.	Ch	Pomona
Polentz, Perry Paul	Eng.	ME	Whittier
Potter, Warren Thomas, Jr.	Eng.	EE	Whittier
Ray, Albert Allen	Eng.	ME	Alhambra
Reynolds, Edward Henry	Sci.	A.Ch	Los Angeles
Ribner, Herbert Spencer	Sci.	Ph	Birmingham, Alabama
Rivas, Dagoberto	Eng.	CE	Calexico
Rossum, John Rudolph	Sci.	A.Ch	St. Paul, Minnesota
Scherb, Ivan Victor	Sci.	Ge	Beverly Hills
Schwartz, Jack William	Eng.	CE	Hollywood
Scott, Claude Trick	Eng.	ME	Pasadena
Seidel, Robert Klensch	Eng.	ME	Los Angeles
Shanahan, Edmond Francis	Sci.	A.Ph	Los Angeles
Sheff, Sander	Eng.	ME	Pasadena
Sheppard, Dickson Marshall	Sci.	A.Ch	Los Angeles
Slater, Alfred Leon	Eng.	ME	Los Angeles
Smith, Apollo Milton Olen	Eng.	AE	Inglewood
Smith, James Norman	Eng.	EE	Pasadena
Snow, Neil Worthington	Eng.	CE	Altadena
Spalding, Luther Payne	Sci.	Ch	Phoenix, Arizona
Stanley, Robert M.	Eng.	AE	Eagle Rock
Stick, John Chester	Eng.	ME	South Pasadena
Stoddard, James Bates	Sci.	A.Ch	Los Angeles
Stoll, Henry William	Sci.	A.Ph	Los Angeles
Stuppy, Laurence	Sci.	Bi	Los Angeles
Swanson, Walfred Ernest	Eng.	CE	Hollywood
Taylor, Jay Camburn	Sci.	Ph	Long Beach
Thomas, Charles Franklin	Eng.	AE	Pasadena
Thompson, Charles Sumner	Eng.	CE	Bisbee, Arizona
Tooby, George Jarvis	Sci.	A.Ch	Eureka
Warner, Robert Collett	Sci.	Bi	Chehalis, Washington
Weber, Bruce Travis	Sci.	Ph	Brooklyn, New York
Webster, Donald Charles	Eng.	ME	Hollywood
Willits, Victor Wilmer	Eng.	ME	Eagle Rock
Wood, Reuben Esselstyn	Sci.	Ch	Monrovia
Woodbury, Herbert Lee	Eng.	EE	Los Angeles
Wright, Richard Carl	Sci.	A.Ch	South Pasadena
Young, Bradley Hobart	Eng.	AE	La Habra

SOPHOMORE CLASS

NAME	COURSE	OPTION	HOME ADDRESS
Baker, Carroll Royer	Eng.		Portsmouth, Virginia
Barnes, Sydney Urbane	Eng.		Los Angeles
*Beal, Dana R.	Eng.		Garden Grove

