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BULLETIN
OF THE
CALIFORNIA INSTITUTE
OF
TECHNOLOGY

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

CATALOGUE

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DECEMBER, 1929

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IN SCIENCE, ENGINEERING, AND THE HUMANITIES

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PASADENA, CALIFORNIA

DECEMBER, 1929

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Calendar

1930

1931

JANUARY

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NOVEMBER

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Calendar

1930

JANUARY 6.....	Registration (9 A. M. to 3 P. M.)
JANUARY 25.....	Examinations for Removal of Conditions
MARCH 1.....	Last Day for Applications for Fellowships and Assistantships
MARCH 19-22.....	Term Examinations
MARCH 20.....	Notifications of Award of Fellowships and Assistantships
MARCH 22.....	End of Second Term
MARCH 23-30.....	Recess
MARCH 29.....	Meetings of Registration Committees
MARCH 31.....	Registration (9 A. M to 3 P. M.)
APRIL 19.....	Examinations for Removal of Conditions
MAY 12.....	Last Day for Removing Senior Deficiencies
MAY 29.....	Last Day for Examinations and Presenting Theses for the Degree of Doctor of Philosophy
MAY 30.....	Memorial Day Recess
JUNE 5.....	Last Day for Examinations and Presenting Theses for the Degree of Master of Science
JUNE 7.....	End of Examinations for Candidates for the Degrees of Bachelor of Science and Master of Science
JUNE 10-14.....	Term Examinations for all Undergraduates except Seniors
JUNE 10.....	Meetings of Committees on Course in Engineering and Course in Science (9 A. M.)
JUNE 10.....	Faculty Meeting (1:30 P. M.)
JUNE 12.....	Class Day
JUNE 13.....	Commencement
JUNE 13.....	Annual Meeting of Alumni Association
JUNE 14.....	End of College Year
JUNE 12-14.....	Examinations for Admission to Upper Classes
JUNE 23.....	Meetings of Registration Committees
JUNE 30, JULY 1.....	Examinations for Admission to Freshman Class and for Freshman Scholarships
SEPTEMBER 16-17.....	Examinations for Admission to Freshman Class
SEPTEMBER 22-23.....	Examinations for Admission to Upper Classes
SEPTEMBER 25.....	Examinations for Removal of Conditions

CALENDAR—Continued

SEPTEMBER 25.....	Registration of Freshmen (8:30 A. M.)
SEPTEMBER 26.....	General Registration (9 A. M. to 3 P. M.)
SEPTEMBER 27.....	General Registration (9 A. M. to 12 M.)
SEPTEMBER 29.....	Beginning of Instruction
NOVEMBER 27-30.....	Thanksgiving Recess
DECEMBER 1.....	Last Day for Announcing Candidacy for Bachelor's Degree
DECEMBER 17-20.....	Term Examinations
DECEMBER 20.....	Last Day for Filing Applications for Candidacy for the Degree of Doctor of Philosophy, to be Con- ferred June, 1931
DECEMBER 20.....	End of First Term (12 M.)
JANUARY 3, 1931.....	Meetings of Registration Committees
JANUARY 5.....	Registration (9 A. M. to 3 P. M.)

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(Arranged in the order of seniority of service)

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716 South El Molino Avenue, Pasadena.	
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1003 South Orange Grove Avenue, Pasadena.	
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Professor of Physics, University of Chicago

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Research Associate in Aeronautics
Professor of Mechanics and Director of the Kaiser Wilhelm
Aerodynamical Institute, University of Göttingen

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Research Associate in Physics
Professor of Mathematical Physics, University of Zurich

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

Staff of Instruction and Research

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

Director of the Norman Bridge Laboratory of Physics

Chairman of the Executive Council

A.B., Oberlin College, 1891; A.M., 1893; Ph.D., Columbia University, 1895. Assistant in Physics, University of Chicago, 1896-1897; Associate, 1897-1899; Instructor, 1899-1902; Assistant Professor, 1902-1907; Associate Professor, 1907-1910; Professor, 1910-1921. Sc.D. (hon.), Oberlin College, 1911; Northwestern University, 1913; University of Pennsylvania, 1915; Amherst College, 1917; Columbia University, 1917; University of Dublin, 1924; Yale University, 1925; Leeds University, 1927; Princeton University, 1928; New York University, 1929; LL.D., University of California, 1924; University of Colorado, 1927; University of Michigan, 1929; Ph.D., (hon.), King John Casimir University, Lwów, Poland, 1926; University of Ghent, 1927. Vice-President, American Association for the Advancement of Science, 1911; President, 1929; President, American Physical Society, 1916-1918; Vice-Chairman, National Research Council, 1916-; Lieutenant-Colonel, U. S. A., and Chief, Science and Research Division of Signal Corps, 1917-1919; American Representative, Troisième Conseil de Physique, Solvay, Brussels, 1921; Exchange Professor, Belgium, 1922; American Representative, Committee on Intellectual Cooperation, League of Nations, 1922-. Member, American Philosophical Society, National Academy of Sciences, American Academy of Arts and Sciences. Corresponding Member, Société Batave de Philosophie Expérimentale à Rotterdam, Académie des Sciences de Russie, Institut de France Académie des Sciences. Hon. Member, Royal Institution of Great Britain, La Société Hollandaise des Sciences, Royal Irish Academy, Die Gesellschaft der Wissenschaften zu Göttingen. Recipient of Comstock Prize, National Academy of Sciences, 1913; of Edison Medal of the American Institute of Electrical Engineers, 1922; of the Nobel Prize in Physics of the Royal Swedish Academy, 1923; of the Hughes Medal of the Royal Society of Great Britain, 1923; of the Faraday Medal of the London Chemical Society, 1924; of the Matteucci Medal of the Società Italiana della Scienze, 1925; of the Gold Medal of the American Society of Mechanical Engineers, 1926; of the Messel Medal of the Society of Chemical Industry of England, 1928; and of the Gold Medal of the Society of Arts and Sciences, 1929. California Institute, 1916-

300 Palmetto Drive

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

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

Member of the Executive Council

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

1149 San Pasqual Street

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

Professor of History and Government

Member of the Executive Council

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

268 Bellefontaine Street

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

Director of the Gates Chemical Laboratory

Member of the Executive Council

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

1025 San Pasqual Street

JOHN AUGUST ANDERSON, PH.D.

Executive Officer of the Observatory Council

Research Associate in Astrophysics*

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

994 Poppy Street, Altadena

EDWARD CECIL BARRETT, B.A.

Secretary of the Institute

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

942 North Chester Avenue

*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.

CHARLES READ BASKERVILL, Ph.D.

Associate in English Literature

B.A., Vanderbilt University, 1896; M.A., 1898; Ph.D., University of Chicago, 1911. Assistant in English, Vanderbilt University, 1898-1899; Head of Department of English, Central State Normal School, Okla-homa, 1903-1905; Instructor in English, University of Texas, 1905-1911; Assistant Professor, 1912-1915; Associate Professor, 1915-1919; Profes-sor of English, University of Chicago, 1919-; Research Associate, Huntington Library and Art Gallery, 1929-. California Institute, 1929-1930.

616 South Sierra Bonita 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 of Amer-ican Philosophical Society. 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 Chem-istry, 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 Cali-fornia Institute of Technology). California Institute, 1914-

1671 Oakdale Street

KARL JOSEF BELAR, Ph.D.

Research Associate in Biology

Ph.D., University of Vienna, 1919. Assistant at the Kaiser Wilhelm Insti-tut of Biology, Berlin-Dahlem, 1919-1928; Associate Member, 1928-; Privat docent in Zoölogy, University of Berlin, 1924-. California Insti-tute, 1929-1930.

570 North Michigan Avenue

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. Böcher Prize, American Mathematical Society, 1924; Vice-President, American Mathematical Society, 1926-; Colloquium Lec-turer, American Mathematical Society, 1927. Professor, summer quarters, University of Chicago, 1924-1928; Visiting Lecturer, Harvard University, first half 1926. Member of National Academy of Sciences. California Institute, 1926-

434 South Michigan Avenue

JAMES EDGAR BELL, Ph.D.

Professor of Chemistry

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

Sierra Madre Villa, R. D. 1, Box 639

GILMOR BROWN

Director of Public Speaking and Dramatics

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

695 Herkimer Street

JOHN PETER BUWALDA, Ph.D.

Professor of Geology

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

315 South Chester Avenue

W. HOWARD CLAPP, E.M.

Professor of Mechanism and Machine Design

E.M., University of Minnesota, 1901. Instructor in Mathematics, Macalester College, 1897-1898. Superintendent and Designing Engineer Sherman Engineering Company, Salt Lake City, 1905-1909; Superintendent, Nevada-Goldfield Reduction Company, Goldfield, Nevada, 1909-1910. California Institute, 1911-

95 South Mentor Avenue

ROBERT L. DAUGHERTY, M.E.

Professor of Mechanical and Hydraulic Engineering

A. B. in Mechanical Engineering, Leland Stanford Junior University, 1909; M. E., 1914. Assistant in Mechanics, Leland Stanford Junior University, 1907-1908; Assistant in Hydraulics, 1908-1909; Instructor in Mechanical Engineering, 1909-1910; Assistant Professor of Hydraulics, Sibley College, Cornell University, 1910-1916; Professor of Hydraulic Engineering, Rensselaer Polytechnic Institute, 1916-1919. Member of Council, American Society of Mechanical Engineers, 1925-1928; Vice-President, 1928-; Vice-Chairman, Board of Directors, City of Pasadena, 1927-1929; Chairman, 1929-. California Institute, 1919-

373 South Euclid Avenue

DONALD RYDER DICKEY, M.A.

Research Associate in Vertebrate Zoology

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

514 Rosemont Avenue

PAUL SOPHUS EPSTEIN, PH.D.

Professor of Theoretical Physics

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

1083 Elizabeth Street

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

Associate in American History

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

179 South Orange Grove Avenue

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

Professor of Mechanics

Dean of Upper Classmen

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

1071 Garfield Avenue

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-

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-

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THEODOR VON KARMAN, PH.D.

Associate in Aeronautics

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

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

GEORGE V. LOMONOSOFF, C.E., DR. ING. E.H.

Research Associate in Engineering

C.E., Institute of Transport, St. Petersburg, 1898; D.Eng., Polytechnical Institute in Kieff, 1905; Dr. Ing. e.h., Technische Hochschule, Berlin, 1927. Locomotive Testing, 1898-1900; Assistant Professor in Engineering, Polytechnical Institute, Warsaw, 1899-1901; Associate Professor in Engineering, Polytechnical Institute, Kieff, 1901-1905; Professor of Railway Engineering and Economics, 1905-1907; Assistant General Superintendent of Motive Power of Ekaterina Railway, 1908; President of Locomotive Experimental Bureau, 1908-1917; General Superintendent of Motive Power of Tashkent Railway, 1909-1910; General Superintendent of Motive Power of Nicolas Railway, 1911; Professor of Railway Engineering and Economics, Institute of Transport in St. Petersburg, 1911-1917; Assistant Director General of Russian Railways, 1912; Member of Supreme Engineering Council, 1913-1917; Acting Undersecretary of Transport, 1915-1917; President of Russian War Railway Mission to U. S. A., 1917-1918; Undersecretary of Transport, 1919-1921; High Commissioner to Western Europe and Canada for Railway Orders, 1920-1923; High Commissioner for Diesel Locomotives, 1923-1926. Recipient of Borodine Gold Medal, 1911; Saloff Prize, 1913. California Institute, 1929-

504 South Los Robles Avenue

JOHN ROBERTSON MACARTHUR, PH.D.Professor of Languages
Dean of Freshmen

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

866 South Pasadena Avenue

FRANCIS GLADHEIM PEASE, D.Sc.

Associate in Optics and Instrument Design*

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

824 North Holliston Avenue

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

RUSSELL WILLIAMS PORTER, M.S.

Associate in Optics and Instrument Design

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

1456 Oakdale Street

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

GEORGE WILEY SHERBURN, PH.D.

Associate in English Literature

B.A., Wesleyan University (Connecticut), 1906; M.A., 1909; Ph.D., University of Chicago, 1915. Instructor in English, Northwestern University, 1906-1910; Instructor, Beloit College, 1910-1911; Instructor, Wesleyan University, 1911-1912; Fellow, University of Chicago, 1912-1914; Instructor, 1914-1919; Professor, 1926-. Associate of the Huntington Library, 1929-1930. California Institute, 1929-

211 South Hudson Avenue

THEODORE GERALD SOARES, PH.D., D.D.

Associate in Philosophy and Ethics

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

1542 Morada Place, Altadena

ROYAL WASSON SORESENSEN, 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-. Consulting Engineer, General Electric Company, 1929-. California Institute, 1910-

384 South Holliston Avenue

CHESTER STOCK, Ph.D.

Professor of Paleontology

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

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. California Institute, 1928-

410 South Oakland 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

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-. California Institute, 1913-

685 South El Molino Avenue

RICHARD CHACE TOLMAN, Ph.D.

Professor of Physical Chemistry and Mathematical Physics

S.B. in Chemical Engineering, Massachusetts Institute of Technology, 1903; Ph.D., 1910; Student, Universities of Berlin and Crefeld, 1903-1904. Dalton Fellow, Instructor in Theoretical Chemistry, and Research Associate in Physical Chemistry, Massachusetts Institute of Technology, 1905-1910; Instructor in Physical Chemistry, University of Michigan, 1910-1911; Assistant Professor of Physical Chemistry, University of Cincinnati, 1911-1912; Assistant Professor of Chemistry,

University of California, 1912-1916; Professor of Physical Chemistry, University of Illinois, 1916-1918; Chief, Dispersoid Section, Chemical Warfare Service, 1918; Associate Director and Director, Fixed Nitrogen Research Laboratory, Department of Agriculture, 1919-1921. Member of National Academy of Sciences, and of American Academy of Arts and Sciences. California Institute, 1921-

345 South Michigan Avenue

HARRY CLARK VAN BUSKIRK, PH.B.

Professor of Mathematics

Registrar

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

390 South Holliston Avenue

WENDELL PHILLIPS WOODRING, PH.D.

Professor of Invertebrate Paleontology

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

1751 Rose Villa Street

WALTER DANIEL BONNER, PH.D.

Visiting Professor in Chemistry

B.S., Nebraska Wesleyan University, 1906; M.A., Princeton University, 1908; Ph.D., Toronto University, 1911. Lecturer in Chemistry, Queen's University, 1909-1911; Assistant Professor of Chemistry, 1911-1915; Professor and Head of the Department of Chemistry, University of Utah, 1916-. California Institute, 1929-1930.

1954 North Raymond 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

IRA SPRAGUE BOWEN, PH.D.

Associate Professor of Physics

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

1848 Keystone Street

ROSCOE GILKEY DICKINSON, Ph.D.

Associate Professor of Physical Chemistry

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

530 Bonita Avenue

ALEXANDER GOETZ, Ph.D.*

Associate Professor of Physics

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

WILLIAM VERMILLION HOUSTON, Ph.D.

Associate Professor of Physics

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

2428 Ridgeway Road, San Marino

WILLIAM NOBLE LACEY, Ph.D.

Associate Professor of Chemical Engineering

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

334 Berkeley Avenue

HOWARD JOHNSON LUCAS, M.A.

Associate Professor of Organic Chemistry

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

97 North Holliston Avenue

GEORGE RUPERT MACMINN, A.B.

Associate Professor of English Language and Literature

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

255 South Bonnie Avenue

*On leave of absence second and third terms, 1929-1930.

ROMEO RAOUL MARTEL, S.B.

Associate Professor of Civil Engineering

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

690 South Mentor Avenue

WILLIAM W. MICHAEL, B.S.

Associate Professor of Civil Engineering

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

388 South Oak Avenue

ARISTOTLE D. MICHAL, PH.D.

Associate Professor of Mathematics

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

1067 San Pasqual Street

LINUS CARL PAULING, PH.D.

Associate Professor of Theoretical Chemistry

B.S., Oregon Agricultural College, 1922; Ph.D., California Institute of Technology, 1925. National Research Fellow in Chemistry, 1925-1926. Foreign Fellow of the John Simon Guggenheim Memorial Foundation, 1926-1927. Lecturer in Physics and Chemistry, University of California, 1928-. California Institute, 1922-

320 South Wilson Avenue

WILLIAM L. STANTON, B.A.

Physical Director

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

515 Manzanita Avenue, Sierra Madre

EARNEST CHARLES WATSON, PH.B.

Associate Professor of Physics

Ph.B., Lafayette College, 1914; Scholar in Physics, University of Chicago, 1914-1915; Assistant in Physics, 1915-1917. California Institute, 1919-1124 Mar Vista Avenue

LUTHER EWING WEAR, PH.D.

Associate Professor of Mathematics

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

68 South Grand Oaks Avenue

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 in Physics of the International Education Board, 1925-1927. California Institute, 1925-

27 South Wilson 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. California Institute, 1921-

218 Highland Avenue, Monrovia

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. California Institute, 1928-

107 South Grand Oaks Avenue

HENRY BORSOOK, PH.D.

Assistant Professor of Biology

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-

165 South Wilson Avenue

GEORGE BICKFORD BRIGHAM, JR.

Assistant Professor of Engineering Drawing

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

1371 San Pasqual Street

THEODOSIUS DOBZHANSKY

Assistant Professor of Genetics

Diploma, University of Kiev, 1921. Assistant in Zoology, Polytechnic Institute of Kieve, 1921-1924. Lecturer in Genetics, University of Leningrad, 1924; Research Fellow, Bureau of Genetics, Russian Academy of Sciences, 1926. California Institute, 1928-

108 South Chester Avenue

HERMAN ELISA DOLK, PH.D.

Assistant Professor of Biology

Ph.D., University of Utrecht, 1927. Assistant in Comparative Physiology, University of Utrecht, 1924-1926; Assistant in Botany, 1926-1928; Plant Physiologist in Government Service, Laboratory for Bulb Culture, Lisse (Holland), 1928-1929. California Institute of Technology, 1930-

HARVEY EAGLESON, PH.D.

Assistant Professor of English Language and Literature

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

529 South El Molino Avenue

STERLING H. EMERSON, PH.D.

Assistant Professor of Genetics

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

1132 Constance Street

HORACE NATHANIEL GILBERT, M.B.A.

Assistant Professor of Business Economics

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

619 South Oak Knoll Avenue

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-

529 South El Molino Avenue

ARTHUR LOUIS KLEIN, PH.D.

Assistant Professor of Aeronautics

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

1122 Cordova Street

SAMUEL STUART MACKEOWN, PH.D.

Assistant Professor of Electrical Engineering

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

1240 Arden Road

CLARK BLANCHARD MILLIKAN, PH.D.

Assistant Professor of Aeronautics

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

2700 Inverness Drive

J. ROBERT OPPENHEIMER, PH.D.

Assistant Professor of Theoretical Physics

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

ARTHUR EMMONS RAYMOND, M.S.

Assistant Professor of Aeronautics (Part Time)

S.B., Harvard University, 1920; M.S. in Aeronautics, Massachusetts Institute of Technology, 1921. Assistant Chief Engineer, Douglas Aircraft Co., Santa Monica, 1925-. California Institute, 1927-

820 Stanford Street, Santa Monica

WILLIAM RALPH SMYTHE, PH.D.

Assistant Professor of Physics

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

120 North Chester Avenue

ERNEST HAYWOOD SWIFT, PH.D.

Assistant Professor of Analytical Chemistry

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

1131 Lura Street

S. HARRISON THOMSON, PH.D., B.LITT.

Assistant Professor of History

A.B., Princeton University, 1923; Ph.D., Charles University, Prague, 1925; B.Litt., Oxford University, 1926. Fellow of the Czechoslovak Ministry of Education, 1924; Lektor in English, National School of Mines, Pritbram, Czechoslovakia, 1924; Instructor in Biblical Literature, Princeton University, 1926-1929; Fellow in Medieval History of the Huntington Library, 1929-. California Institute, 1929-

525 South Sierra Vista Avenue

MORGAN WARD, PH.D.

Assistant Professor of Mathematics

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

700 Linda Vista Avenue

CLYDE WOLFE, PH.D.

Assistant Professor of Mathematics

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

401 South Chester Avenue

DON M. YOST, PH.D.

Assistant Professor of Chemistry

B.S., University of California, 1923; Ph.D., California Institute of Technology, 1926. Instructor in Chemistry, University of Utah, 1923-1924; Fellow of the International Education Board, 1928-1929. California Institute, 1924-

85 South Michigan Avenue

WILLIAM NOEL BIRCHBY, M.A.Instructor in 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. California Institute, 1918-

1500 Sinaloa Avenue

REGINALD BLAND

Director of Orchestra

California Institute, 1926-

609 North Hill Avenue

FRED J. CONVERSE, B.S.

Instructor in Civil Engineering

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

239 South Sierra Bonita Avenue

RENE ENGEL, M.S.

Instructor in Geology

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

1148 Constance Street

EUSTACE L. FURLONG

Curator in Vertebrate Paleontology

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

349 South Mentor Avenue

ARTHUR FREDERICK HALL¹

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

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

1090 Mar Vista Avenue

FLOYD L. HANES, D.O.

Physical Trainer

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

200 South Madison Avenue

MURRAY W. HAWS, M.A.¹

Instructor in Pattern Making (Part Time)

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

1911 Summit Avenue

OSCAR LESLIE HEALD¹

Instructor in Forging (Part Time)

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

2180 Santa Anita Avenue

¹Associated with Pasadena Junior College.

HOWARD BYINGTON HOLROYD, PH.D.

Instructor in Mechanical Engineering

B.S. in M.Eng., Iowa State College, 1924; Ph.D., California Institute of Technology, 1929. California Institute, 1927-

323 South Chester Avenue

LOUIS WINCHESTER JONES, A.B.

Instructor in English Language and Literature

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

351 California Terrace

ROBERT TALBOT KNAPP, PH.D.*

Instructor in Mechanical Engineering

B.S., Massachusetts Institute of Technology, 1920; Ph.D., California Institute of Technology, 1929. Designer with C. M. Gay & Son, Refrigerating Engineers, 1920-1921. California Institute, 1922-

163 South Greenwood Avenue

WALTER WILLIAM MARTIN¹

Instructor in Wood Working (Part Time)

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

1782 Rose Villa Street

FRANCIS WILLIAM MAXSTADT, M.S.

Instructor in Electrical Engineering

M.E., Cornell University, 1916; Certificate of E.E., 1916; M.S., California Institute of Technology, 1925. Draftsman and Designer, Otis Elevator Company, 1916-1917. Assistant in the Electrical Research Division, Interborough Rapid Transit Company, 1917-1919. Assistant in the Thomas A. Edison Laboratories, 1919. California Institute, 1919-

3782 Elma Road

HAROLD Z. MUSSELMAN, A.B.

Instructor in Physical Education

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

834 East California Street

WALTER WILLIAMS OGIER, JR., B.S.*

Instructor in Mechanical Engineering

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

184 South Oak Avenue

¹Associated with the Pasadena Junior College.

*On leave of absence 1929-1930.

ALEXANDER J. SMITH

Band Instructor

California Institute, 1924-

1860 West Forty-first Place, Los Angeles

FRANCES HALSEY SPINING

Librarian

California Institute, 1914-

1067 North Catalina Avenue

ROGER STANTON, M.A.*

Instructor in English Language and Literature

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

840 East Del Mar Street

ALBERT TYLER, PH.D.

Instructor in Embryology

A.B., Columbia University, 1926; A.M., 1927; Ph.D., California Institute of Technology, 1929. Assistant in Zoology, Columbia University, 1926-1928. California Institute, 1928-

258 South Hudson Avenue

RAY EDWARD UNTEREINER, A.M.

Instructor in Economics and History

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

351 West Marigold Street, Altadena

MIGUEL ANTONIO BASOCO, PH.D.

Research Fellow in Mathematics

B.A., University of California, 1924; M.S., University of Chicago, 1926; Ph.D., California Institute of Technology, 1929. California Institute, 1927-

129 West Forty-third Street, Los Angeles

WILLARD HARRISON BENNETT, PH.D.

National Research Fellow in Physics

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

179 South Wilson Avenue

FRANCIS BITTER, PH.D.

National Research Fellow in Physics

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

2050 Galbreth Road

*On leave of absence, 1929-1930.

FRANK WOODBRIDGE CONSTANT, PH.D.

National Research Fellow in Physics

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

Faculty Club

GEORGE ALEXANDER CUMMING, PH.D.

Commonwealth Fund Fellow in Geology

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

1026 Locust Street

JESSE WILLIAM MONROE DUMOND, PH.D.

Research Fellow in Physics

B.S., California Institute of Technology, 1916; M.S. in E.E., Union College, 1918; Ph.D., California Institute of Technology, 1929. California Institute, 1921-

615 South Mentor Avenue

JOHN DYER ELDER, PH.D.

Research Fellow in Mathematics

B.S., University of Chicago, 1925; Ph.D., California Institute of Technology, 1929. California Institute, 1927-

116 South Dillon Street, Los Angeles

HOWARD THEODORE ENGSTROM, PH.D.

National Research Fellow in Mathematics

B.Ch.E., Northwestern University, 1922; M.S., University of Maine, 1925; Ph.D., Yale University, 1929. Instructor in Mathematics, University of Maine, 1923-1926; Instructor in Mathematics, Trinity College, Hartford, 1926-1927; Instructor in Mathematics, Yale University, 1927-1929. California Institute, 1929-

1122 Cordova Street

RUDOLF FRERICHS, PH.D.

Fellow in Physics of the International Education Board

Ph.D., University of Bonn, 1924. Assistant in Physics, University of Bonn, 1922-1927; Privat Docent in Physics, 1927-. Assistant to the President of the Physikalische Technische Reichsanstalt, Charlottenburg, 1927-1928; Fellow in Physics of the International Education Board at the University of Michigan, 1928-1929. California Institute, 1929-

247 South Chester Avenue

SHINICHIRO HAKOMORI, M.S.

Foreign Research Scholar, Japanese Department of Education

"Rigakushi" (M.S.), Tōhoku Imperial University, Japan, 1922. Assistant Professor of Chemistry, Tōhoku University, 1926-; Foreign Research Scholar, Japanese Department of Education, 1929-1931. California Institute, 1929-

407 South Michigan Avenue

BURTON WADSWORTH JONES, PH.D.

National Research Fellow in Mathematics

A.B., Grinnell College, 1923; A.M., Harvard University, 1924; Ph.D., University of Chicago, 1928. Instructor in Mathematics, Western Reserve University, 1924-1926; Instructor in Mathematics, University of Chicago, 1928-1929. California Institute, 1929-

1122 Cordova Street

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National Research Fellow in Chemistry

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

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Fellow in Physics of the John Simon Guggenheim Memorial Fund

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

150 South Orange Grove Avenue

JOSEPH BLAKE KOEPFLI, D. PHIL.

Research Fellow in Organic Chemistry

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

342 South Mariposa Avenue, Los Angeles

CHARLES CHRISTIAN LAURITSEN, PH.D.

Research Fellow in Physics

Odense Tekniske Skole, 1911; Ph.D., California Institute of Technology, 1929. California Institute, 1927-

352 South Chester Avenue

WILLIAM RICHARD MORGANS, M.Sc.

Commonwealth Fund Fellow in Physics

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

1676 Rose Villa Avenue

GORDON PALL, PH.D.

National Research Fellow in Mathematics

B.A., University of Manitoba, 1926; M.A., Toronto University, 1927; Ph.D., University of Chicago, 1929. California Institute, 1929-

1156 Constance Street

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National Research Fellow in Physics

B.S., Carnegie Institute of Technology, 1918; M.S., University of Pittsburgh, 1927; Ph.D., California Institute of Technology, 1929. California Institute, 1928-

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HERMAN C. RAMSPERGER, PH.D.

National Research Fellow in Chemistry

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

286 South Chester Avenue

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Research Fellow in Physics

B.S., Haverford College, 1922; Ph.D., California Institute of Technology, 1929. Instructor in Physics, Miami University, 1922-1925. California Institute, 1925-

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National Research Fellow in Physics

A.B., Johns Hopkins University, 1926; Ph.D., 1929. California Institute, 1929-

323 Grant Street

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Commonwealth Fund Fellow in Geology

B.A., University of British Columbia, 1926; B.A.Sc., 1927; D.Phil., Oxford University, 1929; British Columbia's Rhodes Scholar at Oxford University, 1926-1929. California Institute, 1929-

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A.B., Park College, 1926; M.S., University of Michigan, 1927; Ph.D., 1929. California Institute, 1929-

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M.Sc., University of Cape Town, 1925; B.A., Cambridge University, 1928. Wollaston Student in Gonville and Caius Colleges, Cambridge, 1928-1929. California Institute, 1929-

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No. 4, 406 South Chester Avenue

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B.S., Yale University, 1928.

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B.S., California Institute, 1929.

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<i>123 North Wilson Avenue</i>	
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<i>1504 East Walnut Street</i>	
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<i>515 North Michigan Avenue</i>	
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<i>152 Sacramento Street, Altadena</i>	
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<i>190 South Hudson Avenue</i>	
JOHN L. RIDGWAY.....	Scientific Illustrator in Vertebrate Paleontology
<i>501 Fairmont Street, Glendale</i>	
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<i>1009 Tipton Terrace, Los Angeles</i>	
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<i>621 Indiana Street, Los Angeles</i>	

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<i>997 Elizabeth Street</i>	
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<i>336 South San Gabriel Blvd.</i>	
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<i>Dormitory</i>	
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<i>656 South Mentor Avenue</i>	

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HARRY C. VAN BUSKIRK, Mathematics

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WILLIAM V. HOUSTON, Physics
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EARNEST C. WATSON, Physics
LUTHER E. WEAR, Mathematics
FRITZ ZWICKY, Theoretical Physics

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J. ROBERT OPPENHEIMER, Theoretical Physics
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CLYDE WOLFE, Mathematics

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California Institute Associates

The California Institute Associates are a group of public spirited citizens, interested in the advancement of learning, who have been incorporated as a non-profit organization for the purpose of promoting the interests of the California Institute of Technology.

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The complete list of members of the California Institute Associates from the beginning includes, in addition to the foregoing, the names of the following members, now deceased: Mrs. Norman Bridge, Frank P. Flint, Herbert J. Goudge, Henry E. Huntington, Eugene A. Merrill, William G. Kerckhoff, Seeley W. Mudd, Benjamin E. Page, George S. Patton, Charles H. Ruddock, Douglas Smith.

Educational Policies

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

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

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

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

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

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

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

(6) Throughout the period of undergraduate study every effort shall be made to develop the character, ideals, breadth of view, general culture, and physical well-being of the students of the Institute. To this end the literary, historical, economic, and general scientific subjects shall continue to be taught by a permanent staff of men of mature judgment and broad experience; the regular work in these subjects shall be supplemented

by courses of lectures given each year by men of distinction from other institutions; and the weekly assemblies, addressed by leading men in the fields of education, literature, art, science, engineering, public service, commerce, and industry, shall be maintained as effectively as possible. Great importance is also attached to making the campus attractive in its architectural and landscape features, because of the influence of such surroundings on the students and on the public. Moderate participation of all students in student activities of a social, literary, or artistic character, such as student publications, debating and dramatic clubs, and musical clubs, shall be encouraged; and students shall be required to take regular exercise, preferably in the form of intramural games or contests affording recreation. It is the purpose of the Trustees to create as rapidly as possible additional facilities for these student activities by the erection of a gymnasium and student houses.

(7) In all the scientific and engineering departments of the Institute research shall be strongly emphasized, not only because of the importance of contributing to the advancement of science and thus to the intellectual and material welfare of mankind, but also because research work adds vitality to the educational work of the Institute and develops originality and creativeness in its students. To insure the development of research the Trustees will provide for it financially, not, as is so often the case, out of the residue that may be left after meeting the demands of the undergraduate work, but by duly limiting the extent of this work, and by setting apart, in advance, funds for research and graduate study.

(8) In order that the policies already stated may be made fully effective as quickly as possible, and in order that the available funds may not be consumed merely by increase in the student body, the registration of students at any period shall be strictly limited to that number which can be satisfactorily

provided for with the facilities and funds available. And students shall be admitted, not on the basis of priority of application, but on that of a careful study of the merits of individual applicants, so that the limitation may have the highly important result of giving a select body of students of more than ordinary ability. A standard of scholarship shall also be maintained which rapidly eliminates from the Institute those who, from lack of ability or industry, are not fitted to pursue its work to the best advantage.

Buildings and Educational Facilities

THROOP HALL

Throop Hall, the central building on the campus, was erected in 1910, the gift of a large number of donors, and the first building of the present group. 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 first unit contains a lecture room seating 260 persons, two large undergraduate laboratories with adjoining dark rooms and apparatus rooms, three classrooms, three laboratories for advanced instruction, nine offices, a stock and chemical room, the graduate library of physics, and twelve research rooms, besides shops, machinery, switchboard, and storage battery rooms.

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

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

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

THE HIGH-POTENTIAL RESEARCH LABORATORY

A high-potential laboratory, provided by the Southern California Edison Company, forms a companion building to the first unit of the Norman Bridge Laboratory, which it closely resembles in external design and dimensions. The equipment in this laboratory includes a million-volt transformer specially designed by Professor R. W. Sorensen, which is capable of supplying 1,000 kilovolt amperes at the above potential with one end grounded. It is available both for the pursuit of special scientific problems connected with the structure of matter and the nature of radiation, and for the conduct of the pressing engineering problems having to do with the improvement in the art of transmission at high potentials. It also provides opportunities for instruction in this field, such as are not at present easily obtainable by students of science and engineering.

GATES CHEMICAL LABORATORY

The 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 people, class rooms, four research laboratories, professors' studies, a storeroom for inflammable chemicals, and the usual machinery, switchboard, and service rooms. The architects for this unit were the Bertram G. Goodhue Associates, with Clarence S. Stein.

RESEARCH LABORATORY OF APPLIED CHEMISTRY

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

LABORATORY OF STEAM ENGINEERING AND ENGINEERING RESEARCH

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

The other half of the building is devoted to an engineering research laboratory, in which the research section of chemical engineering has already been installed.

DANIEL GUGGENHEIM AERONAUTICAL LABORATORY

The Daniel Guggenheim Aeronautical Laboratory has recently been completed. Funds for its construction and for its operation for a period of ten years have been provided through a gift of about \$350,000 from the Daniel Guggenheim Fund for the Promotion of Aeronautics. The building is 160 feet long by about 55 feet wide, and has five floors. The largest item of equipment is a wind tunnel of the Göttingen closed circuit type with a working section 10 feet in diameter. Provision is made for using the working section either as an open or closed type. A 750 horse-power, direct-current motor drives a 15-foot propeller, and a wind velocity of much more than 200 miles per hour has been produced. A complete set of aerodynamical balances will permit testing and research work of all kinds to be performed in the wind tunnel. At one end of the building a room 50 by 20 feet and four stories high will house a large testing machine capable of taking a specimen 30 feet long. In the sub-basement is a water channel about 140 feet long with a cross-section 10 by 10 feet, above which a light car will run, attaining a speed of about 40 miles per hour. This equipment will permit research to be conducted on seaplane hulls, pontoons, ship models, and various surface phenomena. A group of compressed air tanks capable of sustaining ten atmospheres pressure will give a four-inch jet of air at approximately the velocity of sound for a period of time long enough to allow accurate observations to be made on bodies placed in the jet. On the first floor are the observation room of the wind tunnel, a wood shop large enough for the building of complete airplanes, and an engine-testing laboratory with dynamometers and equipment for the testing of small engines. On the second floor are a machine shop and a group of six small laboratories for research on the various physical problems connected with engine studies. The third floor contains the balance room in which the wind tunnel measurements are made, a seminar room, library, drafting room, auxiliary equipment room, and five offices.

DABNEY HALL OF THE HUMANITIES

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

CULBERTSON HALL

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

SEISMOLOGICAL RESEARCH LABORATORY

The Seismological Research Laboratory is located on a site west of the Arroyo Seco. In it are carried on studies on earth movements. The general program of research is outlined by the Committee on Seismology of the Carnegie Institution of Washington, of which Dr. Arthur L. Day, director of its Geophysical Laboratory, is chairman. Mr. Harry O. Wood is in immediate charge of the investigations; and with him cooperate Dr. J. A. Anderson, of the Mt. Wilson Observatory, and Prof. John P. Buwalda, of the geological department of the Institute.

THE WILLIAM G. KERCKHOFF LABORATORIES
OF THE BIOLOGICAL SCIENCES

The first building 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 is in process of establishment at Balboa. The building that has been acquired contains four large rooms and several smaller ones which will give ample opportunity for research work in experimental embryology in general. The proximity of the marine station to Pasadena (about 53 miles) will make it possible to supply the biological laboratories with living materials for research and teaching. The fauna at Balboa and at Laguna Beach, which is near-by, is exceptionally rich and varied, and is easily accessible.

LIBRARIES

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

THE ATHENEUM

The Atheneum, which is now in process of construction, is situated at the eastern end of the campus fronting on South Hill Avenue. It will afford a place of residence for visiting professors, research fellows, and a limited number of graduate students. The building will provide ample dining facilities, a large lounge, a library, and an assembly hall. It will serve as a gathering place where members and friends may discuss topics of interest in science, art, literature and history. The Atheneum is a gift to the Institute from two of its loyal and generous friends, Mr. and Mrs. A. C. Balch, of Los Angeles. It will be ready for occupancy in September, 1930.

OTHER BUILDINGS

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

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 room of the Norman Bridge Laboratory of Physics. Special opportunities are made available to students for attendance at concerts given by noted artists under the auspices of the Pasadena Music and Art Association. Lectures given from time to time at the Institute under the auspices of Sigma Xi and of the Astronomical Society of the Pacific are open to the students. They may also arrange to visit the Huntington Library and Art Gallery, and members of the Institute staff give 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 Association elects its officers and a board of control, which investigates breaches of the honor system, or cases of misconduct, and suggests disciplinary penalties to the Associated Student Body for recommendation to the faculty.

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

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

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

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

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

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

national honors in the forensic field. On the odd-numbered years they enter the competition for the trophies offered by the Pacific Province of the order.

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

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

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

A thriving Young Men's Christian Association with a full time Secretary has its office in Dabney Hall and performs many

valuable services. Receptions for new students, hikes, meetings, classes for the study of life and other problems are conducted by this organization. Under its auspices has been formed a Cosmopolitan Club, membership in which is evenly divided between foreign and American students.

Requirements for Admission to Undergraduate Standing

ADMISSION TO THE FRESHMAN CLASS

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

Group A	{	English	3
		Algebra	2
		Plane and Solid Geometry	1½
		Trigonometry	½
		Physics	1
		Chemistry	1
		United States History and Government	1
Group B:	{	Foreign Languages, Shop (up to 1 unit); additional En-	
glish, Mathematics, Laboratory Science, or History.			
Group C:		Drawing, Commercial subjects, additional Shop, etc.	

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

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

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

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

Entrance examinations will be held at the Institute Monday and Tuesday, June 30th and July 1st, and Tuesday and Wednesday, September 16th and 17th. Applicants who take the June-July examinations should report in the Lounge of Dabney Hall June 30th at 8:30 A.M. Applicants who take the September examinations should report in the same place September 16th at 8:30 A.M.

Students living at a distance from Pasadena may, upon request, be allowed to take the spring entrance examinations under the supervision of their local school authorities*; or they may, if they prefer, take the 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 and unless also the Board has notice from the

notebooks at the time of the examination. The schedule for 1930 is as follows: Wednesday, September 24, 9:00 A.M., Mathematics; 2:00 P.M., English. Thursday, September 25, 2:00 P.M., History and Foreign Languages.

These examinations may also be taken under the direction of the College Entrance Examination Board. The examinations are held at various points in the United States on June 16-21, 1930. 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 19, 1930.

*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.

Institute that the candidate has its permission to take his examinations under the New Plan (Plan B).

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 22-24. 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 physician before coming to Pasadena in order to avoid unnecessary expense if obvious physical defects exist. 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 having it on file by the first of May, or even earlier. This enables the Institute to make full use of all information available from high school sources. Applicants whose preparatory work is complete should submit certificates of recommendation from the principals of their high schools, together with their complete scholastic record before taking the entrance examinations. Applicants who wish to take the spring entrance examinations and who have completed their preparatory work but are not able to secure their scholastic records before the examinations, will be admitted to the examinations if such a request is received from their principals. Certificates of recommendation and scholarship records of students who have taken the examinations under the above arrangement should be forwarded to the Institute as soon as possible after the completion of the preparatory work.

No decision can be reached as to the admission of a student until his principal's recommendation and his complete scholastic record are received. Applicants are advised to take the June 30th-July 1st examinations if possible.

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

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

Upon receipt of the registration fee of \$10.00 (which will be deducted from the first-term tuition), 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 Lounge September 25th 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 well 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 may be 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 135-151) 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. Copies 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 classi-

fication 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 1930 is as follows: Thursday, June 12, 9 A.M., Chemistry; Friday, June 13, 9 A.M., Mathematics; Saturday, June 14, 9 A.M., Physics; Monday, September 22, 9 A.M., Mathematics; 1:30 P.M., Physics; Tuesday, September 23, 9 A.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 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.

Physical examinations and certificates of 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.

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

Expenses

TUITION

The tuition fee for undergraduate students who entered the Institute as freshmen prior to September, 1929, and have pursued their course continuously in the Institute, is two hundred and fifty dollars (\$250) a year, payable \$90 at the opening of the first term and \$80 at the opening of each of the other terms.

The tuition fee for undergraduate students entering the Institute as freshmen in September, 1929, and subsequently is two hundred and fifty dollars (\$250) for the freshman year and three hundred dollars (\$300) a year for each of the succeeding years.

For graduate students, see pages 69 and 107.

The Associated Student Body fee, payable by all undergraduate students, is \$11.00 a year. This fee is used for the support of athletics and of other student activities. There is also a fee of 50c a term for locker rental. There are no other fees, but in the Division of Chemistry and Chemical Engineering an annual deposit of \$10 is required the first year, and \$15 the last three years, to cover breakage and loss of laboratory materials. There are also small deposits for locker keys and for padlocks issued in the drawing rooms. Deposits are also required to cover the expense of inspection trips taken by students in various courses.