Name	Course	Option	Home Address
Beckley, William Bruce	Eng.		Las Vegas, Nevada
Best, Charles Ward	Sci.	Ch	Moscow, Idaho
Bingham, William Eugene, Jr.	Sci.	Ch	Los Angeles
Bishop, Arthur Lyman	Sci.	A.Ch	Long Beach
Blodgett, Donald Eugene	Eng.		South Pasadena
Boothe, Raymond Hudson F.	Eng.		Los Angeles
Briggs, Stanford William	Sci.	Ge	Troutdale, Oregon
Bruce, Eugene Leslie	Sci.	Ch	Pasadena
Bucknell, Wilson Henn	Eng.		Los Angeles
Burnight, Thomas Robert	Sci.	Ay	Akron, Iowa
Bush, Kenyon Taylor	Sci.	Ch	Seattle, Washington
Campbell, William Edward, Jr.	Sci.	A.Ch	Pasadena
Carr, Robert Broadwell	Sci.	Ge	Los Angeles
Carroll, George Edward	Eng.		Los Angeles
Cloyd, Charles Edward	Eng.		Rocky River, Ohio
Cohen, Jeffrey Stanley	Sci.	A.Ph	Los Angeles
Colvin, Hugh Frank	Sci.	Ch	Walnut Park
Cortelyou, Curtis Gardner	Eng.		Los Angeles
Cox, Dan	Eng.		Tulsa, Oklahoma
Creal, Albert	Eng.		Los Angeles
Dauben, Elmer Joseph	Sci.	A.Ch	Culver City
Davis, Allan Ripley	Eng.		Garland, Texas
Davis, Frank Wilbur	Eng.		Pasadena
Dickinson, Holley Buckingham	Eng.		Hollywood
Dilworth, Robert Palmer	Sci.	Ph	Hemet
Douglass, Malcolm Ellsworth	Eng.		Pasadena
Elconin, William	Sci.	Ph	Los Angeles
Ellery, William Perrigo	Eng.		Monrovia
Elliott, Robert Dunshee	Sci.	A.Ph	Clarendon, Virginia
Estep, Carl Robert	Eng.		Los Angeles
Fahrmann, Minor Louis	Eng.		El Monte
Feagans, Raymond Geary	Sci.	Bi	Nevada City
Ferguson, Stuart Russell	Sci.	A.Ch	Puente
Frost, Arthur Mitchell	Eng.		Huntington Beach
Gardner, Robert Irving	Eng.		Los Angeles
Gates, John Irwin	Sci.	A.Ch	Torrance
Gelder, Robert Tolman	Sci.	A.Ch	Los Angeles
George, John Wesley	Sci.	Ge	Santa Barbara
Gerfen, W. Howard	Eng.		South Pasadena
Gilbert, Matthew James	Sci.	Ge	Beverly Hills
Gocke, Blye Winfield	Eng.		Long Beach
*Goodheart, Clarence Francis	Eng.		Roscoe
Goodwin, Henry John	Eng.		Santa Monica
Griffith, Everette Elijah	Sci.	Ge	Woodland
Gruenberg, Howard	Sci.	Ge	San Diego
Hamacher, Howard Franklin	Sci.	A.Ch	Spokane, Washington
Hammond, Paul Harvey	Eng.		Spokane, Washington
Hart, Stephen Price	Sci.	Bi	Portland, Oregon
Hartlein, Robert L.	Eng.		Altadena
Haver, Ralph Lawrence	Eng.		San Fernando
Hayman, Richard Lowell	Eng.		Los Angeles

NAME	COURSE	OPTION	HOME ADDRESS
Heath, Charles Oswald	Eng.		Montebello
*Heitz, Robert George	Sci.	Ch	Huntington Beach
Henderson, Everett Benedict	Eng.		Beverly Hills
*Hicks, Bruce Lathan	Sci.	A.Ph	Pasadena
Holmes, Frederick Bausman	Sci.	Ch	Los Angeles
Hopkins, Henry Stuart	Eng.		Butte, Montana
Humason, William Dowd	Sci.	Bi	Pasadena
*Janes, Robert Lee	Eng.		St. Paul, Minnesota
Jensen, Ray	Eng.		San Marino
Jerauld, Robert L.	Eng.		Phoenix, Arizona
Jones, Clyde Branson	Eng.		Wapella, Illinois
Jones, Paul Stevenson	Eng.		Los Angeles
Jordan, Charles Borromeo	Sci.	A.Ph	Los Angeles
Jorgensen, John Detleff	Eng.		Shelby, Idaho
Kasnicka, Edward John	Eng.		Monrovia
Kent, Robert Dana	Sci.	A.Ch	Covina
Kiger, Wallace Leo	Eng.		Pasadena
Kimura, Ben	Eng.		Compton
Klocksiem, John Paul	Eng.		Long Beach
*Kossiakoff, Alexander Ivan	Sci.	Ch	Seattle, Washington
Kostock, Francis Robert	Sci.	A.Ch	Los Angeles
LaBoyteaux, Ellsworth	Sci.	Ge	Nevada City
*Lauritsen, Tom	Sci.	A.Ph	Pasadena
Lawrence, Franklin Reid	Sci.	A.Ph	Ontario
Lew, Harry W.	Eng.		Los Angeles
*Lewis, Harry Glenn	Eng.		Payette, Idaho
Logan, Robert Egleston	Sci.	Ch	Alhambra
Manley, Harold Leonard	Sci.	A.Ch	Los Angeles
Manning, Maurice Norman	Sci.	Bi	Beaverton, Oregon
*McIntyre, Robert Alfred	Sci.	Ch	Maywood
McMahon, Michael Martin	Eng.		Pomona
McRary, Willard Lee	Sci.	Ch	Los Angeles
Milan, Leo Joseph	Sci.	A.Ch	North Hollywood
Moore, James Aston	Eng.		Sterling, Colorado
Morgan, Herbert Roy	Sci.	Bi	Bell
Morse, Charles Adelbert	Eng.		Los Angeles
Müller, Conrad Roeben	Eng.		Portland, Oregon
Nance, Guy Russell	Sci.	A.Ch	Los Angeles
Nelson, Loyal Edward	Sci.	Ge	Pasadena
Nestler, Wasson Walter	Eng.		Pasadena
Nichols, Dean	Sci.	Bi	La Jolla
Nollan, John Lloyd	Eng.		Los Angeles
Nutting, Perley Gilman	Sci.	A.Ph	Washington, D. C.
Parker, Robert Gray	Sci.	A.Ch	West Los Angeles
Patterson, Thomas C.	Eng.		Pasadena
Perry, Tom McFaul	Sci.	A.Ph	Portland, Oregon
Quarles, Miller Wenthrop, Jr.	Sci.	Ge	San Diego
Rector, Eugene Martin	Eng.		Los Angeles
Richey, William Coulter	Sci.	A.Ch	Los Angeles
Riddell, John Tate, Jr.	Eng.		Evanston, Illinois
Rollow, Douglas Keesee	Sci.	A.Ch	Los Angeles