The cost of supplies and of books ranges from \$60 to \$75 the first year, the larger part of which is required the first term, and from \$20 to \$30 a term thereafter.

LOAN FUNDS

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

In 1923, Mr. Howard R. Hughes, of Galveston, Texas, gave \$5,000 to constitute an additional fund for loans to students.

Mr. Raphael Herman, of Los Angeles, has provided a like sum to establish the Raphael Herman Loan Fund, which may be used for loans or for scholarships at the discretion of the Institute. Additional gifts of \$5,000 and \$1,000 have been made by anonymous donors for the same general purpose.

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

THE PUBLIC WORKS FUND

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

STUDENT EMPLOYMENT

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

DORMITORY

The Institute has provided on the campus one dormitory, of frame construction, two stories in height, with rooms for about sixty students. Several of the rooms have sleeping porches, and there are attractive living and recreation rooms. Accommodations in the dormitory are limited to first-year students, and students entering the Institute are expected to live in the dormitory dur-

ing their first year unless they live at home or for other satisfactory reasons are permitted to live off the campus.

The present minimum rate for room rent and dinner five nights in the week is \$190, the maximum is \$230 for the year. The rates are subject to modification by the Institute prior to the opening of any college year. The students are expected to furnish their own bed linen, blankets, and towels. A cafeteria conducted in connection with the dormitory provides breakfast and luncheon to occupants of the dormitory and any other students who may wish to take these meals there.

Registration and General Regulations

Registration for the second term, 1929-1930, will take place January 6, 1930 (9 A.M. to 3 P.M.); for the third term, March 31, 1930 (9 A.M., to 3 P.M.). Registration for the first term, 1930-1931, will take place, for freshmen, September 25, 1930 (8:30 A.M.), and for other students September 26, 1930 (9 A.M. to 3 P.M.), and September 27, 1930 (9 A.M. to 12 M.). A special fee of two dollars is charged for registration after these dates.

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

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

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

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

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

Scholastic Grading and Requirements

SCHOLASTIC GRADING

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

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

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

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

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

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

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

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

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

SCHOLASTIC REQUIREMENTS

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

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

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

*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.

and must arrange his schedule of studies and limit his outside activities in accordance with the advice of his Dean.

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

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

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

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

6. A student will be given *honor standing* in any term if he received during the preceding term 145 credits, 130 of which result from grades of 3 and 4 in non-italicized subjects; such honor standing to entitle him to special privileges and opportunities, such as relief from some of the more routine study and laboratory work, and admittance to more advanced subjects and research work. But a student in honor standing may not be admitted to an honor section pursuing any particular subject (other than those of the freshman year) unless he has also obtained a grade of 3 or better in the work prerequisite to that subject.

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

SPECIAL REGULATIONS

With the permission of the Registration Committee, a student of ability who must support himself wholly or in part by outside work and consequently would be unable to meet the scholarship requirements in four years may be admitted at the beginning of his sophomore year to a part-time schedule allowing an extra year for the completion of his course. The scholastic standing of students in these part-time courses shall be determined on the basis of seventy-five per cent of the credits mentioned in scholastic requirements 1 and 2 above. Tuition shall be at the rate of \$200 per year for students who entered as freshmen prior to September, 1929, and have pursued their course continuously in the Institute. For students entering as freshmen in September, 1929, or thereafter, the tuition will correspond to the advanced rates of tuition as stated on page 71.

If for any other reason a student is carrying less than 40 units, the credits required (as stated in paragraphs 1 and 2 on pages 76-77) shall be prorated on the basis of 40 as a maximum. For example, a man carrying 32 units of work shall be expected to obtain four-fifths of 80, or 64 credits, to remain off probation.

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

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

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

CANDIDACY FOR THE BACHELOR'S DEGREE

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

Scholarships and Prizes

FRESHMAN PRIZE SCHOLARSHIPS

A number of freshmen scholarships are awarded by the Institute, and a further scholarship by its Alumni, upon the basis of a competition open to properly qualified male students in the senior classes of the high schools or college preparatory schools. The Institute Scholarships will carry a payment sufficient to cover either the whole or half of the year's tuition; and the Alumni Scholarship one of \$300.

To enter the competition the student must meet the following conditions: He must complete by the end of the current school year at least fifteen units of studies of such a character as will fulfill the requirements for admission to the Institute, as set forth on pages 65-68, and he must, if awarded a scholarship, expect to enter the Institute at the beginning of the next college year. The competitor for the Alumni Scholarship must be elected by vote of the male members of the senior class of his high school. Any competitor for the Alumni Scholarship is eligible for an Institute Scholarship (in case he should fail to receive the Alumni Scholarship).

Each student nominated for the Alumni Scholarship must mail to the Registrar of the Institute not later than June 10th, on forms provided for the purpose, credentials giving the usual statistical information, and showing his high-school record, his participation in student activities, and his outside activities and personal interests.

All competitors for the scholarships must present themselves at the Institute for examination on June 30th and July 1st. The examinations will cover the branches of mathematics required for admission to the Institute, high-school physics and chemistry, English, American history, and general information. They will be of such a character as to determine the ability of the student to think and to express himself clearly, and to demonstrate his

initiative and resourcefulness in planning experiments, and his power of applying his knowledge to concrete problems, rather than to test memorized information. The ten or twelve most successful applicants will be expected to present themselves later for personal interviews.

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

DRAKE SCHOLARSHIPS

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

SOPHOMORE AND JUNIOR PRIZE SCHOLARSHIPS

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

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

JUNIOR TRAVEL PRIZES

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

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

CONDITIONS OF THE COMPETITION FOR THE PRIZE SCHOLARSHIPS AND TRAVEL PRIZES

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

THE CONGER PEACE PRIZE

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

SCHOLARSHIP AID FOR HONOR STUDENTS

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

Physics 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, some ten in number, 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 ten members of the staff participate in giving this lecture. 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 forty to fifty 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 of the Norman Bridge Laboratory are positions in colleges and universities, and in the increasing number of industrial research laboratories of the country.

Study and Research in Mathematics

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

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

Upon the completion of the prescribed graduate work in mathematics, the degree of Doctor of Philosophy is awarded, and the graduate may look forward to a career of teaching or of research. In the larger universities teaching and research are ordinarily combined, but academic advancement and freedom for research

usually depend upon demonstrated ability to do original work. Positions as mathematicians with engineering corporations maintaining research departments are available from time to time; and the United States Civil Service frequently announces positions for trained mathematicians.

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

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

Study and Research in 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 Chemical Engineering. 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 given to the highly important field of chemical reactions between gases and between gases and solids, which is often neglected in elementary instruction.

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 the absorption of X-rays in its chemical relations.

Study and Research in 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 of broad, yet intensive and thorough character, leading to 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 during the first three years, 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 fourth year 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 courses in Electrical Engineering provide for advanced work in the theory of electrical machine design, electric transients, high voltage engineering courses, electrical engineering problems involving the use of vacuum tubes, and problems relating to the distribution of electrical power for lighting and industrial purposes.

Daniel Guggenheim Graduate School of Aeronautics and The Daniel Guggenheim Airship Institute

Through the aid of the Daniel Guggenheim Fund for Aeronautics the Institute has established the Daniel Guggenheim Graduate School of Aeronautics and has constructed a laboratory containing a ten-foot, high-speed wind tunnel. (See page 58.) Recently the Daniel Guggenheim Fund has provided funds for the Daniel Guggenheim Airship Institute to be located at Akron, Ohio. The research work at the Airship Institute is to be directed by the California Institute of Technology, and this laboratory will contain a large wind tunnel and other experimental facilities for lighter-than-air research. The Institute will carry on theoretical and experimental work in the lighter-than-air field both at Pasadena and at Akron.

A few fellowships are available for selected workers in both fields of Aeronautics.

The following program of instruction and research is being undertaken:

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

2. Initiation of a group of practical courses 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 being provided at the Institute combined with those of the Douglas plant.

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

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

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

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

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

Excellent opportunities are available for studies in physical and geological seismology. A fully equipped Seismological Re-

search Laboratory is situated on a site west of the Arroyo Seco in Pasadena. The laboratory is largely devoted to researches conducted by the Carnegie Institution of Washington, but graduate students in the Division of Geology and Paleontology will be received in the laboratory for the purpose of taking part in the researches or of becoming 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 118.

Study and Research in Biology

The establishment of a Department of Biology, rather than the traditional departments of Botany and Zoology, calls for a word of explanation. It is with a desire to lay emphasis on the fundamental principles underlying the life processes in animals and plants that an effort is being made to bring together, in a single group, men whose common interests are in the discovery of the unity of the phenomena of living organisms rather than in the investigation of their manifold diversities. That there are many properties common to the two great branches of the living world is becoming almost daily more manifest, as shown, for example, in the discoveries that the same principles of heredity that obtain among flowering plants apply also to human traits, and that, in their response to light, animals and plants conform to a common law of physics. It is true that, at what may be called the biological level, an immense diversity of form and function manifests itself, but enough insight has already been gained to make evident that this diversity is in large part due to permutations and combinations of relatively few fundamental and common properties. It is in the search for these properties that the zoologist and botanist may profitably pool their interests. The animal physiologist today, who wishes to have a broad outlook over his field, can as little neglect the physiology of bacteria, yeast and higher plants as the bacteriologist and plant physiologist can ignore the modern discoveries in animal physiology. The geneticist who works with animals will know only half his subject if he ignores the work on plants, and both plant and animal geneticists will fail to make the most of their opportunities if they overlook the advances in cytology and embryology. It is, then, to bring together in sympathetic union a group of investigators and teachers whose interests lie in the fundamental aspects of their subjects, that a department of Biology 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. As rapidly as leaders can be found, it is proposed to organize groups of investigators in general physiology, genetics, biophysics, biochemistry, developmental mechanics, and perhaps later experimental psychology. The choice of these fields of modern research implies that emphasis will be laid on the intimate relations of biology to the physical sciences. That a closer association of these sciences with biology is imperative is becoming more and more apparent as indicated by the development of special institutes for such work.

The Astrophysical Observatory and Laboratory

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

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

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

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

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

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

personnel of its Advisory Committee are shown on page 46 of this Catalogue.

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

The extensive investigation of 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 ordered, and will be used in a comparative study of various forms of this instrument. The radiometer recently used very successfully by Dr. C. G. Abbot, of the Smithsonian Institution, in measuring the distribution of energy in the spectra of stars of several types has been developed and improved. A comparative study of possible sites for the 200-inch telescope has been undertaken by Dr. Anderson, aided by a dozen trained observers.

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

Owing to the rapid development of astronomical and spectroscopic research throughout the country, there are now more professional positions in universities, endowed observatories, and the Government service than can be satisfactorily filled, for able young men well trained in optics, astrophysics, and subatomic physics. The number of such positions, however, is not large; and only those well qualified for such work should undertake graduate study and research.

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 re-

sult, 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 new Hall of the Humanities, erected in 1928, was given by Mr. and Mrs. Joseph B. Dabney, of Los Angeles. In connection with the acceptance of this gift, a special endowment fund of \$400,000 was raised for the support of instruction in the humanistic fields, this amount being subscribed by several friends of the Institute.

In addition to the regular staff of the Institute, several scholars from other institutions are giving instruction in the Division of the Humanities during the current year. Among these are Dr. Max Farrand, formerly of Yale University and now Director of the Huntington Library; Professor Charles Read Baskervill, of the University of Chicago, and Professor George W. Sherburn of the same institution. With the opportunities for research in English Literature and American History which are afforded by the proximity of the Huntington Library, it is anticipated that the instruction given at the Institute in these fields will be steadily strengthened by the association of visiting scholars.

Information and Regulations for the Guidance of Graduate Students

I. ADMISSION TO GRADUATE STANDING

1. A graduate student is defined to be any man who has been admitted to graduate standing; (a) by the Committee on Graduate Courses of Study for work normally leading to the degree of Doctor of Philosophy, or (b) by the Committee on Engineering Courses or the Committee on Science Courses for work normally leading to the degree of Master of Science. To be admitted to graduate standing at the Institute an applicant must in general have received a Bachelor's degree representing the completion of an undergraduate course in science or engineering substantially equivalent to one of those offered by the Institute. He must, moreover, have attained such a scholastic record and must present such recommendations as indicate that he is fitted to pursue with distinction advanced study and research.

2. Application for admission to graduate standing at the Institute to work either for the Master's or 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. In the case of insufficient preparation, applicants for the Doctor's degree may be required to register for the Master's degree first. 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. Unless students who desire to register for work leading to the degree of Master of Science, show definite promise to the Committee on Engineering or Science Courses of ability to secure this degree within two years, they will not be admitted to graduate standing. Doubtful cases will be referred to the Committee on Admission to Upper Classes, who may require examinations before admission to the Institute.

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

4. Since admission to graduate work will be granted only to a limited number of students of superior ability, applications should be made as long as possible before the opening of the school year, preferably by the first of March. Students applying for assistantships or fellowships do not need to make separate application for admission to graduate standing. See Section X.

5. Admission to graduate standing does not of itself admit to candidacy for the degree of Master of Science or Doctor of Philosophy. As to this, see pages 110, 111.

II. FEES

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

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

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

III. REGISTRATION

1. Application for admission should be made well in advance of the time of registration (see page 68).

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

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

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

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

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

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

8. Graduate students who are devoting their whole time to

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

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

IV. EXAMINATIONS AND GRADES

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

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

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

The same scholastic requirements apply to students who expect to receive a Master's degree as are in force for undergraduates.

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

5. The Doctor's degree is awarded with the designations

"summa cum laude," "magna cum laude," "cum laude," or without designation.

V. REQUIREMENTS FOR HIGHER DEGREES

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

Members of the permanent Institute staff of rank higher than that of Assistant Professor are not admitted to candidacy for a higher degree.

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

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

A. MASTER OF SCIENCE

To receive the degree of Master of Science, the student must complete in a satisfactory way the work indicated in the schedule of one of the Fifth-Year Courses, as well as in the schedule of the Four-Year Course in Science or in Engineering (see pages 138-139, 143-146), except that in the case of students transferring from other institutions equivalents will be accepted in subjects in which the student shows by examination or otherwise that he is proficient, and except in so far as substitutions may be approved by special vote of the Committee in charge.

A student before entering upon work for the degree of Master of Science should, after consultation with the department concerned, submit a plan of study (together with his previous record if he transfers from another institution), and make application to the Committee in charge for acceptance as a candidate for that degree. Application forms for admission to candidacy for the degree of Master of Science may be obtained from the Regis-

trar, and must be submitted not later than the end of the first week of the first term of the year in which the degree is to be granted.

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

B. DOCTOR OF PHILOSOPHY

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

The work for the degree must consist of scientific research and the preparation of a thesis describing it and of systematic studies of an advanced character in some branch of science or engineering, which will be termed the "major subject" of the candidate. In addition as "minor subject" (or subjects) studies such as will give a fundamental knowledge and research point-of-view must be pursued in at least one other branch of science or engineering. The choice and scope of the minor subject must

be approved in each case by the department in charge of the course of study.

The minor subject must involve not less than 45 units of advanced study. In addition the candidate must have acquired the power of expressing himself clearly and forcefully both orally and in written language, and he must have a good reading knowledge of French and German.

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

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

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

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

(b) *Admission to Candidacy:* Any student in graduate standing who has been in residence one term or more, who has satisfied the several departments concerned by written or oral examination or otherwise that he has a comprehensive grasp of his major and minor subjects as well as of subjects fundamental to them, who has satisfied the department of modern languages that he can read scientific German and French with reasonable fa-

cility, 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.

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

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

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

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

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

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

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

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

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

- 1, a. To be recommended for candidacy for the Doctor's de-

gree in Mathematics the applicant must pass the following courses with a grade of 2 or better:

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

b. To be recommended for candidacy for the Doctor's degree in Physics the applicant must pass the following courses with a grade of 2 or better: Analytical Mechanics, Ph. 12 a, b, c, Electricity and Magnetism, Ph. 8 a, b, c, Physical Optics, Ph. 22 a, b, c, and Introduction to Mathematical Physics, Ph. 15 a, b, c. In case the applicant is minoring in Mathematics he must also pass with a grade of 2 or better the following courses: Advanced Calculus, Ma. 8 a, b, and Differential Equations, Ma. 11. In case the applicant is minoring in Chemistry he must also pass with a grade of 2 or better: Chemical Principles, Ch. 21 a, b, c.

c. To be recommended for candidacy for the Doctor's degree in Electrical Engineering the applicant must pass the following courses with a grade of 2 or better: Analytical Mechanics, Ph. 12, a, b, c, or Applied Mechanics, AM. 1 a, b, and Strength of Materials, AM. 1 c; Electricity and Magnetism, Ph. 8 a, b, c, or Electricity and Magnetism, Ph. 7 a, b, and Theory of Electricity and Magnetism, Ph. 122; Advanced Calculus, Ma. 8 a, b, and Differential Equations, Ma. 11; Alternating Current Analysis, EE. 20; Induction Machinery, EE. 22; Transmission Lines, EE. 44; Dielectrics, EE. 52.

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. In general at least one-half of the requirements should be met by the end of the first year of graduate work. Failure

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

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

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

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

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

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

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

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

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

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

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

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

VIII. 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 recommended for candidacy for the Doctor's degree in the Division in Geology and Paleontology the applicant must have shown more than average ability in mastering the previous geological and paleontological subjects.

2. The candidate must pass a qualifying examination which may be oral, or written, or both.

3. After admission to candidacy, students must in general

pursue advanced study and research for not less than six terms, or approximately two years (counting each summer of field work as a term), before they will be recommended by the Division of Geology and Paleontology for the final examination for the Doctor's degree.

IX. GRADUATE LIFE

The Atheneum, now under construction, will be ready for occupancy in September, 1930. (See page 60.) It will afford 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 will also provide living quarters for a limited number of men associated with the foregoing institutions.

X. FELLOWSHIPS AND ASSISTANTSHIPS

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

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

Teaching fellows will devote not more than fifteen hours a week to instruction of a character that will afford them useful experience. This time includes that required in preparation and in marking note-books and papers, as well as that spent in classroom and laboratory. Of the remaining time at least one-half must be devoted to research; and the obligation to prosecute this earnestly is regarded as no less binding than that of showing proper interest in teaching. Advanced courses of study may also be pursued as far as time permits.

Teaching Fellows and Assistants must obtain permission from

their department before undertaking work for remuneration outside of the Institute.

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

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

XI. RESEARCH FELLOWSHIPS

1. Institute Research Fellowships: In cases where the success of the research justifies it, Assistants and Fellows may be relieved from teaching in order to devote all their time to research.

2. The National Research Fellowships in Physics, Chemistry, and Mathematics established by the Rockefeller Foundation are awarded by the National Research Council to men who have their Doctor's degree. Fellows may choose the institution in

which they desire to pursue research. Applications should be made to the National Research Council, Washington, D. C.

3. The Petroleum Institute has, through the National Research Council, inaugurated researches at the Institute which call, in 1929-1930, for an expenditure of \$12,000. These funds are used mainly for supporting the work of research fellows who are carrying on fundamental researches connected with the physics or chemistry of petroleum or of the hydrocarbons of which it is composed.

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

XII. INSTITUTE GUESTS

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

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From October 1, 1928, to October 1, 1929

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Description of the Undergraduate and Fifth-Year Courses

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

THE COURSES IN ENGINEERING

The five-year plan of engineering instruction is based on recognition of the fact that a four-year period of study is inadequate to give satisfactorily the combination of cultural, basic scientific, and engineering studies essential to the highest type of engineer, and to afford at the same time leisure for the development of the physical well-being and human interests of the students. The four-year Course will train, more broadly and fundamentally than the Engineering Courses now given at most institutions, the large proportion of students who study engineering not to make themselves engineering experts in a specialized sense, but to fit themselves to fit satisfactorily into administrative positions in the utilities and manufacturing industries, and to serve as operating and constructing engineers in such industries. The fifth-year Courses, based on this broad fundamental preparation, and coordinated with it so as to constitute a harmonious, unified, five-year period of study, with no sharp breaks between the undergraduate and graduate periods, will afford the more intensive

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

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

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

THE COURSES IN SCIENCE

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

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

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

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

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

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

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

Schedules of the Undergraduate Courses

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

The subject numbers correspond to those given in the Description of Subjects on pages 152-214. For the explanation of the subject numbers in italics, see page 76. The abbreviations denote the various branches of instruction as follows:

Aeronautical Engineering.....	AE
Applied Mechanics	AM
Assembly	As
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
Philosophy	Pl
Physical Education	PE
Physics	Ph
Shop	Sh
Thesis	Th

BOTH COURSES

FIRST YEAR, ALL THREE TERMS

SUBJECTS	SUBJECT NUMBER	HOURS PER WEEK			UNITS
		Class	Lab.	Prep.	
English.....	En 1 a b c	3	0	3	6
Physics.....	Ph 1 a b c	3	3	6	12
Chemistry.....	Ch 1 a b c	3	6	3	12
Mathematics.....	Ma 1 a b c	4	0	8	12
History.....	H 1 a b c	3	0	2	5
Drawing*.....	D 1 or 10, 40, 41a	0	3	0	3
Assembly†.....	As 1 a b c	1	0	0	1
Physical Education.....	PE 1 a b c	0	3	0	3
					54

*Students with a recommended high school credit of $\frac{1}{2}$ unit or more in mechanical drawing, and all science students, take D 1; others take D 10. All freshmen are required to take D 40 and D 41a the second and third terms, respectively.

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

COURSE IN ENGINEERING

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

SECOND YEAR

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

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

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

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

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

COURSE IN ENGINEERING

THIRD YEAR

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

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

COURSE IN ENGINEERING

FOURTH YEAR

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

*For the Humanities Electives see below.

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

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

HUMANITIES ELECTIVES (9 units)

First Term

American Literature (MacMinn)
Modern Drama (Huse, MacMinn)
Contemporary Literature (Judy,
Eagleson)

Third Term

American Literature (MacMinn)
Contemporary Literature (Judy,
Eagleson)
German Literature (Macarthur)
Literature of the Bible (MacMinn)
Modern Drama (Huse, MacMinn)
Sociology (Untereiner)
History of Christianity (Thomson)

COURSE IN ENGINEERING

FOURTH YEAR (Continued)

SUBJECTS	SUBJECT NUMBER	HOURS PER WEEK			UNITS		
		Class	Lab.	Prep.	1st Term	2nd Term	3rd Term
<i>Mechanical Engineering</i>							
<i>Option:</i>							
Structures.....	CE 9 ^{5-c}	3	3	6	..	12	..
Machine Design.....	ME 2, 4	2	3	4	9	..	9
Machine Design.....	ME 3, 5	2	6	4	..	12	..
Metallurgy.....	ME 10	3	0	6	9	..	..
Heat Engineering....	ME 16	4	0	8	12	..	..
Heat Engineering....	ME 17	3	3	3	..	..	9
Heat Eng. Lab. or	ME 26	0	3	3	..	6	..
Elective(see below)							
<i>Electrical Engineering</i>							
<i>Option:</i>							
Structures.....	CE 9	3	3	6	..	..	12
Diff. Equations.	Ma 11	4	0	8	..	..	12
Heat Engineering....	ME 16	4	0	8	..	12	..
Electrical Eng. Lab..	EE 7	0	3	3	..	..	6
Elect. and Magnetism.	Ph 7 and 9 a b	3	3	6	12	12	..
Electrical Machinery	EE 6 a b	2	0	4	6	6	..
Electrical Machinery	EE 40	2	0	4	..	6	..
<i>Civil Engineering</i>							
<i>Option:</i>							
Advanced Surveying.	CE 2	3	6	3	12	..	..
Railway Engineering	CE 8 a b c	..	..	..	6	6	6
Theory of Structures	CE 10 a b c	3	3	6	12	12	12
Highway Engineering	CE 4	3	0	3	..	..	6
Reinforced Concrete.	CE 12	2	0	4	..	..	6
<i>Aeronautics Option:</i>							
Advanced Calculus..	Ma 8 a b c	4	0	8	12	12	12
Aeronautics.....	AE 1	3	0	6	..	9	..
Metallurgy.....	ME 10	3	0	6	9	..	..
Machine Design.....	ME 8	3	3	6	12	..	..
Structures.....	CE 11 a b	2	3	4	..	9	9
<i>General Electives:</i>							
Advanced Calculus..	Ma 8 a b c	4	0	8	12	12	12
Accounting.....	Ec 17	3	0	6	..	9	..
Business Study .....	.....	..	..	..	6	6	6

COURSE IN SCIENCE

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

SECOND YEAR

SUBJECTS	SUBJECT NUMBER	HOURS PER WEEK			UNITS		
		Class	Lab.	Prep.	1st Term	2nd Term	3rd Term
Mathematics*†.....	Ma 2 a b c	4	0	8	12	12	8*
Physics*†.....	Ph 2 a b c	3	3	6	12	12	8*
Mathematics Review.....	Ma 2 d	4	0	8	..	..	4*
Physics Review.....	Ph 2 d	3	3	6	..	..	4*
History.....	H 2 a b c	2	0	4	6	6	6
Chemistry.....	Ch 12 a b	2	6	2	10	10	..
Geology.....	Ge 1 a	3	3	3	9	..	..
Biology.....	Bi 1	3	3	3	..	9	..
Paleontology or.....	Ge 1 b	4	1	4	..	..	} 9
Biology or.....	Bi 2	3	4	2	..	..
Astronomy.....	Ay 1	3	1	5	..	..
Options as below†.....		..	..	..	..	..	10
Assembly.....	As 2 a b c	1	0	0	1	1	1
Physical Education.....	PE 2 a b c	0	3	0	3	3	3
<i>Options†</i>							
Analytical Chemistry..	Ch 12	2	6	2	..	..	10
Organic Chemistry....	Ch 43	2	6	2	..	..	10
Surveying.....	CE 1	3	4	3	..	..	10
Theory of Equations..	Ma 3	4	0	8	..	..	12
Descriptive Geometry.	D 42	0	6	0	..	..	6

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

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

‡Students take Qualitative Analysis (Ch 12c) if they are preparing for the Option in Chemistry or Chemical Engineering; Organic Chemistry (Ch 43) if preparing for the Option in Experimental Physics or Biology; Surveying (CE 1) if preparing for the Option in Geology; Theory of Equations (Ma 3) if preparing for the Option in Mathematics or Theoretical Physics. Non-honor students are admitted to the Mathematics Option only by special vote of the Committee on Science Courses. Students in the Geology Option substitute for the 3rd term Mathematics, Descriptive Geometry (D 42) and Crystallography (Ge 3a).

COURSE IN SCIENCE

FOR CLASSES ENTERING IN 1928 AND THEREAFTER

THIRD YEAR

SUBJECTS	SUBJECT NUMBER	HOURS PER WEEK			UNITS		
		Class	Lab.	Prep.	1st Term	2nd Term	3rd Term
English.....	En 7 a b c	3	0	5	8	8	8
German.....	L 32 a b c	4	0	6	10	10	10
Chem. Principles.....	Ch 21 a b c	4	0	6	10	10	10†
Options, as below.....	.....	2	3	5	21	21	21
Assembly.....	As 3 a b c	1	0	0	1	1	1
Physical Education....	PE 3 a b c	0	3	0	3	3	3
					53	53	53
<i>Experimental Physics</i>							
Option:							
Mathematics.....	PH 22 a b c	3	0	6	9	9	9
Direct Currents.....	EE 2, 3	3	3	6	12	12	12
Alternating Cur'nts...	EE 4, 5	3	3	6	12	12	12
Heat Engineering...	ME 15	3	3	6	12	12	12
or							
Optics.....	Ph 22 a b c	3	0	6	12	12	12
	Ph 23 a b c	0	3	0			
<i>Theoretical Physics</i>							
Option:							
Advanced Calculus...	Ma 8 a b c	4	0	8	12	12	12
Differ. Equations...	Ma 10 a b c	3	0	6	12	12	12
<i>Chemistry Option:</i>							
Inorganic Chemistry	Ch 13 a b	2	0	2	4	4	..
Surface and Colloid							
Chemistry.....	Ch 29	3	0	5	..	..	8
Instrum'tal Analysis	Ch 16	0	6	2	8	..	..
Physico-Chem. Lab.	Ch 26 a b	0	6	2	8	..	..
	Ch 26 c	0	3	1	..	..	4
Inorganic Chem. Lab.	Ch 14 a b	0	9	0	9	9	9*
or Mathematics...	PH 22 a b c	3	0	6	9	9	9
Options:							
(Cont'd next page)							

*Students who have taken Modern Physics substitute Chemical Research for Physico-Chemistry Laboratory.

COURSE IN SCIENCE

THIRD YEAR (Continued)

SUBJECTS	SUBJECT NUMBER	HOURS PER WEEK			UNITS		
		Class	Lab.	Prep.	First Term	Second Term	Third Term
<i>Chemical Engineering Option:</i>							
Applied Mechanics..	AM 2 a b	4	0	8	12	12	..
Heat Engineering...	ME 15	4	0	8	..	..	12
Economics.....	Ec 2, 3, 4	3	0	3	6	6	..
Physico-Chem. Lab..	Ch 26 a b	0	3	1	..	4	4
Industrial Chemistry	Ch 61	2	0	4	..	..	6
<i>Mathematics Option*:</i>							
Advanced Calculus..	Ma 8 a b c	4	0	8	12	12	12
Differ. Equations...	Ma 10 a b c	3	0	6	9	9	9
<i>Astronomy Option:</i>							
Mathematics.....	.....	3	0	6	9	9	9
Optics.....	Ph 22 and 23, a b c	3	3	6	12	12	12
<i>Geology Option†:</i>							
Mineralogy.....	Ge 3 b c	..	..	..	8	10	0
Drawing.....	D 50, 51	0	6	0	6	0	6
Petrology.....	Ge 5 a b	..	..	..	0	11	7
Field Geology.....	Ge 7 a	..	..	..	0	0	12
Historical Geology..	Ge 1 c	2	3	4	8	0	0
Summer Field Geology required after Junior year.							
<i>Biology Option:</i>							
Physico-Chem. Lab..	Ch 26	0	3	1	..	4	4
Colloid and Surface Chemistry.....	Ch 29	3	0	5	..	..	8
Economics.....	Ec 2, 3, 4	3	0	3	6	6	..
General Biology....	Bi 3	3	4	2	9	..	..
Histological Tech...	Bi 4	0	6	0	6	..	..
Physiology.....	Bi 5 b c	..	..	..	..	11	9

*Students taking the Mathematics Option substitute in the 2nd and 3rd terms Analytic Geometry (Ma 4 a b) for Chemical Principles.

†Students taking the Geology Option substitute in the 3rd term Plane Table Surveying (CE 3) for Chemical Principles.

COURSE IN SCIENCE
FOR CLASSES ENTERING PREVIOUS TO 1928

FOURTH YEAR

SUBJECT	SUBJECT NUMBER	HOURS PER WEEK			UNITS		
		Class	Lab.	Prep.	First Term	Second Term	Third Term
Humanities Electives*	.....	3	0	6	9	..	9
Philosophy	Pl 1	3	0	6	..	9	..
Current Topics	H 5 a b	1	0	1	2	2	..
U. S. Constitution....	H 10	1	0	1	..	..	2
Economics	Ec 2, 3, 4	3	0	3	6	6	..
Assembly	As 4 a b c	1	0	0	1	1	1
Physical Education ..	PE 4 a b c	0	3	0	3	3	3
Options as below .....	.....	..	..	..	33	33	33
					54	54	48
<i>Physics Option:</i>							
Analytic Mechanics.	Ph 12 a b c	4	0	8	12	12	12
Electricity	Ph 8 a b c	3	0	6	9	9	9
Electrical Measure.	Ph 9 a b c	0	3	0	3	3	3
Electrical Eng.†....	EE 2,3,4,5	3	3	6	12	12	..
Heat Engineering†..	ME 15	3	3	6	..	..	12
<i>Mathematics Option:</i>							
Differ. Equations.....	Ma 10 a b c	3	0	6	9	9	9
Electives:							
Complex Variable..	Ma 114	4	0	8	12	..	..
Modern Theory of							
Diff. Equations..	Ma 116 a b	4	0	8	..	12	12
Relativity	Ma 122	4	0	11	15	..	..
Modern Algebra....	Ma 123 abc	4	0	8	12	12	12
Differ. Geometry...	Ma 108 abc	4	0	8	12	12	12
<i>Other Options:</i>							
See next page.							

*See page 138.

†Or research for Honor Students.

COURSE IN SCIENCE
FOR CLASSES ENTERING PREVIOUS TO 1925

FOURTH YEAR (Continued)

SUBJECTS	SUBJECT NUMBER	HOURS PER WEEK			UNITS		
		Class	Lab.	Prep.	First Term	Second Term	Third Term
<i>Chemistry Option:</i>							
Organic Chemistry...	Ch 41 a b	3	0	5	8	8	..
Organic Chemistry...	Ch 41 c	2	0	4	..	..	6
Organic Chemistry Laboratory.....	Ch 46 a b	0	9	0	9	9	..
Chemical Thermo- dynamics.....	Ch 22 a b	3	0	6	9	9	..
Instrumental Analysis	Ch 16	0	6	2	8†	..	..
Industrial Chemistry.	Ch 61	2	0	4	..	6	6
Research.....	Ch 70-73	..	..	..	..	..	20
<i>Chemical Engineering Option:</i>							
Organic Chemistry...	Ch 41 a b	3	0	5	8	8	..
Organic Chemistry...	Ch 41 c	2	0	4	..	..	6
Organic Chem. Lab.	Ch 46 a b	0	9	0	9	9	..
Chemical Thermo- dynamics.....	Ch 22 a b	3	0	6	9	..*	..
Electrical Engineering	EE 2,3,4,5	3	3	6	..	12	12
Heat Engineering...	ME 15	3	3	6	..	..	12
Accounting.....	Ec 17	3	0	6	9	..	..
Industrial Chemistry	Ch 61	2	0	4	..	6*	6
<i>Geology Option:</i>							
Historical Geology ..	Ge 1 c	2	3	4	9	..	..
Petrology.....	Ge 5 a b	1	6	2	9	9	..
Field Geology.....	Ge 7 a b	..	..	..	8	..	10
Structural Geology...	Ge 9	3	0	5	..	..	8
Vertebrate Paleon...	Ge 12	2	6	2	..	10	8
Invertebrate Paleon.	Ge 11 a b	..	..	..	10	8	..
Research.....	Ge 21, 22	..	..	..	..	8	8

*Honor students, especially those intending to take the fifth-year Course in Chemical Engineering, should take Thermodynamic Chemistry in the second term, and should take Industrial Chemistry (3 units) as an extra subject.

†Honor students may substitute Research for Ch 16.

COURSE IN SCIENCE

FOR CLASSES ENTERING IN 1928 AND THEREAFTER

FOURTH YEAR

SUBJECTS	SUBJECT NUMBER	HOURS PER WEEK			UNITS		
		Class	Lab.	Prep.	First Term	Second Term	Third Term
Humanities Electives*	.....	3	0	6	9	..	9
Philosophy.....	Pl. 1	3	0	6	..	9	..
Current Topics.....	H 5 a b	1	0	1	2	2	..
U. S. Constitution....	H 10	1	0	1	..	..	2
Economics.....	Ec 2, 3, 4, L 35 a b c	3	0	3	6†	6†	..
German or French....	or	4	0	6	10	6	6
	L 1 a b				10	10	10
Assembly.....	As 4 a b c	1	0	0	1	1	1
Physical Education....	PE 4 a b c	0	3	0	3	3	3
Options as below.....	.....	..	..	..	22	22	28
					53	49 or 53	49 or 53
<i>Experimental Physics</i>							
<i>Option:</i>							
Applied Mechanics...	AM 1 a b c	4	3	7	14	14	14
or Analytical Mech.	Ph 12 a b c	4	0	8	12	12	12
Electricity and Magnetism.....	Ph 7 a b	3	0	6	9	9	..
Elec. Measurements.	Ph 9 a b	0	3	0	3	3	..
Vacuum Tubes.....	EE 62	4	0	8	..	..	12
or Fourth Year En- gineering Subjects	.....	..	..	..	..	..	12
<i>Theoretical Physics</i>							
<i>Option:</i>							
Analytical Mech....	Ph 12 a b c	4	0	8	12	12	12
Electricity and Magnetism.....	Ph 8 a b c	3	0	6	9	9	9
Elec. Measurements.	Ph 9 a b c	0	3	0	3	3	3
<i>Chemistry Option:</i>							
Organic Chemistry..	Ch 41 a b c	{3 3}	0 0	5 3}	8	6	8
Organic Chem. Lab..	Ch 46 a b	0	9	0	9	9	..
Thermodynamic Ch.	Ch 22 a b	{3 3}	0 0	3 5}	6	8	..
Industrial Chem.....	Ch 61	2	0	4	..	..	6
Chemical Research..	Ch 70-73	0	12	0	..	..	12

*See page 138.

†Omit in Chemical Engineering and Biology Options, leaving 28 units for these options in all terms.

COURSE IN SCIENCE

FOR CLASSES ENTERING IN 1928 AND THEREAFTER

FOURTH YEAR (Continued)

SUBJECTS	SUBJECT NUMBER	HOURS PER WEEK			UNITS		
		Class	Lab.	Prep.	First Term	Second Term	Third Term
<i>Chemical Engineering Option:</i>							
Organic Chemistry	Ch 41 a b c	{3	0	5}			
Organic Chem. Lab.	Ch 46 a b	{3	0	3}	8	6	8
Chemical Thermodynamics.....	Ch 22 a	0	9	0	9	9	..
Industrial Chem....	Ch 61	3	0	3	6	..	..
Colloid and Surface Chemistry.....	Ch 29	2	0	4	6	..	..
Direct Currents....	EE 2, 3	3	0	5	..	..	8
Alternating Currents	EE 4, 5	3	3	6	..	12	..
		3	3	6	..	..	12
<i>Mathematics Option:</i>							
Electives to total 24 units.							
Complex Variables	Ma 114	4	0	8	12	..	..
Modern Theory of Differ. Equations	Ma 116 ab	4	0	8	..	12	12
Modern Algebra...	Ma 123 abc	4	0	8	12	12	12
Differ. Geometry...	Ma 108 abc	4	0	8	12	12	12
<i>Astronomy Option:</i>							
Analytical Mech....	Ph 12 a b c	4	0	8	12	12	12
Astronomy.....	Ay 5 a b c	4	1	7	12	12	12
<i>Geology Option:</i>							
Field Geology.....	Ge 7 b	..	..	..	6	0	0
Structural Geology	Ge 9	..	..	..	..	..	10
Vertebrate Paleon..	Ge 12 a b	..	..	..	..	10	8
Invertebrate Paleon.	Ge 11 a b	..	..	..	10	8	..
Thesis.....	Ge 21, 22	..	..	..	4	4	8

Summer Geology required after Senior Year.

Biology Option:

Details to be arranged later.

Schedules of the Fifth-Year Courses

SUBJECTS COMMON TO ALL COURSES, ALL TERMS	NUMBER OF UNITS
Seminar in American History and Government.....	} 12
<i>or</i> English Literature.....	
<i>or</i> Philosophy.....	
Engineering or Research Seminars.....	2
Professional Subjects.....	39
	53

CIVIL ENGINEERING

PROFESSIONAL SUBJECTS	SUBJECT NUMBER	NUMBER OF UNITS		
		1st Term	2nd Term	3rd Term
Statically Indeterminate Structures.....	CE 23	15	..	..
Masonry Structures.....	CE 16	..	9	..
Machine Design.....	ME 9	9	..	..
Irrigation and Water Supply.....	CE 15	..	12	..
Structural and Civil Engineering Design.....	CE 21 a b c	9	9	12
Sewerage.....	CE 17	..	..	9
Research or Other Thesis.....		6	9	9
Accounting.....	Ec 17	..	..	9
		39	39	39
<i>Supplementary Professional Subjects</i>				
Water Power Plant Design.....	CE 101 a b	10	10	..
Arched Dams.....	CE 103 a b	5	5	..
Statically Indeterminate Structures.....	CE 105 b c	..	15	15
Geodesy and Precise Surveying.....	CE 107 a b c	6	6	6
Highway Problems.....	CE 108	..	..	..
Sewage Treatment Plant Design....	CE 110 b c	..	10	10
Sanitation Research.....	CE 112	..	..	..
Analysis of Earthquake Effects upon Structures.....	CE 114	..	..	..

FIFTH-YEAR COURSES

ELECTRICAL ENGINEERING

PROFESSIONAL SUBJECTS	SUBJECT NUMBER	NUMBER OF UNITS		
		1st Term	2nd Term	3rd Term
Alternating Current Analysis	EE 20	12	..	..
Advanced A. C. Machinery	EE 22	..	12	..
Transmission Lines	EE 44	..	..	12
Alternating Current Laboratory	EE 21 a b c	6	6	6
Specifications and Design	EE 48	6	..	..
Electric Transients	EE 60	..	6	..
Dielectrics	EE 52	..	..	6
Research or Thesis . . . . .	.....	9	9	9
Electives, as below . . . . .	.....	6	6	6
		39	39	39
<i>Electives:</i>				
Vacuum Tubes	EE 62 a b	..	6	6
Electric Traction	EE 28	6	..	..
Electrical Communication	EE 56	6	..	..
Light and Power Distribution	EE 30	..	..	6

MECHANICAL ENGINEERING

Power Plant Engineering	ME 121, 122	..	12	12
Thermodynamics	ME 120	12	..	..
Heat Engineering Laboratory	ME 130	15	..	..
Research or Thesis	ME 100	..	15	15
Elective as below . . . . .	.....	12	12	12
		39	39	39
<i>Electives:</i>				
Science of Metals	ME 111	..	12	..
Metallography	ME 110	12	..	..
Metals Research	ME 112	..	..	12
Machine Design	ME 101	12	..	..
Machine Design	ME 102, 103	..	12	12
Internal Combustion Engines	ME 135, 136	..	12	12

FIFTH-YEAR COURSES

AERONAUTICAL ENGINEERING

PROFESSIONAL SUBJECTS	SUBJECT NUMBER	NUMBER OF UNITS		
		1st Term	2nd Term	3rd Term
Aerodynamics of the Airplane.....	AE251abc	9	9	6
Elementary Airplane Design.....	AE252abc	11	15	20
Mathematical Analysis.....	Ma119	15	15	15
Aeronautical Power Plants.....	AE256	6	..	..
Aerodynamics.....	AE266	..	..	15
Research or Electives.....				
<i>Electives as follows:</i>				
Subjects of Four-Year Engineering or Science Course		12	12	12
Properties of Fluids and Elementary Hydrodynamics.....	AE265	..	9	..
Wind Channel.....	AE286abc	..	..	..
Advanced Thermodynamics.....	ME120	12	..	..
Calculus of Observations.....	Ma105	..	..	6

FIFTH-YEAR COURSES

PHYSICS OR INDUSTRIAL PHYSICS

SUBJECT	SUBJECT NUMBER	NUMBER OF UNITS		
		1st Term	2nd Term	3rd Term
<i>Electives as follows:</i>				
Kinetic Theory	Ph 110	..	..	12
Thermodynamics	Ph 111	12	..	..
Atomic Structure	Ph 114	9	..	..
Mathematical Physics	Ph 15 a b c	12	12	12
Optics	Ph 22 a b c	9	9	9
Optics Lab.	Ph 23 a b c	3	3	3
Vacuum Tubes	EE 62 a b	..	6	6
Mathematical Analysis	Ma 119 a b c	15	15	15
Research . . . . .	..	15	15	15

CHEMISTRY OR CHEMICAL ENGINEERING*

Electives from Four-Year Course in Science or Fifth-Year Course in Physics				
Other Electives as follows:				
Photochemistry	Ch 158	6	..	..
Quantum Theory Practicum .....	..	..	6	6
Chemical Reaction Rates	Ch 175	..	..	6
Crystal Structure	Ch 177 a b c	2	2	2
Organic Chemistry (special topics) ..	Ch 161 a b	..	6	6
Organic Chemical Analysis	Ch 162	6	..	..
Chemical Engineering*	Ch 166 a b c	12	12	12
Research .....	..	12-18	12-18	12-18

*Candidates for the 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 Chemical Engineering Option of the Four-Year Course in Science.