Name	Course	Option	Home Address
Salisbury, Orange James, Jr.	Eng.		Pasadena
Sandberg, T. Robert	Sci.	A.Ch	Long Beach
Schaffner, Paul Corwin	Eng.		Upland
Scheer, Bradley Titus	Sci.	Bi	Hollywood
Schneider, Paul Jean	Sci.	Ch	Berkeley
Scoville, Allan Romig	Eng.		Ogden, Utah
Seaman, James Roy, Jr.	Eng.		Glendale
Serrell, Peter Van Horne	Eng.		Redlands
Shapiro, Herbert B.	Eng.		Los Angeles
Sheppard, Charles Wilcox	Sci.	A.Ph	Coldwater, Ontario Canada
*Sklar, Maurice	Sci.	A.Ph	Los Angeles
*Smith, Carl Mayn	Sci.	Ch	Long Beach
Stevenson, William Kincaid	Eng.		Riverside
Streib, John Fredrick	Sci.	Ch	Pasadena
Summers, Joseph	Eng.		Pasadena
*Thompson, Tyler F.	Sci.	Ph	Corona
Tyler, John Garnett	Sci.	Bi	Beverly Hills
Van Riper, Dale Hatfield	Eng.		Bakersfield
*Vermeulen, Theodore	Sci.	Ch	Los Angeles
Veysey, Victor	Eng.		Los Angeles
Von Werner, William Karl	Eng.		Huntington Park
*Watanabe, Kenichi	Sci.	Ch	Honolulu, Hawaii
*Watts, Euclid Vance	Eng.		Honolulu, Hawaii
Webb, John Leyden	Sci.	Ch	Eagle Rock
Wiget, Clark Hamilton	Eng.		Concord
Williams, Harrison Grant	Eng.		San Gabriel
Williams, James Simons	Sci.	A.Ch	San Diego
Williamson, Frank Potts, Jr.	Sci.	Ch	Fontana
Woodbury, William White	Sci.	Ma	Alhambra
Works, Jack Dwight	Eng.		Los Angeles
*Young, Donald Laurence	Sci.	A.Ch	Pasadena

FRESHMAN CLASS

Name	Home Address
Ashkenas, Irving Louis	Los Angeles
Austen, John Reynolds	Los Angeles
Austin, Hoyt	Coronado
Axelrod, Joseph Mayer	Los Angeles
Barry, Robert Joseph	South Pasadena
Belzer, Thomas Russell	Portland, Oregon
Benton, Ralph Stalnaker	Phoenix, Arizona
Bertness, Theodore Arnold	La Jolla
Blue, John	Monterey Park
Bodine, Albert George	Buellton
Bonham, Elliott Hinman	Pomona
Boyd, Willis Blair	Hillsboro, Ohio
Bryan, Wharton Whitworth	Escondido
Bussard, Gordon Lucas	Spokane, Washington