FIFTH-YEAR COURSES

GEOLOGY AND PALEONTOLOGY

PROFESSIONAL SUBJECTS	SUBJECT NUMBER	NUMBER OF UNITS		
		1st Term	2nd Term	3rd Term
<i>Electives as follows:</i>				
Economic Geology	Ge 195-196	..	10	10
Paleontology	Ge 187-188	10	10	10
Petrography	Ge 181 a b c	10	10	10
Geomorphology	Ge 186	10	..	..
Seismology	Ge 183	6	..	..
Seminar		5-10	5-10	5-10
Electives . . . . .	..	20	20	20
Research	Ge 187	12-18	12-18	12-18

MATHEMATICS

SUBJECT	SUBJECT NUMBER	NUMBER OF UNITS		
		1st Term	2nd Term	3rd Term
<i>Electives as follows:</i>				
Modern Algebra	Ma123 a b c	12	12	12
Differential Geometry	Ma108 a b c	12	12	12
Modern Geometry	Ma109 a b c	12	12	12
Relativity	Ma122	15	..	..
Analytic Mechanics	Ph 12 a b c	12	12	12
Electricity	Ph 8, 9	12	12	12
Research		6	6	6
Subjects in fifth-year Physics Course				

Division of Physics, Mathematics, and Electrical Engineering

PHYSICS

PROFESSORS: ROBERT A. MILLIKAN, HARRY BATEMAN, PAUL S. EPSTEIN,
RICHARD C. TOLMAN

ASSOCIATE PROFESSORS: IRA S. BOWEN, WILLIAM V. HOUSTON, EARNEST C.
WATSON, FRITZ ZWICKY

ASSISTANT PROFESSORS: SAMUEL S. MACKEOWN, J. ROBERT OPPENHEIMER,
WILLIAM R. SMYTHE

NATIONAL RESEARCH FELLOW: FRANCIS BITTER, FRANK W. CONSTANT

RESEARCH FELLOWS: CHARLES C. LAURITSEN, RICHARD M. SUTTON

TEACHING FELLOWS AND GRADUATE ASSISTANTS: CARL D. ANDERSON,
WARREN N. ARNQUIST, RAYMOND A. BEELER, JOHN S. CAMPBELL,
ROBLEY D. EVANS, MAURICE F. HASLER, ARCHER HOYT, LORENZ D.
HUFF, C. C. LASH, EDSON C. LEE, WALTER C. MICHELS, JAMES C.
MOUZON, H. VICTOR NEHER, ROBERT E. PUGH, JR., LYNN H. RUM-
BAUGH, EDWARD M. THORNDIKE, J. A. VAN DEN AKKER

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 trigonome-
try.

The first year of a general college course in physics extending through
two years. It is a thorough analytical course, in which the laboratory
carries the thread of the work, and the problem method is largely used.
A bi-weekly demonstration lecture, participated in by all members of
the department, adds the inspirational and informational element, and
serves for the development of breadth of view.

Text: Mechanics, Molecular Physics, and Heat, Millikan.

Instructors: Watson, Houston, Anderson, Arnquist, Evans, Rum-
baugh, Thorndike, Van den Akker.

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: Smythe, Sutton, Campbell, Constant, Hoyt, Lauritsen, Neher.

Ph. 2 d. PHYSICS REVIEW. 4 units; last three weeks of sophomore year.

The last three weeks of the sophomore year are devoted to a comprehensive review and examination covering the whole of the two years' work (Ph. 1 a, b, c, and 2 a, b, c).

Ph. 3. MODERN PHYSICS. 12 units (2-6-4); third term.

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

A brief survey of recent developments in electron theory, quantum theory, radioactivity, and atomic structure. Experiments to determine e , $\frac{e}{m}$, h , and other fundamental constants will be performed. Open only to students on honor standing, sophomore year.

Instructor: Bowen.

Ph. 7 a, b. ELECTRICITY AND MAGNETISM. 9 units (3-0-6); first and second terms.

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

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

Text: Electrodynamics for Engineers, Bennett and Crothers.

Instructor: Mackeown.

Ph. 8 a, b, c. ELECTRICITY AND MAGNETISM. 9 units (3-0-6); first, second and third terms.

Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; Ma. 8 a, b, c; Ma. 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. 9 a, b, c. ELECTRICAL MEASUREMENTS. 3 units (0-3-0).

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

A laboratory course in advanced electrical measurements.

Text: Mimeographed instructions.

Instructors: Smythe, Michels, Lash, Lee, Neher.

Ph. 12 a, b, c. ANALYTICAL MECHANICS. 12 units (4-0-8); first, second and third terms.

Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; Ma. 8 a, b, c; Ma. 10 a, b, c.

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

Texts: Statics, Lamb; Dynamics, Lamb; Higher Mechanics, Lamb.

Instructor: Zwicky.

FIFTH-YEAR SUBJECTS

Ph. 15 a, b, c. INTRODUCTION TO MATHEMATICAL PHYSICS. 12 units (4-0-8); first, second and third terms.

Prerequisites: Ph. 1 a, b, c, 2 a, b, c, d; ~~Ma. 8 a, b, c; Ma. 10 a, b, c.~~ *Mathematical Physics*

An introduction to the application of mathematics to physics and chemistry, and practice in the solution of problems.

Text: ~~Introduction to Theoretical Physics, Page.~~

Instructor: Houston.

Ph. 22 a, b, c. OPTICS. 9 units (3-0-6); first, second and third terms.

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

Lecture and class work dealing with the fundamental equations of geometrical optics, of diffraction, interference, spectroscopy, etc., and their experimental verification. Ph. 23 a, b, c (Optics Laboratory), should accompany this course.

Text: Theory of Optics, Drude.

Instructor: Bowen.

Ph. 23 a, b, c. Optics Laboratory. 3 units (0-3-0); first, second and third terms.

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

Text: Manual of Advanced Optics, Taylor.

Instructors: Bowen and Mouzon.

Ph. 110. KINETIC THEORY. 12 units; third term.

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

Presents the modern aspects of the kinetic theory of gases, liquids

and solids largely from the experimental point of view, covering in gases the Clausius equations, Maxwell distribution law, viscosities, specific heats, mean free paths, molecular magnitudes, etc.; in liquids, critical states, Brownian movements, diffusion, osmotic pressure; in solids, the interpretation of specific heats.

Instructor: Bitter.

Ph. 111. THERMODYNAMICS. 12 units; first term.

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

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

Instructor: Epstein.

Ph. 114. ATOMIC STRUCTURE. 9 units; first term.

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

A general presentation of the developments of the past fifteen years in the field of atomic structure, including photo-electric, isotopic, spectroscopic, field current, and cosmic-ray effects and their interpretation.

Instructors: Millikan and Bowen.

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

ADVANCED SUBJECTS

Ph. 121. POTENTIAL THEORY. 15 units; third term.

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

An exposition of the properties of the potential functions occurring in the theories of gravitation, electricity and magnetism, hydrodynamics, conduction of heat, and the theory of elasticity. Solution of special problems.

(Not given in 1929-1930.)

Instructor: Bateman.

Ph. 122. THEORY OF ELECTRICITY AND MAGNETISM. 12 units; first term.

Prerequisites: Ph. 8 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 1929-1930.)

Instructor: Epstein.

Ph. 123. THEORY OF ELECTROMAGNETIC WAVES. 12 units; second term.

Prerequisites: Ph. 8 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 1929-1930.)

Instructor: Epstein.

Ph. 125. HIGHER DYNAMICS. 12 units; third term.

Prerequisites: Ph. 12 a, b, c, 15 a, b, c; Ma. 8 a, b, c, 10 a, b, c.

Methods of solution of the Hamiltonian equations, conditionally periodic motions, contact transformations, introduction to the theory of perturbations, applications to special cases of interest in atomic theory and the theory of quanta.

(Not given in 1929-1930.)

Instructor: Epstein.

Ph. 126. HEAT RADIATION AND QUANTUM THEORY. 12 units; second term.

Prerequisites: Ph. 8, a, b, c, 12 a, b, c, 111; Ma. 8 a, b, 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. 127. PHYSICAL OPTICS AND QUANTUM THEORY OF SPECTRAL LINES. 12 units; third term.

Prerequisites: Ph. 12 a, b, c, 22 a, b, c; Ma. 8 a, b, c, 10 a, b, c.

Treatment of dispersion and optical activity on the basis of the classical theory. Rutherford's atom model and the application of the quantum theory to it. Action of magnetic and electric fields on the emission of spectral lines. X-ray spectra and the structure of atoms.

(Not given in 1929-1930.)

Instructor: Epstein.

Ph. 128. MODERN ASPECTS OF THE QUANTUM THEORY. 12 units; third term.

Prerequisites: Ph. 12 a, b, c, 15 a, b, c, 126, 127; Ma. 8 a, b, c, 10 a, b, c.

Principle of correspondence, Heisenberg's form of it, Born and Jordan's matrix calculus, Schroedinger's wave equations, Weyl's theory, applications to spectroscopic problems.

Instructor: Epstein.

Ph. 130. **HYDRODYNAMICS.** 30 units; first term.

Prerequisites: Ma. 114.

Mathematical theories of sustenance and resistance. Waves and tides. Vortex motion and turbulence. Motion of a viscous fluid. Rotating masses of fluid.

(Not given in 1929-1930.)

Text: Lamb, *Hydrodynamics*.

Instructor: Bateman.

Ph. 131. **THEORY OF ELASTICITY.** 30 units; first term.

Stresses in beams, bars, struts, springs, plates, tubes, and shells from the standpoint of the mathematical theory of elasticity. Theories of plasticity and failure. Strength of crystals. Waves in elastic solids. Earthquake waves.

(Not given in 1929-1930.)

Texts: Love, *Mathematical Theory of Elasticity*; Jeffery, *The Earth*; J. Prescott, *Applied Elasticity*.

Instructor: Bateman.

Ph. 132. **AEROLOGY AND METEOROLOGY.** 15 units; one term.

Variation with altitude of pressure, wind velocity, temperature, and humidity. General circulation of the atmosphere. Prevailing winds. World's air routes. Studies relating to clouds, fogs, thunderstorms, evaporation, and atmospheric eddies. Atmospheric electricity, visibility.

(Not given in 1929-1930.)

Text: Shaw, *Forecasting Weather*; Gregg, *Aeronautical Meteorology*; Humphreys, *Physics of the Air*.

Instructor: Bateman.

Ph. 134 a, b. **QUANTUM THEORY.** 9 units (3-0-6); second and third terms.

Prerequisites: Ph. 12 a, b, c, 15 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. 136 a, b. INTRODUCTION TO THE THEORY OF RELATIVITY. 6 units; first and second terms.

The special theory of the relativity of motion in free space, with applications to mechanical and electromagnetic problems. Use of four dimensional language for expressing the results of relativity. Introduction to tensor analysis. The general theory of relativity and the theory of gravitation.

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

(Not given in 1929-1930.)

Instructor: Tolman.

Ph. 138. SEMINAR IN THEORETICAL PHYSICS. 4 units; first, second and third terms.

Recent development of the theory of quanta for specialists in mathematical physics.

Instructors: Epstein, Bateman, Houston, Oppenheimer, Zwicky.

Ph. 141. RESEARCH CONFERENCES IN PHYSICS. 4 units; first, second and third terms.

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

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

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

ASTRONOMY AND PHYSICS CLUB.

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

MATHEMATICS

PROFESSORS: HARRY BATEMAN, ERIC T. BELL, HARRY C. VAN BUSKIRK

ASSOCIATE PROFESSORS: ARISTOTLE D. MICHAL, LUTHER E. WEAR

ASSISTANT PROFESSORS: MORGAN WARD, CLYDE WOLFE

INSTRUCTOR: WILLIAM N. BIRCHBY

RESEARCH FELLOWS: MIGUEL A. BASOCO, JOHN D. ELDER

TEACHING FELLOWS AND ASSISTANTS: J. LAWRENCE BOTSFORD, LAWRENCE S. KENNISON, ROBERT S. MARTIN, STEPHEN O. RICE

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

UNDERGRADUATE SUBJECTS

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

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

Text: Analytical Geometry, Hardings and Mullins; Differential and Integral Calculus, Cohen.

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

Prerequisite: Ma. 1 a, b, c.

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

Text: Analytic Geometry, Ford; Differential and Integral Calculus, Cohen.

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

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

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

Ma. 3. THEORY OF EQUATIONS. 12 units (4-0-8); third term.

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

Instructor: Wear.

Ma. 4 a, b. ANALYTIC GEOMETRY. 12 units (4-0-8); second and third terms.

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

Instructor: Wear.

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

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

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

Text: Advanced Calculus, Woods.

Instructors: Birchby, Basoco.

Ma. 10 a, b, c. DIFFERENTIAL EQUATIONS. 9 units (3-0-6); first, second and third terms.

Prerequisite: Ma. 8 a, b, c, or to be taken concurrently with Ma. 8 a, b, c.

An introductory course in differential equations, designed to be helpful both to the student of mathematics and the student of science or engineering.

Texts: Differential Equations, Piaggio, Woods.

Ma. 11. DIFFERENTIAL EQUATIONS. 12 units (4-0-8); third term.

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

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

Texts: Differential Equations, Piaggio.

Instructor: Birchby.

Ma. 12. PROBABILITY AND LEAST SQUARES. 5 units (2-0-3); third term.

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

A study of the fundamental principles of probability and their 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.

Text: Weatherburn's Vector Analysis.

UNDERGRADUATE OR GRADUATE SUBJECTS

Ma. 108 a, b, c. DIFFERENTIAL GEOMETRY. 12 units; first, second and third terms.

Prerequisites: Ma. 8 a, b, c, 10 a, b, c.

In this course geometrical ideas gained in previous courses will be extended, and the methods of the calculus applied to twisted curves and surfaces.

Instructor: Wear.

Ma. 109 a, b, c. ALGEBRAIC GEOMETRY. 12 units; first, second, and third terms.

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

A course in the modern methods of analytic geometry.

(Not given in 1929-1930.)

Instructor: Wear.

Ma. 112 a, b, c. THEORY OF REAL VARIABLES. 12 units; first, second, and third terms.

Real number system, theory of point sets and classes, continuity of functions, derivatives, Riemann integration, Lebesgue integration, infinite series, implicit functions, Fourier series.

(Not given in 1929-1930.)

Instructor: Ward.

Ma. 114. COMPLEX VARIABLE. 12 units; first term.

Prerequisites: Ma. 8 a, b, c, 10 a, b, c.

Real and complex numbers, limits, convergence and continuity, Riemannian integration. Properties of analytic functions, Cauchy's theory of residues. Conformal representation, elementary Riemann surfaces, multiform functions.

Texts: Whittaker and Watson, Modern Analysis; Ince, Ordinary Differential Equations.

Instructor: Ward.

Ma. 116 a, b. MODERN THEORY OF DIFFERENTIAL EQUATIONS. 12 units; second and third terms.

Prerequisites: Ma. 114, or equivalent.

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

Texts: Whittaker and Watson, Modern Analysis; Ince, Ordinary Differential Equations.

Instructor: Ward.

Ma. 118 a, b, c. PARTIAL DIFFERENTIAL EQUATIONS AND TENSOR ANALYSIS. 12 units; first, second, and third terms.

Prerequisite: Ma. 8 a, b, c, 10 a, b, c.

An introductory course in the calculus of tensors and the classical theory of partial differential equations of the first order from the tensor standpoint. The topics treated will include Cauchy problems, complete systems of partial differential equations, Pfaffian systems, invariants of quadratic differential forms, Riemannian differential geometries, elementary Lie theory of continuous groups, calculus of variations, dynamical systems and their integral invariants.

Instructor: Michal.

Ma. 123 a, b, c. MODERN ALGEBRA. 12 units; first, second and third terms.

Prerequisite: Ma. 8.

Introductions to algebraic invariants, matrices and bilinear forms, substitution groups and their simpler applications.

(Not given in 1929-1930.)

Instructor: Bell.

ADVANCED SUBJECTS

Ma. 101. VECTOR ANALYSIS. 15 units; second term.

In this course the fundamental operations of vector analysis are developed, using the notation of Gibbs, and the use of the analysis is illustrated by means of examples in mechanics and other branches of mathematical physics. Complex quantities are also represented by vectors and geometrical applications are indicated.

(Not given in 1929-1930.)

Instructor: Bateman.

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

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

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

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

Instructor: Wolfe.

Ma. 105. CALCULUS OF OBSERVATIONS. 6 units; one term.

Prerequisites: Ma. 8 a, b, c, 10 a, b, c, 12.

Methods of determining the roots of algebraic and transcendental equations. Method of least squares. Law of error and theory of graduation of data. Statistics. Periodogram analysis. Numerical solution of differential equations.

(Not given in 1929-1930.)

Text: Whittaker, Calculus of Observations.

Instructors: Bateman, Wolfe.

Ma. 112. INTEGRAL EQUATIONS. 9 units; third term.

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

In this course the linear integral equations of the first and second kinds are discussed and the solutions of Abel, Fourier and Fredholm are applied to various physical problems.

(Not given in 1929-1930.)

Instructor: Bateman.

Ma. 113. GEOMETRICAL TRANSFORMATIONS AND INVARIANTS. 15 units; third term.

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

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

Instructor: Bateman.

Ma. 118 a, b, c. INFINITE SERIES. 15 units; first, second and third terms.

Prerequisites: Ma. 8 a, b, c, 10 a, b, c.

Uniform convergence, integration of series, methods of summation and expansion, use and applications of complex variable, elliptic functions.

Instructor: Bell.

Ma. 119 a, b, c. MATHEMATICAL ANALYSIS. 15 units; first, second and third terms.

Prerequisites: Ma. 8 a, b, c, 10 a, b, c.

Fourier series and integrals, functions of Legendre, Bessel; the fundamental equations of mathematical physics; functions of a complex variable. Numerous applications to physical problems; tensor analysis.

Texts: Byerly's Fourier Series and Spherical Harmonics; Curtis, Complex Variable; MacRobert, Functions of a Complex Variable; Edington, Mathematical Theory of Relativity; assigned readings.

Instructor: Bell.

Ma. 120. MODERN ANALYSIS. 15 units; first, second, and third terms.

Prerequisites: Ma. 8 a, b, c, 10 a, b, c.

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.

Text: Whittaker and Watson, Modern Analysis.

Instructor: Bateman.

Ma. 121 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, partial differential equations of the second order; differentials of functionals, functional equations with functional derivatives; infinite matrices.

(Not given in 1929-1930.)

Instructor: Michal.

Ma. 122. RELATIVITY. 15 units; third term.

Prerequisites: Ma. 8, 10; Ph. 1, 2.

Tensor analysis; the general theory of relativity and gravitation.

Instructor: Bell.

Ma. 140 a. SEMINAR (I) IN ALGEBRA AND THE THEORY OF NUMBERS. 9 units; third term.

Prerequisites: Graduate standing.

The Dedekind theory of algebraic numbers, Kronecker's theory of

modular systems with applications to algebraic functions; comparison of recent theories of algebraic numbers.

(Not given in 1929-1930.)

Instructor: Bell.

Ma. 140 b. SEMINAR (II) IN ALGEBRA AND THE THEORY OF NUMBERS. 9 units, third term.

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

Applications of algebra and special functions to the theory of numbers.

Instructor: Bell.

Ma. 141 a, b, c. SEMINAR IN ELLIPTIC FUNCTIONS AND ANALYSIS. 6 units; first, second and third terms.

Prerequisite: Graduate standing in Mathematics, including a course in Complex Variable.

The theories of Jacobi, Hermite, and Weierstrass will be developed and applied, particularly to algebra and the theory of numbers.

(Not given in 1929-1930.)

Instructor: Bell.

Ma. 145 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. 146 a, b, c. SEMINAR IN FUNCTIONALS AND FUNCTIONAL EQUATIONS. 10 units; first, second, and third terms.

Prerequisite: Graduate standing in Mathematics.

Selected topics in the theory of differential and integral equations. Differential and integral invariants. Algebra and analysis of functionals. Tensor analysis and its generalizations to function space.

Instructor: Michal.

One or two of courses Ma. 118, 121, 145, 146, will be given according to demand.

ELECTRICAL ENGINEERING

PROFESSOR: ROYAL W. SORENSEN

ASSISTANT PROFESSOR: SAMUEL S. MACKEOWN

INSTRUCTOR: FRANCIS W. MAXSTADT

ASSISTANTS: RAYMOND AGER, ANDREW V. HAEFF, VAINO A. HOOVER,
CHARLES C. LASH, KARL M. WOLFE

UNDERGRADUATE SUBJECTS

EE. 2. DIRECT CURRENTS. 7 units (3-0-4); first or second terms.

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

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

Text: Elements of Electrical Engineering, Cook.

Instructors: Maxstadt, Ager, Hoover.

EE. 3. DIRECT CURRENT LABORATORY. 5 units (0-3-2); first or second terms.

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

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

Text: Laboratory notes.

Instructors: Maxstadt, Lash, Wolfe.

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

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

Elementary study of alternating currents by analytical and graphical methods; 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: Elements of Electrical Engineering, Cook.

Instructors: Maxstadt, Ager, Hoover.

EE. 5. ALTERNATING CURRENT LABORATORY. 5 units (0-3-2); second or third terms.

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

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

Text: Laboratory Notes.

Instructors: Maxstadt, Lash, Wolfe.

EE. 6 a, b. ELECTRICAL MACHINERY. 6 units (2-0-4); first and second 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: Maxstadt.

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, Lash, Wolfe.

EE. 30. ELECTRIC LIGHTING AND POWER DISTRIBUTION. 6 units (2-0-4); third term.

Prerequisites: EE. 2, 4, 6.

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

Text: Electric Power Equipment, Tarboux.

Instructor: Ager.

EE. 56. ELECTRICAL COMMUNICATION. 6 units (2-0-4); first term.

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

A study of the elements of telephone, telegraph and signalling devices.

Instructor: Mackeown.

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

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

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

Instructors: Sorensen, Mackeown, Maxstadt.

FIFTH-YEAR SUBJECTS

EE. 20. ALTERNATING CURRENT ANALYSIS. 12 units (5-0-7); first term.

Prerequisites: EE. 7 and preceding courses.

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

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

Instructor: Sorensen.

EE. 21 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.

Instructors: Maxstadt, Haeff.

EE. 22. ADVANCED ALTERNATING CURRENT MACHINERY. 12 units (5-0-7); second term.

Prerequisites: EE. 20 and preceding courses.

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. 28. ELECTRIC TRACTION. 6 units (2-0-4); first term.

Prerequisites: EE. 2, 4, 6.

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

Text: Electric Traction and Transmission Engineering, Sheldon and Hausman.

Instructor: Maxstadt.

EE. 44. TRANSMISSION LINES. 12 units (4-0-8); third term.

Prerequisites: EE. 22 and preceding courses.

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

Instructor: Sorensen.

EE. 48. SPECIFICATIONS AND DESIGN OF ELECTRICAL MACHINERY. 6 units (4-0-2); first term.

Prerequisites: EE. 7 and preceding courses.

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

Text: Electrical Machine Design, Gray.

Instructor: Sorensen.

EE. 52. DIELECTRICS. 6 units (2-0-4); third term.

Prerequisites: EE. 22 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, Maxstadt.

EE. 60. ELECTRIC TRANSIENTS. 6 units (2-0-4); second term.

Prerequisites: EE. 20 and preceding courses.

A detailed study of circuits, including advanced work in wave propagation and transient phenomena in electric conductors; oscillographic study of transients in simple inductances and capacities.

Text: Electric Transients, Magnusson.

Instructor: Mackeown.

EE. 62 a, b. VACUUM TUBES. 6 units (2-0-4); second and third terms.

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.

ADVANCED SUBJECTS

STUDY AND RESEARCH IN ELECTRICAL ENGINEERING

The science of electrical engineering has, due to advances in physics and its applications, reached a status such as to demand electrical engineers qualified to conduct researches involving a knowledge of mathematics, physics, and electrical engineering far in excess of that obtainable in an undergraduate engineering course. To meet this need the Institute has provided courses of graduate study and research in electrical engineering which may be taken by students who have completed the five-year engineering course at the Institute, or by students from other colleges who have substantially the same preparation.

Students desiring to become research men, college teachers or professional experts in electrical engineering will naturally continue their work at least two years more for the degree of Doctor of Philosophy.

This graduate school of electrical engineering greatly strengthens the undergraduate courses by bringing students, who feel the five and four-year courses are best adapted to their needs, in close touch with research men and problems, and by providing special work for undergraduate students wishing to do a limited amount of research work.

EE. 200. ADVANCED WORK IN ELECTRICAL ENGINEERING.

Special problems relating to electrical engineering will be arranged to meet the needs of students wishing to do advanced work in the field of electricity. The Institute is equipped to an unusual degree for the following lines of work: Theory of Electrical Machine Design, Electric Transients, and High Voltage Engineering Problems, under the direction of Professor R. W. Sorensen; Electrical Engineering Problems using vacuum tubes under the direction of Professor S. S. Mackeown; Electrical Engineering Problems relating to the distribution and uses of electric power for lighting and industrial uses under the direction of Mr. F. W. Maxstadt.

EE. 220. SEMINAR ON TECHNICAL HIGH VOLTAGE PROBLEMS. Units to be based on work done; first, second and third terms.

A study of the literature of high voltage phenomena, and insulation problems.

Instructor: Sorensen.

EE. 221 a, b. TRANSMISSION LINE PROBLEMS. 15 units.

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

Instructor: Sorensen.

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

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

Instructor: Sorensen.

EE. 224 a, b, c. VACUUM TUBE AND RADIO FREQUENCY CIRCUITS.

Units to be based on work done; first, second and third terms.

A study of the literature on vacuum tube circuits. Experimental work with oscillators, transmitters, and receivers.

Instructor: Mackeown.

EE. 225. PRINCIPLES OF ELECTRICAL DESIGN. 15 units.

A discussion and calculation course in the analysis of the principles and methods used in the design of electrical machinery.

Instructors: Sorensen, Maxstadt.

Division of Chemistry and Chemical Engineering

CHEMISTRY

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

ASSOCIATE PROFESSORS: ROSCOE G. DICKINSON, WILLIAM N. LACEY, HOWARD J. LUCAS, LINUS C. PAULING

ASSISTANT PROFESSORS: RICHARD McLEAN BADGER, ARNOLD O. BECKMAN, ERNEST H. SWIFT, DON M. YOST

RESEARCH FELLOWS: LOUIS S. KASSELL, JOSEPH B. KOEPFLI, HERMAN C. RAMPSBERGER

TEACHING FELLOWS AND GRADUATE ASSISTANTS: LEE R. BRANTLEY, PHILIP D. BRASS, FRED J. EWING, JAMES L. HOARD, RALPH HULTGREN, CECIL E. P. JEFFREYS, JOHN A. LEERMAKERS, WILLIAM B. LEWIS, DANIEL McRAE, PHILIP G. MURDOCK, S. FREDERICH RAVITZ, MAPLE D. SHAPPELL, JACK SHERMAN, JAMES H. STURDIVANT, GUY WADDINGTON, SIDNEY WEINBAUM, HOMER B. WELLMAN, RALPH R. WENNER

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; in the second term with qualitative analysis; and in the third term with equilibria in gaseous systems and with the chemistry of solids and gases.

Texts: A. A. Noyes, Introduction to the Chemistry of Solutions; A. A. Noyes, Qualitative Analysis.

Instructors: Bell, Beckman, and Teaching Fellows.

Ch. 6. ENGINEERING CHEMISTRY. 10 units (4-0-6); first, second or third term.

Prerequisite: Ch. 1 a, b, c.

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

Text: Leighou, Chemistry of Engineering Materials.

Instructor: Lacey.

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

Prerequisite: Ch. 1 c.

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

Text: Treadwell-Hall, Quantitative Analysis.

Instructor: Swift.

Ch. 12 c. QUANTITATIVE ANALYSIS. 10 units (2-6-2), third term.

Prerequisite: Ch. 12 b.

A study of special methods in chemical analysis. These will include electrolytic and electrometric determinations and the analysis of selected alloys and minerals. The principles involved in the laboratory work will be emphasized by conferences and problems.

Text: Treadwell-Hall, Quantitative Analysis.

Instructor: Swift.

Ch. 13 a, b. INORGANIC CHEMISTRY. 4 units; first and second terms.

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. INORGANIC CHEMISTRY LABORATORY. 9 units; first and second terms.

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. (1929-30, 10 units, 0-6-4.)

Prerequisite: Ch. 12 b.

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

Text: Lacey, Instrumental Methods of Chemical Analysis.

Instructor: Lacey.

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

Prerequisites: Ch. 12 b; Ph. 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.

For certain groups of students this course may be given as 2-0-4-6 in the second term, in order that they may take the laboratory course Ch. 26 a.

Text: Noyes and Sherrill, Chemical Principles.

Instructors: Bates, Dickinson.

Ch. 22, a, b. **THERMODYNAMIC CHEMISTRY.** 6 units (3-0-3) first term; second and third terms.

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

Text: Noyes and Sherrill, Chemical Principles, and mimeographed notes.

Instructor: Bates.

Ch. 26 a, b, c. **PHYSICAL CHEMISTRY LABORATORY.** 4 units (0-3-1); second and third terms.

Laboratory exercises to accompany Ch. 21.

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

Instructor: Bates.

Ch. 29. **COLLOID AND SURFACE CHEMISTRY.** 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: 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.

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: Norris, The Principles of Organic Chemistry.

Instructor: Lucas.

Ch. 43. ORGANIC CHEMISTRY. 10 units (2-6-2); third term.

Prerequisites: Ch. 1 a, b, c.

Lectures and recitations, accompanied by laboratory exercises, dealing with the more important compounds of carbon and with the structural theory from the electron point of view.

Text: Moore, Outlines of Organic Chemistry.

Instructor: Lucas.

Ch. 46 a, b. ORGANIC CHEMISTRY LABORATORY. 9 units (0-9-0); first and second terms.

Prerequisite: Ch. 12.

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

Text: Adams and Johnson, Experiments in Organic Chemistry.

Instructor: Lucas.

Ch. 61. INDUSTRIAL CHEMISTRY. 6 units (2-0-4); second and third terms. (1930-1931, third and first terms.)

Prerequisites: Ch. 21 a, b, c.

A study of the more important industrial chemical processes, from the point of view not only of the chemical reactions, but of the conditions and equipment necessary to carry on these reactions.

Text: Badger and Baker, Inorganic Chemical Technology.

Instructor: Lacey.

Ch. 69. FOREIGN SCIENCE JOURNALS. 6 units (2-0-4); third term.

This subject consists in readings and reports by the students on researches published in recent German and French chemical journals. It has the double object of giving practice in the reading of scientific German and French and of affording an acquaintance with important lines of research in progress.

Ch. 70-73. CHEMICAL RESEARCH.

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

FIFTH-YEAR AND ADVANCED SUBJECTS**Ch. 152. SURFACE AND COLLOID CHEMISTRY. 8 units; third term.**

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

Text: Mimeographed Notes.

Instructor: Badger.

Ch. 153 a, b. THERMODYNAMIC CHEMISTRY. 9 units; first and second terms.

This course is the same as Ch. 22 a, b. See page 174.

Text: Chemical Principles, Noyes and Sherrill, and mimeographed notes.

Instructor: Bates.

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

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

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

(Not given in 1929-1930.)

Instructors: Tolman, Dickinson, Yost.

Ch. 156 a, b. INTRODUCTION TO WAVE MECHANICS, WITH CHEMICAL APPLICATIONS. 6 units; first and second terms.

After a discussion of the development and significance of the new quantum mechanics, the wave equation of Schrödinger is used in the treatment of the oscillator, rotator, and hydrogen atom. The perturbation theory and the theory of the Heisenberg-Dirac resonance phenomenon are then developed and applied to various problems, including the Stark effect, helium atom, hydrogen molecule ion, hydrogen molecule, forces in the hydrogen halides, Van der Waals' forces in helium, the scattering of X-rays by bound electrons, and the shared electron pair bond.

(Not given in 1929-1930.)

Instructor: Pauling.

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

The subject treats the methods of determining the structures of crystals with X-rays; the various structures occurring in nature, and their relation to the phenomena of isomorphism, solid solution formation, cleavage, etc.; ionic and atomic sizes and their bearing on the chemical properties of substances; interatomic forces in crystals; the crystal energy and its use in chemical thermodynamics, and related topics.

(Not given in 1929-1930.)

Instructor: Pauling.

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

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

(Not given in 1929-1930.)

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, Swift.

Ch. 161 a, b. ORGANIC CHEMISTRY (Special Topics). 6 units; second and third terms.

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

Instructor: Lucas.

Ch. 162. ORGANIC CHEMICAL ANALYSIS. 6 units; first term.

A laboratory study of the class reactions of carbon compounds and practice in the methods of identifying unknown substances, followed by the quantitative determination of the elements through combustion analysis.

Instructor: Lucas.

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

Prerequisites: Ch. 61; ME. 15.

Problems and discussions designed to bring the student in touch with the problems involved in efficiently carrying out chemical reactions on a commercial scale. The basic operations of chemical industry (such as 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. 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.

Rates of chemical reactions in relation to the quantum theory.

Crystal structure determined by X-ray methods.

The determination of the distribution of electrons in crystals.

Catalytic mechanism of homogeneous reactions.

Chemical reactions produced by atoms excited by radiations.

Activation of atoms and molecules by electron impact.
Band spectra in their chemical relations.
Relation between the chemical properties and the electron structures of carbon compounds.
Isomerism in the ethylene series.
Substitution in the benzene series.
Rates of absorption of gases by liquids.
Flow of liquids through porous solid masses.
Drying of wood.
Conduction of heat by liquids.

For a fuller survey of the researches in progress, see Publications of the Gates Chemical Laboratory, pages 130-133.

Ch. 174. RESEARCH CONFERENCE IN ORGANIC CHEMISTRY. 2 units.

Weekly reports on recent researches in organic chemistry, including those in progress in the Gates Chemical Laboratory.

Instructors: Lucas, Alles, Koepfli.

Ch. 175. CHEMICAL APPLICATIONS OF SPECTRAL DATA (Seminar). 6 units; first, second and third terms.

A phenomenological discussion of atomic and molecular spectra, including pure rotation and oscillation-rotation spectra, Raman spectra, and molecular spectra involving electronic transitions, followed by their interpretation with the aid of the quantum mechanics and the vector model of the atom and molecule. Especial emphasis is laid on the applications of spectral data to chemical problems, such as: ionization potentials and ion-formation; the determination of heats of dissociation of molecules and of heat capacity and entropy values of gases from molecular spectra; dissociation through rotation; predissociation spectra; isotope effect in molecular spectra; symmetric and antisymmetric molecules; molecules of transitory existence.

Texts: Condon and Morse, "Quantum Mechanics"; Pauling and Goudsmit, "The Structure of Line Spectra."

Instructors: Tolman, Dickinson, Pauling, Badger.

Ch. 176. PHOTOCHEMISTRY (Seminar). 2 units; first, second and third terms.

Reports on selected topics and recent researches in photochemistry and related subjects are presented by those attending the seminar.

Instructors: Dickinson, Beckman.

Ch. 177. CRYSTAL STRUCTURE AND MOLECULAR STRUCTURE (Seminar).
2 units; first, second and third terms.

Reports on recent researches dealing with the structure of crystals and molecules are presented by those taking part in the seminar.

Instructor: Pauling.

Ch. 178. RESEARCH CONFERENCES IN PHYSICAL AND INORGANIC CHEMISTRY. 2 units; first, second and third terms.

This subject consists of reports on the researches in progress in the laboratory and on others which have appeared recently in the literature. These conferences are participated in by all men engaged in research in the laboratory.

Instructors: Noyes, Tolman, Dickinson

Division of Civil and Mechanical Engineering*

CIVIL ENGINEERING

PROFESSOR: FRANKLIN THOMAS

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

INSTRUCTOR: FRED J. CONVERSE

TEACHING FELLOWS AND ASSISTANTS: J. H. A. BRAHTZ, WILLIAM H. MOHR, SAMUEL OLMAN

UNDERGRADUATE SUBJECTS

CE. 1. SURVEYING. 10 units (3-4-3); first, second or third term.

A study of the elementary operations employed in making surveys for engineering work, including the use, care, and adjustment of instruments, linear measurements, angle measurements, note keeping, stadia surveys, calculation and balancing of traverses, topographic mapping and field methods.

Text: Surveying, Davis, Foote, and Rayner.

Instructor: Michael.

CE. 2. ADVANCED SURVEYING. 12 units (3-6-3); first term.

Prerequisite: CE. 1.

A continuation of CE. 1, covering topographic surveys, plane table surveys, base line measurements, triangulation, determination of latitude and a true meridian by sun and circumpolar star observations, curves, cross-section surveys and earthwork estimates, stream gauging, draughting room methods and mapping, and the solution of problems.

Text: Surveying, Davis, Foote, and Rayner.

Instructor: Michael.

CE. 3. PLANE TABLE SURVEYING. 8 units (1-6-1); third term.

A course offered primarily for students in geology but may be elected by arrangement with the department. Theory and use of the plane table as applied to geological surveys. The class devotes one entire day a week to field surveys over typical terrain completing a topographic map of the region covered.

Text: Surveying, Davis, Foote, and Rayner.

Instructor: Michael.

*See Division of Physics, Mathematics and Electrical Engineering pages 166-173, for subjects in Electrical Engineering.

CE. 4. HIGHWAY ENGINEERING. 6 units (3-0-3); third term.

Prerequisite: CE. 1.

A comparison of various types of highway construction; the design, construction and maintenance of roads and pavements; methods of road improvement; financing, contracts and specifications.

Text: Construction of Roads and Pavements, Agg.

Instructor: Michael.

CE. 8 a. RAILWAY ENGINEERING. 6 units (3-0-3); first term.

Prerequisites: CE. 1, 2.

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

Text: Elements of Railroad Engineering, Raymond.

Instructors: Thomas, Michael.

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

Prerequisites: CE. 1, 2.

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

Text: Railway Curves and Earthwork, Allen.

Instructor: Michael.

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

Prerequisite: CE. 8 b.

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

Text: Railway Curves and Earthwork, Allen.

Instructor: Michael.

CE. 9. ELEMENTS OF STRUCTURES. 12 units (3-3-6); second term for 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, Martel, Converse.

CE. 10 a. THEORY OF STRUCTURES. 12 units (3-3-6); first term.

Prerequisites: AM. 1 c.

Methods used in the calculation of stresses in and proportioning of beams, girders, and columns of timber, steel and concrete; study of the effects of moving load systems; graphic statics applied to roofs and bridges.

Text: Theory of Structures, Spofford.

Instructors: Thomas, Martel.

CE. 10 b, c. THEORY OF STRUCTURES. 12 units (3-3-6), second and third terms.

Prerequisite: CE. 10 a.

A continuation of CE. 10 a, covering the computation of stresses in truss members, the design of structural parts, connections, portals, and bracing; a study of arch, cantilever, and continuous bridges; and deflection of trusses.

Text: Theory of Structures, Spofford.

Instructors: Thomas, Martel.

CE. 11 a, b. STRUCTURES. 9 units (2-3-4), second and third terms.

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.

Instructors: Thomas, Martel.

CE. 12. REINFORCED CONCRETE. 6 units (2-0-4); third term.

Prerequisites: AM. 1 c; CE. 10 a.

The theory of reinforced concrete design, with a study of the applications of this type of construction to various engineering structures.

Text: Reinforced Concrete Construction, Vol. I, Hool.

Instructor: Martel.

CE. 14 a, b, c. ENGINEERING CONFERENCES. 2 units (1-0-1); first, second and third terms.

Conferences participated in by faculty and seniors of the Civil Engineering department. The discussions cover current developments and advancements within the field of civil engineering and related sciences.

FIFTH-YEAR SUBJECTS

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

Prerequisite: Hy. 1.

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

Text: Principles of Engineering Irrigation, Newell and Murphy.

Instructor: Thomas.

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

Prerequisite: CE. 12.

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

Text: Masonry Structures, Spalding, Hyde and Robinson.

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 Eddy.

Instructor: Martel.

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

Prerequisites: CE. 10 a, b, c.

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

Instructors: Thomas, Martel.

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

Prerequisites: CE. 10 a, 12.

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

Instructors: Thomas, Martel.

CE. 21 c. CIVIL ENGINEERING DESIGN. 12 units (0-12-0); third term.

Prerequisites: CE. 15, 21.