NAME	HOME ADDRESS
Calhoun, Alexander John	San Diego
Campbell, Robert Samuel	Hollywood
Cato, William Raymond	Los Angeles
Chapman, Harvey Hewett	Ontario
Chatham, Carroll Fred	San Francisco
Clagett, Marshall	Pasadena
Connelly, Ronald Boerner	Huntington Park
Cornwall, Ellsworth William	Portland, Oregon
de Grummond, Lyle Marquis	Pasadena
Dennis, Paul Arthur	St. Louis, Missouri
DeVault, Don Charles	Inglewood
Dion, Frederic Eugene	Glendive, Montana
Dixon, Cyril John	San Diego
Dorwart, George Martin	Carmel
Dowd, Munson White	El Centro
Drake, Clarence Ronald	Los Angeles
Drummond, Donald Holland	La Jolla
Dunbar, Bruce Waugh	Pasadena
Dusel, Alvin Kenneth	Kentfield
Edwards, Don Patterson	Los Angeles
Edwards, John Stevenson, Jr.	Goleta
Edwards, Paul Carroll	Palo Alto
Erickson, Virgil	Los Angeles
Fahrner, Ted	San Diego
Farnham, Willard	Bend, Oregon
Fenzi, Warren Emanuele	Santa Barbara
Freeman, Carl Frederick	Los Angeles
Frolich, Guilford Seinga	Los Angeles
Frost, Holloway	Long Beach
Gates, Charles Fredrick	Torrance
Gerlough, Daniel Lauder	Palo Alto
Gibson, Gordon Davis	Piedmont
Gilmore, Hugh Mack, Jr.	Hollywood
Goddard, Winfred Rawdon, Jr.	Hollywood
Goodell, Richard Rohrer	Puente
Gorham, William Hoch	Tokyo, Japan
Griffis, LeVan	Los Angeles
Grobecker, Alan John	San Diego
Gruenberger, Peter	North Hollywood
Guardia, Tomás Emilio, Jr.	Panama City, Panama
Guethlein, Robert Fredrik	Beverly Hills
Harding, J. Gordon	San Diego
Harper, Thomas Sinclair	Denver, Colorado
Harris, Norman Westlake	San Dimas
Hayward, Russell Edward	Glendale
Higley, Ray Franklin	Long Beach
Hoffman, Lee Hawley	Portland, Oregon
Hopkins, Boyd Richard	Ogden, Utah
Hopkins, Joe Harrison	Gardena
Horkey, Edward James	La Canada
Horne, George Henry, Jr.	Glendale

NAME	HOME ADDRESS
Horovitz, Leon	Los Angeles
Hotz, George Marion	Los Angeles
Hurst, James Arnold	Hinsdale, Illinois
Jones, Wilson Burdette	Alhambra
Kapin, Herbert Russell	Los Angeles
Keens, George Hendricks	Monrovia
Kido, Koichi	Los Angeles
Kimball, Dorr	Evanston, Illinois
Labbe, Robert Cain	Hollywood
Larson, Carl Elmer	Arcadia
Leard, Robert Marshall	Los Angeles
Legge, John Allan	Las Cruces, New Mexico
Lilly, John Cunningham	St. Paul, Minnesota
Lockwood, Robert Bruce	Glendale
Lycett, Eustace Arden	Carlsbad, New Mexico
MacMichael, Ethan S.	El Paso, Texas
Mahoney, Robert Matthew	Los Angeles
Mann, George Edward	El Centro
Mason, Jack	San Diego
Miller, Harry Heyburn	Bend, Oregon
Miller, Wendell Bower	Hollywood
Moncrief, Ernest	Orosi
Montag, George Delmer	Portland, Oregon
Moore, Frederic Hollway	Los Angeles
Moore, Walter Leon	Pasadena
Morgan, Bruce Fitzgerald, Jr.	Seattle, Washington
Morse, Nathan L.	Los Angeles
Nellis, Donald Charles	Burbank
Nojima, Noble Masaaki	San Pedro
Nolte, Claude Byron	Los Angeles
Offeman, Richard Emil	Hollywood
Olds, Robert Horner	Los Angeles
Osborne, Herbert George	Fullerton
Owen, Noel LeGrande	Los Angeles
Park, Noel Robertson	Pomona
Peek, Howard Marion	Phoenix, Arizona
Penn, William Lee	Manila, Philippine Islands
Percival, John Cary	Tulsa, Oklahoma
Peterson, Joseph James	Pachuca, Hgo, Mexico
Poggi, Martin Joseph	Nutley, New Jersey
Pressman, David	Los Angeles
Price, Edward Thomas	Claremont
Putlitz, Fritz Helmuth	Santa Monica
Radcliffe, Fremont Fisher	Morro Bay
Rice, Fred David	Pasadena
Ridgeway, Richard Lee	Los Angeles
Rosencranz, Richard, Jr.	Evansville, Indiana
Sasaki, Teruo	Honolulu, Hawaii
Schombel, Leonard Frederick	Alhambra
Schuman, Daniel	San Diego
Scott, Nathan George	Salinas