Special problems including preliminary investigations of irrigation or water power projects; study of stream flow data, the effect of reservoir

storage upon distributed flow, determination of size and type of economic development.

Instructors: Thomas, Martel.

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

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

Text: *Statically Indeterminate Stresses*, Parcell and Maney.

Instructor: Martel.

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

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

ADVANCED SUBJECTS

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

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

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

Instructor: Thomas.

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

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

Instructor: Martel.

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

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

Text: *Statically Indeterminate Stresses*, Parcell and Maney.

Instructor: Martel.

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

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

Instructor: Michael.

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

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

Instructor: Michael.

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

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

Instructors: Thomas, Martel.

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

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

Instructors: Thomas, Martel.

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

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

Instructors: Thomas, Martel.

MECHANICAL ENGINEERING

PROFESSORS: ROBERT L. DAUGHERTY, W. HOWARD CLAPP

INSTRUCTOR: HOWARD B. HOLROYD

TEACHING FELLOWS AND ASSISTANTS: DONALD S. CLARK, RICHARD G. FOLSOM, ERNEST B. HUGG, HOMER C. REED, ERNEST E. SECHLER

UNDERGRADUATE SUBJECTS

ME. 1. MECHANISM. 10 units (3-3-4); first, second or third term.

Prerequisites: Ma. 1 a, b, c; Ph. 1 a, b, c; D. 1 a, b.

An analytical study of constrained motion in machines and of the relations of machine elements. Desirable types of motion; displacements of machine parts using simple valve motions, cam actuating parts, and other reciprocating and oscillating machine members as examples. Velocity studies; average and instantaneous values; velocity analysis by vectors using centros; relative velocities; application of vectors to cyclic trains and other differential motions. Acceleration analysis; inertia forces. The various linkages and combinations of machine elements are introduced and used as a means of mastering the geometry of machine motion.

Text: Mechanism, Clapp and Sechler.

Instructor: Clapp.

ME. 2. MACHINE DESIGN. ~~3 units (3-3-0)~~; first term.

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

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

Text: Principles of Machine Design, Norman.

Instructor: Clapp.

ME. 3. MACHINE DESIGN. 12 units (2-6-4); second term.

Prerequisite: ME. 2.

A continuation of the work in design with especial reference to belting; pulleys; rope driving; chains; friction drives; wire rope and

hoisting; plain bearings; ball bearings; roller bearings; shafts and couplings; clutches; brakes; high speed disks; piping. Class exercises and drawing board studies.

Text: Principles of Machine Design, Norman.

Instructor: Clapp.

9 units (0-9-0)

ME. 4. MACHINE DESIGN. ~~3 units (0-3-0)~~; third term.

Prerequisite: ME. 3.

A study of manufacturing processes with especial reference to the economics of design. Lectures and inspection trips.

Instructor: Clapp.

ME. 8. MACHINE DESIGN. 12 units (3-3-6); 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: Holroyd.

ME. 9. MACHINE DESIGN. 9 units (3-0-6); first term.

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

An abbreviated course in machine design for fifth-year students in civil engineering, somewhat similar in scope to course ME. 8.

ME. 10. METALLURGY. 9 units (3-0-6); first term.

Prerequisite: Ch. 6.

A study of the principles underlying the manufacture and heat treatment of the ferrous metals and some of the non-ferrous alloys.

Instructor: Clapp.

ME. 15. HEAT ENGINEERING. 12 units (3-3-6); first or third term.

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

Principles of thermodynamics, and their application to steam engines, steam turbines, and internal combustion engines; types of steam, gas, and oil engines, boilers, and auxiliaries. Inspection of local power plants, elementary tests in the laboratory, and computing or drawing room exercises.

Instructors: Daugherty, Folsom, Holroyd.

ME. 16. HEAT ENGINEERING. 12 units (4-0-8); first or second term.

Prerequisite: ME. 15.

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

Instructor: Daugherty.

ME. 17. HEAT ENGINEERING. 9 units (3-3-3); third term.

Prerequisite: ME. 16.

A study of the application of thermodynamics to modern practice in power plants and also to refrigeration; heating and ventilating; and other thermal processes. Class-room work and computing-room problems.

Instructor: Daugherty.

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

Prerequisite: ME. 15.

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

Text: Power Plant Testing, Moyer.

Instructors: Clark, Folsom.

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

Prerequisite: ME. 15.

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

Text: Power Plant Testing, Moyer.

Instructor: Folsom.

ME. 50 a, b, c. ENGINEERING CONFERENCES. 2 units (1-0-1); first, second and third terms.

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

Instructors: Daugherty, Clapp.

FIFTH-YEAR AND ADVANCED SUBJECTS

ME. 100. ADVANCED WORK IN ENGINEERING.

In addition to the regular fifth-year and other advanced courses which are here outlined, the staff of the mechanical engineering department will arrange special courses or problems to meet the needs of advanced students.

ME. 101. ADVANCED MACHINE DESIGN. 12 units (4-0-8); first term.
Prerequisites: AM. 1 a, b; ME. 4, 10.

The student electing this course will be expected to have a comprehensive knowledge of the constitution and properties of the principal materials of construction, and to be acquainted with machine shop processes. The various relations developed in mechanics of materials are examined as to their authority and limitations and as to their application. Examples of evolved design for parts subjected to complex stresses are critically studied. Investigation of the failure of materials under repeated stresses.

Text: Applied Elasticity, Timoshenko and Lessells.

Instructor: Clapp.

ME. 102 and 103. MACHINE DESIGN OPTIONS. 12 units (0-12-0); second and third terms.

The work in these terms may follow various lines as the student may elect. He may desire to work out the design of some especial machine, or he may wish to take up internal combustion engine design, or other suitable project. This time may be combined with that for thesis, in case the latter is of a design character.

Instructor: Clapp.

ME. 110. METALLOGRAPHY. 12 units (2-6-4); first term.

Prerequisite: ME. 10.

A continuation of the course ME. 10 with especial reference to the structure of metallic alloys, their causes, and the relation between structure and physical properties.

Text: Science of Metals, Jeffries and Archer.

Instructor: Clapp.

ME. 111. SCIENCE OF METALS. 12 units (2-6-4); second term.

Prerequisite: ME. 110.

The structure of the ferrous alloys; causes and effects of the thermal critical points; theories of hardening and hot and cold working; constitution, properties, heat treatment, and uses of the principal alloy steels; the phase rule; preparation of specimens for microscopic analysis; optics of metallography. Lectures and laboratory exercises.

Text: The Metallography of Iron and Steel, Sauveur.

Instructor: Clapp.

ME. 112. METALS RESEARCH. 12 units (1-9-2); third term.

Special problems investigated with the aid of the electric furnace, microscope, and testing materials equipment.

ME. 120. THERMODYNAMICS. 12 units (4-0-8); first term.

Prerequisite: ME. 17.

Advanced work in engineering thermodynamics, with applications 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.

ME. 135 and 136. INTERNAL COMBUSTION ENGINES. 12 units (3-3-6); second and third terms.

Prerequisites: ME. 120, 130.

Theoretical, experimental, and design problems. The subject will be approached from the performance point of view rather than from that of the mechanical design. Fuels, carburetion, superchargers, explosion, combustion, detonation, heat transfer. Work with test engine equipped with optical indicator.

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

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

AERONAUTICS

PROFESSOR: HARRY BATEMAN

ASSOCIATE: THEODOR VON KARMAN

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

TEACHING FELLOWS: W. BAILEY OSWALD, ERNEST E. SECHLER

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*.

Instructor: Sechler.

See also Courses CE. 11 and ME. 8.

FIFTH-YEAR AND ADVANCED SUBJECTS

AE. 251 a, b. ELEMENTARY AERODYNAMICS OF THE AIRPLANE. 9 units, first and second terms; 6 units, third term.

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

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

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

Instructor: C. B. Millikan.

AE. 252 a, b, c. ELEMENTARY 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 or subsequently to 251.

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

Instructors: Klein, Raymond.

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

Prerequisite: AE. 251.

Instructor: Raymond.

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

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

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

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

Instructor: Klein.

AE. 258. PROPELLER DESIGN. 6 units; one term.

Prerequisite: AE. 251.

Design of propellers for aircraft, windmills, wind channels, and air turbines.

Instructor: Klein.

AE. 260 a, b. ADVANCED THERMODYNAMICS AND AIRPLANE ENGINES. 9 units; second and third terms.

Prerequisites: ME. 101, 120.

Thermodynamics of the internal combustion engine. Ideal and real efficiencies. Mechanics of high speed engines. Engine balance. Carburation. Conduction, radiation and cooling. Ignition systems. High speed gearing. Lubrication.

Text: Judge, Automobile and Aircraft Engines.

(Not given in 1929-1930.)

AE. 264. DESIGN OF AERO FOILS AND STREAMLINE BODIES. 6 units; third term.

Instructor: Bateman.

AE. 265. PROPERTIES OF FLUIDS AND ELEMENTARY HYDRODYNAMICS. 9 units; second term.

Prerequisites: Ph. 1 a, b, c, or Hy. 1, 2.

Density, compressibility, viscosity. Equations of motion and theory of steady flow. Flow through pipes and around obstacles. Pitot and Venturi tubes. Principles of similitude. Turbulence and Reynolds' criterion. Theory of lubrication.

Text: The Mechanical Properties of Fluids, a collective work.

Instructor: Bateman.

AE. 266. AERODYNAMICS. 15 units; third term.

Prerequisite: Ma. 114.

Elementary hydrodynamical theory as applied to aeronautics. Air-foils, shapes and streamlines. Wing theory. Theories of resistance.

Texts: Glauert, The Elements of Aerofoil and Airscrew Theory; Prandtl, Applications of Modern Hydrodynamics to Aeronautics.

Instructor: C. B. Millikan.

AE. 267. PROPELLER THEORIES. 9 units; second term.

Prerequisite: AE. 266.

Various extensions and developments of the blade element theory. Froude theory. Vortex theory. Effect of constricting walls; effect of fuselage and wings.

Text: Glauert, The Elements of Aerofoil and Airscrew Theory.

Instructor: Bateman.

AE 268. ADVANCED AERODYNAMICS. 12 units; third term.

Prerequisite: AE. 266.

Mathematical discussion of various theories of lift and drag. Soaring flight. Katzmayer effect. Autorotation. Special types of flight. Theory and discussion of new types of aircraft.

Instructor: Bateman.

AE. 269. THEORY OF STABILITY AND CONTROL. 15 units.

Prerequisite: AE. 266.

Discussion of stability based on the mathematical theory of small oscillations. Effect of prescribed movements of the control surfaces. Effect of slipstream and downwash.

Texts: Bairstow, Aerodynamics; Wilson, Aeronautics.

Instructors: Bateman, C. B. Millikan.

AE. 286 a, b, c. AERONAUTICS LABORATORY. Units by arrangement.

Experimental work of all kinds in the aerodynamical laboratory: wind tunnel, water channel, structure laboratory, etc.

Instructors: C. B. Millikan, Klein, Martel.

AE. 290 a, b, c. AERONAUTICAL SEMINAR. 2 units; first, second and third terms.

Study and critical discussion of current contributions to aerodynamics and aeronautical engineering.

Additional and supplementary courses will be offered as the need arises. Lectures will be given from time to time by visiting scientists and engineers from this country and Europe. Flying is not given officially at the Institute, but there are ample opportunities for a student to learn to fly at one of the neighboring flying fields.

APPLIED MECHANICS

PROFESSOR: FREDERIC W. HINRICHS, JR.

INSTRUCTOR: FRED J. CONVERSE

TEACHING FELLOWS: DONALD P. BARNES, C. HAWLEY CARTWRIGHT,
THOMAS H. EVANS

UNDERGRADUATE SUBJECTS

AM. 1 a, b. APPLIED MECHANICS. 14 units (4-3-7); first and second terms.

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

Action of forces on rigid bodies; composition and resolution of forces; equilibrium, couples, framed structures; cords and chains; centroids; displacement; velocity and acceleration; translation, rotation, and plane motion; moments of inertia; inertia forces; kinetic and potential energy; work and energy; impulse and momentum; impact; power; efficiency.

Text: Seely and Ensign's Analytical Mechanics for Engineers.

Instructors: Hinrichs, Converse, Cartwright, Evans.

AM. 1 c. STRENGTH OF MATERIALS. 14 units (4-3-7); third term.

Prerequisite: AM. 1 a, b.

Elasticity and strength of materials of construction; theory of stresses and strains; elastic limit; yield point; ultimate strength; safe loads; repeated stresses; beams; cylinders; shafts; columns; riveted joints; structural shapes.

Texts: Poorman's Strength of Materials, and Steel Construction, A. I. S. C.

Instructors: Hinrichs, Converse, Cartwright, Evans.

AM. 2 a, b. APPLIED MECHANICS AND STRENGTH OF MATERIALS. 12 units (4-0-8); first and second terms.

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

An abridged course for students electing the Chemical Engineering Option in the Science Course, condensing in the work of two terms as much as possible of the general field outlined above in AM. 1 a, b, c.

Texts: Wood's Text-book of Mechanics; Poorman's Strength of Materials; and Steel Construction, A. I. S. C.

Instructor: Barnes.

AM. 3. TESTING MATERIALS LABORATORY. 6 units (0-3-3); first, second, or third term.

Prerequisite: AM. 1 c.

Tests of the ordinary materials of construction in tension, compression, torsion, and flexure; determination of elastic limits; yield point, ultimate strength, and modulus of elasticity; experimental verification of formulas derived in the theory of strength of materials.

Texts: Upton's Materials of Construction, and Hinrichs' and Martel's Laboratory Manual for Testing Materials.

Instructor: Converse.

FIFTH-YEAR AND ADVANCED SUBJECTS

AM. 202 a, b, c. THEORY OF ELASTICITY. Units to be based on work done; first, second and third terms.

A study of the behavior of an elastic solid under stress.

Instructor: Hinrichs.

ENGINEERING DRAWING

ASSISTANT PROFESSOR: GEORGE B. BRIGHAM, JR.

TEACHING FELLOWS AND ASSISTANTS: DONALD P. BARNES, KENNETH A. BELKNAP, FREDERICK R. CLINE, ERNEST C. HILLMAN, GEORGE S. LUFKIN, SAMUEL OLMAN, ERNEST E. SECHLER, NATHAN D. WHITMAN

D. 1. 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.

Instructor: Brigham.

D. 2. FREEHAND DRAWING. 3 units (0-3-0); elective.

Prerequisite: D. 1.

Similar to D. 1 but with advanced subject matter.

Instructor: Brigham.

D. 10. ELEMENTARY MECHANICAL DRAWING. 3 units (0-3-0); first term.

The study of shape and size, description by means of mechanical drawing, and the care and use of drawing instruments. Accuracy and precision are required.

Text: Svensen, Machine Drawing.

Machine Drawing, D. 20 a, b, and c, and D. 21 a, b, c, and 22 a, b, c, are planned to prepare all engineering students for the drawing required in the professional work of the engineering departments. Accuracy, neatness and good lettering are required.

D. 20 a. MACHINE DRAWING AND LETTERING. 3 units (0-3-0); first term.

Prerequisite: D. 10.

The study of the general principles of working drawings of machinery covering conventional representations and dimensioning. The work includes the making of simple working drawings. It also includes lettering plates.

Text: Svensen, Machine Drawing.

Instructors: Belknap, Sechler.

D. 20 b. MACHINE DRAWING AND LETTERING. 3 units (0-3-0); second term.

Prerequisite: D. 20 a.

A continuation of D. 20 a, covering dimensioned freehand sketches of machine parts, and complete detail working drawings made from the sketches. The lettering plates will continue throughout this course.

Text: Svensen, Machine Drawing.

Instructors: Belknap, Sechler.

D. 20 c. MACHINE DRAWING AND LETTERING. 3 units (0-3-0); third term.

Prerequisite: D. 20 b.

A continuation of D. 20 b, covering assembly and outline drawings of small machines or groups of machine parts. The lettering plates will continue in the form of bills of material.

Text: Svensen, Machine Drawing.

Instructors: Belknap, Sechler.

D. 21 a, b, c. ADVANCED MACHINE DRAWING. 3 units (0-3-0); elective any term.

Prerequisite: D. 20 a, b, c.

The study and execution of design drawings for proposed mechanisms designed by upper class students.

Instructor: Brigham.

D. 22 a, b, c. ADVANCED MACHINE DRAWING. 6 units (0-6-0); elective any term.

Prerequisite: D. 20 a, b, c.

A six unit course similar to D. 21 a, b, c.

Instructor: Brigham.

Structural Drawing, D. 30 a, b, c, and D. 31 a, b, c, and 32 a, b, c, are especially planned to prepare civil engineering students for the drawing required in the professional work of the civil engineering department. Accuracy, neatness and good lettering are required.

D. 30 a. STRUCTURAL DRAWING AND LETTERING. 3 units (0-3-0); first term.

Prerequisite: D. 10.

The study of the general principles of working drawings of structural steel and reinforced concrete covering conventional representations, billing and dimensioning. The work includes the making of

simple working drawings. It also includes lettering plates similar to those required for D. 20 a.

Text: Bishop, Structural Drafting and the Design of Details.

Instructors: Brigham, Barnes.

D. 30 b. STRUCTURAL DRAWING AND LETTERING. 3 units (0-3-0); second term.

Prerequisite: D. 30 a.

A continuation of D. 30 a, covering complete detail working drawings of structural steel members. The lettering plates will continue throughout this course.

Text: Bishop, Structural Drafting and the Design of Details.

Instructors: Brigham, Barnes.

D. 30 c. STRUCTURAL DRAWING AND LETTERING. 3 units (0-3-0); third term.

Prerequisite: D. 30 b.

A continuation of D. 30 b, covering working drawings of trusses, erection plans, and checking. The lettering plates will continue in the form of material, shop and shipping bills.

Text: Bishop, Structural Drafting and the Design of Details.

Instructors: Brigham, Barnes.

D. 31 a, b, c. ADVANCED STRUCTURAL DRAWING. 3 units (0-3-0); elective any term.

Prerequisite: D. 30 a, b, c.

The study and execution of drawings of structural steel or reinforced concrete for structures designed by upper class civil engineering students.

Instructor: Brigham.

D. 32 a, b, c. ADVANCED STRUCTURAL DRAWING. 6 units (0-6-0); elective any term.

Prerequisite: D. 30 a, b, c.

A six-unit course similar to D 31 a, b, c.

Instructor: Brigham.

Descriptive Geometry, D. 40, 41 a, b, c, 42 and 43, are planned to cover a thorough study of shape description and representation. Especial emphasis will be placed upon the visualization of problems in order to develop three dimensional observation. The work will include practical as well as purely geometrical problems.

D. 40. ELEMENTARY DESCRIPTIVE GEOMETRY. 3 units (0-3-0); second term.

The study of the graphical representation of three dimensional geometrical constructions by means of orthographic projection. The work includes principle, auxiliary and oblique views.

Text: Hood, Geometry of Engineering Drawing.

D. 41 a. DESCRIPTIVE GEOMETRY. 3 units (0-3-0); first or third term.
Prerequisite: D. 40.

A continuation of D. 40 covering the "Analysis of Structures" and straight and curved line constructions.

Text: Hood, Geometry of Engineering Drawing.

D. 41 b DESCRIPTIVE GEOMETRY. 3 units (0-3-0) second term.
Prerequisite: D. 41 a.

A continuation of D. 41 a, covering problems involving the relationship of lines and planes and the intersection and development of surfaces.

Text: Hood, Geometry of Engineering Drawing.

D. 41 c. DESCRIPTIVE GEOMETRY. 3 units (0-3-0); second or third term.
Prerequisite: D. 41 b.

A continuation of D. 41 b, covering more complicated problems involving single curved surfaces, warped and double curved surfaces.

Text: Hood, Geometry of Engineering Drawing.

D. 42. DESCRIPTIVE GEOMETRY. 6 units (0-6-0); second term.

This course is planned primarily for geology students, and includes practical problems in mining and earth structures.

Text: Cutter, Descriptive Geometry.

Instructor: Brigham.

D. 43. ADVANCED DESCRIPTIVE GEOMETRY. 3 units (0-3-0); elective any term.

Prerequisite: D. 41 a, b, c.

The study of lineal perspective and the execution of mechanical perspective drawings of machines, bridges, and other structures.

Instructor: Brigham.

D. 44. PERSPECTIVE SKETCHING. 3 units (0-3-0); elective any term.
Prerequisite: D. 43.

The study of freehand perspective drawing. Models will be selected by the student and executed in various mediums. The work is planned to illustrate the relation between mechanical and natural perspective and to develop freedom in pictorial representation.

Instructor: Brigham.

D. 50. BLOCK DIAGRAMS AND LAND FORMS. 6 units (0-6-0); second term.

The graphical representation of land forms and geological structure by means of pictorial drawings. The work, which will be mainly free-hand, includes the drawing of block diagrams of various land forms in perspective, and of "isometric diagrams and problems in structural geology."

Text: Lobeck, Block Diagrams.

Instructor: Brigham.

D. 51. PHYSIOGRAPHIC SKETCHING. 6 units (0-6-0); third term.

Freehand sketching from landscape forms and details of geological structure. Sketches will be made in both the drawing room and the field, and by means of various mediums. Required of geology students; elective students of all other courses.