NAME	HOME ADDRESS
Scully, Charles Norman	Los Angeles
Selberg, John Peter	Portland, Oregon
Seligman, Irving Otto	Albuquerque, New Mexico
Sharp, Harold Wilson	Santa Paula
Sheppard, Herbert Ramsey	Los Angeles
Shimer, John Morris, Jr.	Dallas, Texas
Smith, Fred Lester	Leadville, Colorado
Smith, Joe Mauk	Pasadena
Smith, Josiah Edward	Corona
Snelling, Wilbur Fisher	Penryn
Stackhouse, William Valentine	Pasadena
Stein, Benjamin Frederick	Mt. Carmel, Illinois
Stones, James Eugene	Bakersfield
Strathearn, Robert Baldwin	Pasadena
Swain, Robert Kimball	Monrovia
Teague, Donald Spencer, Jr.	Santa Paula
Torrance, Jerry Badgley	San Diego
Townsend, Robert Dawson, Jr.	Arcadia
Trefethen, Everett Annable	Seattle, Washington
Tsubota, George Yoshio	Riverside
Tulagin, Vsevolod	Los Angeles
Van Der Werff, Jay Boreas	Pasadena
Van Fleet, John Ricard	Santa Barbara
Vye, John Hall	San Diego
Walker, William Jenkins	LaMesa
Wallace, George Rockwell	Montesano, Washington
Warner, Hugh Francis	San Pedro
Watson, James Wendell	Grand Island, Nebraska
Webster, Martin Haskell	Los Angeles
Wetmore, William Owen	Huntington Park
Wheatfill, Edward Lewis	Long Beach
Wheeler, Henry Lewis	Auberry
Wheeler, Walter George	Van Nuys
Wickett, Walton Ames	Palo Alto
Wileman, Edward Earl	Fillmore
Williamson, John Bridgers	Fontana
Wing, Paul Ashton	Vancouver, British Columbia, Canada
Wylie, Willard Gordon	Whittier
Yale, William Dickinson	Burbank
Zezukevich, Victor Boris	Harbin, Manchukuo
Zimmerman, Albert Herman	Los Angeles

UNCLASSIFIED

Clark, Allan Covel	Pasadena
Fennel, Lester Haines	Sierra Madre
George, Joe Johnson	Burbank
Rhodes, Robert Edgar	Pasadena

SUMMARY

GRADUATE SCHOOL

RESEARCH FELLOWS

National Research Fellows	8	
Rockefeller International Fellows	5	
International Exchange Fellow	1	
C. R. B. Educational Foundation Fellows	3	
Guggenheim Airship Institute Fellows	3	
Research Fellows of the Institute	28	
Visiting Research Fellows	4	52

GRADUATE STUDENTS

Physics	50	
Chemistry	30	
Applied Chemistry	1	
Mathematics	8	
Geology	20	
Biology	8	
Astrophysics	2	
Meteorology	2	
Electrical Engineering	27	
Mechanical Engineering	17	
Civil Engineering	14	
Aeronautics	22	201

UNDERGRADUATE SCHOOL

SENIORS	111	
JUNIORS	127	
SOPHOMORES	137	
FRESHMEN	157	
UNCLASSIFIED	4	536

Total Number of Students   737

COURSES AND OPTIONS OF UNDERGRADUATE STUDENTS

SCIENCE COURSE	Seniors	Juniors	Sophomores
Physics	0	7	3
Applied Physics	9	10	11
Chemistry	6	12	18
Applied Chemistry	9	16	18
Mathematics	4	2	1
Geology	2	3	9
Biology	4	5	8
Total	34	55	68

ENGINEERING COURSE	Seniors	Juniors	Sophomores
Electrical	29	27	....
Civil	16	15	....
Mechanical	27	23	....
Aeronautical	5	7	....
Total	77	72	69

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