Text: Lobeck, Block Diagrams.

Instructor: Brigham.

HYDRAULICS

PROFESSOR: ROBERT L. DAUGHERTY

TEACHING FELLOWS AND ASSISTANTS: JOHN H. A. BRAHTZ, DONALD S. CLARK, ERNEST B. HUGG

UNDERGRADUATE SUBJECTS

Hy. 1. HYDRAULICS. 12 units (4-0-8); first, second or third term.
Prerequisite: AM. 1 a, b.

Physical properties of water; hydrostatics; flow of water in pipes, nozzles, and channels; theory, construction, and installation of hydraulic turbines, and a study of their characteristics with a view to intelligent selection of the proper type for any given conditions; centrifugal pumps and other hydraulic equipment.

Text: Hydraulics and Hydraulic Turbines, Daugherty.

Instructors: Daugherty, Brahtz, Clark.

Hy. 2. HYDRAULIC LABORATORY. 6 units (0-3-3); first, second or third term.

Prerequisite: AM. 1 a, b.

Experiments on the flow of water through orifices and nozzles, through pipes and Venturi meters, over weirs; use of Pitot tube; tests of impulse and reaction turbines, centrifugal pumps, and other hydraulic apparatus.

Instructor: Hugg.

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.

SHOP INSTRUCTION

INSTRUCTORS: ARTHUR F. HALL, MURRAY W. HAWS, OSCAR L. HEALD,
WALTER W. MARTIN

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

UNDERGRADUATE SUBJECTS

Sh. 1. WOOD WORKING. PROPERTIES OF WOOD AND OTHER MATERIALS USED IN TIMBER CONSTRUCTION.

Study of wood growth and structure from illustrative timber sections; discussion of the relation of wood-cell structure to strength, hardness, etc., of timber; experimental comparison of wood and metals as to their strength and other properties; strength of joining devices, as glue, nails, joints; study of the general design and operation of wood working tools and machines.

Instructor: Martin.

Sh. 2. FORGING. HOT WORKING OF METALS.

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

Instructor: Heald.

Sh. 3. PATTERN MAKING. METAL CASTINGS AND THE PATTERNS THEREFOR.

Lectures on the requirements of patterns for metal castings; the necessity for and the determination of the amount of shrinkage, draft and other allowances; the effects of chilling and other heat treatments on cast metals; study of moulding methods and pattern construction.

Instructor: Henck.

Sh. 4. MACHINE SHOP. WORKING OF METALS.

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

Instructor: Hall.

Sh. 1-4. (Above subjects.) Distributed through the three terms and the summer period of the freshman year. (8 units for the year.)

Division of Geology and Paleontology

PROFESSORS: JOHN P. BUWALDA, F. L. RANSOME, CHESTER STOCK, WENDELL P. WOODRING

INSTRUCTOR: RENE ENGEL

CURATOR IN VERTEBRATE PALEONTOLOGY: EUSTACE L. FURLONG

CURATOR IN INVERTEBRATE PALEONTOLOGY: W. P. POPENOE

ARTIST: JOHN L. RIDGWAY

COMMONWEALTH FUND FELLOWS: GEORGE A. CUMMING, H. V. WARREN

TEACHING FELLOWS AND GRADUATE ASSISTANTS: GEORGE H. ANDERSON,

JOHN W. DALY, WILLARD A. FINDLAY, C. LEWIS GAZIN, KENNETH E.

LOHMAN, STANLEY W. LOHMAN, RALPH L. LUPHER, JOHN H. MAXSON,

BERNARD N. MOORE, JOHN C. SUTHERLAND, GEORGE F. TAYLOR

UNDERGRADUATE SUBJECTS

Ge. 1 a. PHYSICAL GEOLOGY. 9 units (3-3-3); first term.

Prerequisites: Ch. 1 a, b, c; Ph. 1 a, b, c.

A consideration of the composition and structure of the Earth and the internal and external processes which modify the crust and the surface. Dynamical and structural geology. Lectures, recitations, laboratory and weekly field trips.

Text: Pirsson and Schuchert's Text-book of Geology, Part I.

Instructors: Buwalda, Gazin, Maxson.

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, Gazin, Maxson.

Ge. 1 c. HISTORICAL GEOLOGY. 9 units (2-3-4); 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.

Instructor: Woodring.

Ge. 3 a. CRYSTALLOGRAPHY. 12 units (1-6-2); 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 of crystal structure; also, the physical properties characteristic of crystals.

Text: Dana's Text-book of Mineralogy.

Instructors: Engel, Anderson.

Ge. 3 b, c. MINERALOGY. 9 units (1-6-2), first term; 6 units (1-3-2), 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, Anderson.

Ge. 5 a, b. PETROLOGY. 11 units, second term; 7 units, third term.

Prerequisites: Ge. 3 a, b.

The origin, properties, and macroscopic identification of the common rocks. Lectures and laboratory.

Text: Rocks and Rock Minerals, Pirsson-Knopf.

Instructors: Engel, Anderson.

Ge. 7 a, b. FIELD GEOLOGY. 8 units, first term; 10 units, third term.

Prerequisites: Ge. 1 a-c; 3 a, b; 5 a, b.

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 textbook 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, Moore.

Ge. 9. STRUCTURAL GEOLOGY. 8 units (3-0-5); third term.

Prerequisite: Ge. 7 a.

A consideration of the structural features of the Earth's crust; joints, folds, faults, foliation. Computation of thicknesses and depths. Determination of the nature and amount of displacements on faults by use of descriptive geometry.

Instructor: Buwalda.

Ge. 11 a, b. INVERTEBRATE PALEONTOLOGY. 10 units first term, 8 units 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: Woodring.

Ge. 12 a, b. VERTEBRATE PALEONTOLOGY. 10 units (2-6-2) second term; 8 units third term.

Prerequisite: Ge. 1 b.

Osteology, affinities, and history of the principal groups of fossil mammals and reptiles. History of vertebrate life with special reference to the region of western North America.

Instructor: Stock.

Ge. 21. THESIS PROBLEM IN GEOLOGY. 8 units; second and third terms.

Prerequisite: Ge. 7 a.

The student investigates a limited geologic problem, preferably of his own choosing, under direction, in the field or laboratory. Individual initiative is developed, principles of research are acquired, and practice gained in technical methods. The student prepares a thesis setting forth the results of the research and their meaning.

Ge. 22. THESIS PROBLEM IN PALEONTOLOGY. 8 units; second and third terms.

Prerequisites: Ge. 11 a, b, or Ge. 12 a, b; may be taken concurrently.

Special investigations in either invertebrate or vertebrate paleontology. Research on a limited problem involving either field relationships of fossil assemblages or consideration in the laboratory of the structural characters and relations of fossil forms. Preparation of a thesis.

Ge. 23. SUMMER FIELD GEOLOGY. 12 units.

Intensive geologic mapping of a selected area from a centrally located field camp. Determination of the stratigraphy, fossil content, structure, and geologic history. The area chosen will probably lie in the California Coast Ranges in odd-numbered years and in the Great Basin region in the alternate years. Course begins immediately after Commencement (about June 12th). Required at the end of both the Junior and the Senior Year for the Bachelor's degree in the Geology and Paleontology course. Tuition, \$15.00.

Instructor: Buwalda (even-numbered years); Woodring (odd-numbered years).

FIFTH-YEAR SUBJECTS

Ge. 181 a, b, c. PETROGRAPHY. 10 units; first, second and third terms.

Optical mineralogy and study of the petrographic characteristics of certain important types of rocks. Use of the microscope in the identification of minerals and rocks.

Instructor: Engel.

Ge. 183. SEISMOLOGY. 6 units; first term of even-numbered years.

Study and conferences on the principles of physical and geological seismology.

Text: Davidson's Manual of Seismology.

Instructor: Buwalda.

Ge. 184. LABORATORY STUDIES IN SEISMOLOGY. First, second or third term.

Laboratory practice in the measurement and interpretation of instrumental earthquake records; investigation of specific seismologic problems.

Instructors: Staff of Seismological Laboratory.

Ge. 186. GEOMORPHOLOGY. 10 units; first term of odd-numbered years.

Nature and origin of the physiographic features of the earth. Geologic processes involved in their development. Use of physiography in elucidating the later geologic history of regions.

Instructor: Buwalda.

Ge. 187. RESEARCH.

Original investigation, designed to give training in methods of research, to serve as theses problems for higher degrees, and to yield contributions to scientific knowledge. These may at present be most advantageously carried on in the fields of (n) general areal geology, (o) stratigraphic geology, (p) structural geology, (q) physiography or geomorphology, (r) mineralogy and petrology, (s) vertebrate paleontology, (t) invertebrate paleontology, (u) seismology, (v) economic geology. Regions within easy reach of Pasadena offer an extraordinary variety of research problems.

ADVANCED SUBJECTS

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, c. SEMINAR IN PHYSICAL GEOLOGY. 5 units; first and third terms.

Study and critical discussion of current contributions to geologic knowledge. Papers taken up during the first term will be mainly in Structural Geology. Papers on a variety of topics in General Geology will be assigned in the third term.

Instructor: Buwalda.

Ge. 190 a, b. SEMINAR IN VERTEBRATE PALEONTOLOGY. 5 units; second and third terms.

Discussion of progress and results of research in vertebrate paleontology. Critical review of current literature.

Instructor: Stock.

Ge. 191 a, b. SEMINAR IN INVERTEBRATE PALEONTOLOGY. 5 units; first and second terms.

Conferences on research in invertebrate paleontology and reviews of literature. Discussions of particular aspects of invertebrate paleontology with special reference to the Pacific Coast.

Instructor: Woodring.

Ge. 195. ORE DEPOSITS. 10 units; second term.

Prerequisites: Ge. 1, 3, 5, 7.

A study of metalliferous deposits with particular reference to their geological relations and origins. Lectures, recitations, and field trips.

Text: Not prescribed, but Emmons' Principles of Economic Geology is suggested, with Lindgren's Mineral Deposits as collateral reading.

Instructor: Ransome.

Ge. 196. NON-METALLIFEROUS DEPOSITS. 10 units; third term.

Prerequisites: Ge. 1, 3, 5, 7.

Modes of occurrence, distribution, and origin of the principal non-metallic mineral products, including mineral fuels, building materials, etc.

Text: Not prescribed, but Ries' Economic Geology or an equivalent text will be found useful.

Ge. 197 a, b. ADVANCED ECONOMIC GEOLOGY. 8 units; 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 a, b. SEMINAR IN MINERALOGY AND PETROLOGY. 5 units; first and second terms.

Discussion of current literature and recent advances in these fields.

Division of Biology

PROFESSORS: THOMAS HUNT MORGAN, ALFRED H. STURTEVANT

ASSOCIATE PROFESSORS: ERNEST G. ANDERSON, KARL BELAR

ASSISTANT PROFESSORS: HENRY BORSOOK, THEODOSIUS DOBZHANSKY, H. E.

DOLK, STERLING H. EMERSON

INSTRUCTOR: ALBERT TYLER

TEACHING FELLOWS: RUSSELL L. BIDDLE, W. ALFORD HETHERINGTON,

CARL C. LINDEGREN, MARCUS M. RHOADES

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

A new option in biology has been introduced into the four-year undergraduate Course in Science. This option will include those fundamental biological subjects that are an essential preparation for work in any special field of pure or applied biology. This three-year course will afford 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 will also be 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.

Bi. 2. COMPARATIVE PHYSIOLOGY AND ANATOMY. 9 units (3-4-2); third term.

An introductory course for students expecting to elect the biological group. The course will include a brief survey of the animal kingdom, with dissection of representatives of some of the chief groups.

Bi. 3. GENERAL BOTANY. 9 units (3-4-2); first term.

A course in the structure and physiology of plants.

Bi. 4. HISTOLOGICAL TECHNIQUE. 6 units (0-6-0); first term.

A laboratory course in the preparation of materials for studies on cells and tissues.

Bi. 5 b, c. **PHYSIOLOGY.** 11 units (3-6-2), second term; 9 units (2-4-3), third term.

Physiology of animals and plants, each term dealing primarily with one of these two divisions.

Fourth-year courses will be offered, as needed, in embryology, biochemistry, cytology, and genetics.

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. **GENETICS:** Seminar and research work will be given to graduate students specializing in heredity and related subjects.

Instructors: Sturtevant, Anderson, Dobzhansky, and Emerson.

Bi. 110. **BIOCHEMISTRY:** Courses in biochemistry will be 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. **EXPERIMENTAL ZOÖLOGY.** A course of lectures and seminar work, including reports to the Journal Club on the general field of experimental zoölogy, will be given to graduate students at the beginning of their graduate work.

Instructor: Morgan.

Bi. 140. **CYTOLOGY.** A seminar course with laboratory demonstrations and individual laboratory work.

Instructor: Belar.

Bi. 150. **PLANT PHYSIOLOGY.** A course of lectures and laboratory work on general plant physiology.

Instructor: Dolk.

Bi. 160. **ADVANCED PHYSIOLOGY.** It is expected to offer graduate courses in general physiology to students prepared to carry on research work.

Division of the Humanities

ENGLISH

PROFESSOR: CLINTON K. JUDY

ASSOCIATES: CHARLES R. BASKERVILL, GEORGE W. SHERBURN

ASSOCIATE PROFESSOR: GEORGE R. MACMINN

ASSISTANT PROFESSORS: HARVEY EAGLESON, WILLIAM HUSE, JR.

INSTRUCTOR: L. W. JONES

ASSISTANT: WALTER WILKINSON

A course in English composition is prescribed for all students in the Freshman year, and a course in the survey of English literature is prescribed for all students in the Junior year. In the Senior year the students are offered a number of options in English, American, and European literature.

The instruction in composition is intended to give a thorough training in both written and spoken English. The instruction in literature is intended to provide an appreciative acquaintance with the chief works of the most significant authors, past and present, in the development of modern civilization, and to foster the habit of self-cultivation in books.

The regular courses in English do not exhaust the attention given at the Institute to the student's use of the language; all writing, in whatever department of study, is subject to correction with regard to English composition.

UNDERGRADUATE SUBJECTS

En. 1 a, b, c. ENGLISH COMPOSITION AND READING. 6 units (3-0-3); first, second and third terms.

This course is designed to give the student a thorough review of the principles of composition, with much practice in writing and speaking, and a broad introduction to good reading. The student is offered every inducement to self-cultivation, and is allowed ample opportunity for the exercise of special talents or the pursuit of special intellectual interests.

The work of the honor section is directed toward the stimulation of intellectual initiative. Each member of the section may study some

carefully chosen topic in accordance with the elementary principles of research. He is held to high standards of excellence in writing and speaking, and is expected to undertake a considerable amount of cultural reading.

Texts: Freshman Rhetoric and Practice Book, Peckham and Wilson; Contemporary Thought, Taft, McDermott, and Jensen; Webster's Collegiate Dictionary.

Instructors: Eagleson, Huse, Jones, MacMinn.

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, Lieders, Lovett and Root.

Instructors: Eagleson, Huse, Jones, Judy, MacMinn.

En. 8. CONTEMPORARY ENGLISH AND EUROPEAN LITERATURE. 9 units (3-0-6); first and third terms.

Prerequisite: En. 7 a, b, c.

A continuation of the survey of English literature to cover the period, 1890-1928; with some extension into Continental literature. Wide reading is required.

Text: English Literature During the Last Half-Century, Cunliffe.

Instructors: Eagleson, Judy.

En. 9. CONTEMPORARY AMERICAN LITERATURE. 9 units (3-0-6); first and third terms.

Prerequisite: En. 7 a, b, c.

A survey of the literature of the United States during the past half-century, with emphasis upon the chief writers of the present time. Special attention is given to the reflection of national characteristics in the novel, the short story, drama, and poetry.

Text: Recent American Literature, Foerster.

Instructor: MacMinn.

EN. 10. MODERN DRAMA. 9 units (3-0-6); first and third terms.

Prerequisite: En. 7 a, b, c.

A study of the leading European and British dramatists, from Ibsen to the writers of the present time. Special attention may be given to new movements in the theatre, to stage decoration and production. Wide reading of plays is required.

Text: Chief Contemporary Dramatists, first series, Dickinson.

Instructors: Huse, MacMinn.

EN. 11. LITERATURE OF THE BIBLE. 9 units (3-0-6); third term.

Prerequisite: En. 7 a, b, c.

A study of the Old and New Testaments, exclusively from the point of view of literary interest. Special attention is given to the history of the English Bible. Opportunity is offered for reading modern literature based on Biblical subjects.

Text: The Modern Reader's Bible, Moulton.

Instructor: MacMinn.

EN. 12 a, b, c. DEBATING. 4 units (2-0-2).

Elective, with the approval of the Registration Committee, for upper classmen in the first and second terms. Study of the principles of argumentation; systematic practice in debating; preparation for 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.

Text: Newspaper Writing and Editing, Bleyer.

Instructor: MacMinn.

En. 16. SPELLING. No credit.

This course may be prescribed for any student whose spelling is unsatisfactory.

En. 20. SUMMER READING. Maximum, 16 credits.

Credits are allowed to the maximum number of 16 for vacation reading from a selected list of books in various subjects, and written report thereon.

FIFTH-YEAR AND ADVANCED SUBJECTS

En. 100. LITERATURE. 12 units; first, second and third terms.

A study of some selected period, or type, or author, or group of authors in American, English or European literature, with an introduction to the methods of research and criticism applicable thereto.

Instructors: Baskervill, Eagleson, Sherburn.

LANGUAGES

PROFESSOR: JOHN R. MACARTHUR

ASSISTANTS: FRED J. EWING, FRANK A. NICKELL

The courses in this department are primarily arranged to meet the needs of scientific students who find it necessary to read books, treatises, and articles in French, German, and Italian. In these languages correct pronunciation and the elements of grammar are taught, but the emphasis is laid upon the ability to translate from them into English. An elective course in Greek is offered to students interested in that language.

UNDERGRADUATE SUBJECTS

L. 1 a, b. ELEMENTARY FRENCH. 10 units (4-0-6); second and third terms.

A course in grammar, pronunciation, and reading that will provide the student with a vocabulary of extent and with a knowledge of grammatical structure sufficient to enable him to read at sight French scientific prose of average difficulty. Accuracy and facility will be insisted upon in the final tests of proficiency in this subject.

Texts: An Introduction to the Study of French, Bond; Technical and Scientific French, Williams.

Instructor: Macarthur.

L. 11. ELEMENTARY ITALIAN. 9 units (3-0-6); one term, as required.

A course designed to give the student who has already some acquaintance with Latin or with another Romance language sufficient knowledge of the forms and vocabulary of Italian to enable him to read scientific Italian, especially in the field of Mathematics.

Text: Elementary Italian, Marinoni and Passarelli.

Instructor: Macarthur.

L. 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; German Science Reader, Wright.

Instructors: Macarthur and Assistants.

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. 31 a, b, c, or one year of college German.

This is a continuation of L. 31 a, b, c, with special emphasis on the reading of scientific literature.

Texts: Aus der Werkstatt grosser Forscher, Danneman; Die Radioaktivitat, Fajans; German Science Reader, Wright.

L. 39 a, b, c. READING IN FRENCH, ITALIAN, OR GERMAN. Units to be determined for the individual by the department. Elective, with the approval of the Registration Committee, in any term.

Reading in scientific or literary French, Italian, or German, done under direction of the department.

L. 40. GERMAN LITERATURE. 9 units (3-0-6); ~~first term~~ *3rd term*

Prerequisites: L. 37 a, b, c; L. 38 a, b, c.

The reading of selected German classics, poetry and drama, accompanied by lectures on the development of German literature.

Instructor: Macarthur.

L. 51 a, b, c. GREEK. 6 units (3-0-3).

This is a course in the elements of the classical Greek language. Special reference is made to scientific nomenclature. Outside reading upon topics drawn from Greek literature, art, philosophy, and science is reported on in term papers. The course is elective.

Texts: Alpha, Frost; Xenophon's Anabasis; The Study of Greek Words in English, Including Scientific Terms, Hoffman.

Instructor: Macarthur.

HISTORY AND GOVERNMENT

PROFESSORS: JOHN R. MACARTHUR, WILLIAM B. MUNRO

ASSOCIATE: MAX FARRAND

ASSISTANT PROFESSOR: S. HARRISON THOMSON

INSTRUCTOR: RAY E. UNTEREINER

READER: JOHN H. MAXSON

UNDERGRADUATE SUBJECTS 5

H. 1 a, b, c. ANCIENT AND MEDIEVAL HISTORY. ~~4~~ 5 units (2-0-2); first, second and third terms.

Lectures and discussions upon the early civilizations out of which modern Europe developed, and upon the institutions of the Middle Ages. The students are referred to original sources in the library.

Texts: Ancient Times, Breasted; History of Western Europe, Vol. I, Robinson.

Instructors: Macarthur, Thomson

H. 2 a, b, c. MODERN EUROPEAN HISTORY. 6 units (2-0-4); first, second and third terms.

Prerequisite: En. 1 a, b, c.

The general political and social history of Europe from 1500 to 1926, presented as the background and development of movements underlying present conditions.

Instructors: Judy, Munro, Untereiner.

H. 5 a, b. CURRENT TOPICS. 2 units (1-0-1); first and second terms.

This course is given collaterally with En. 10, and is articulated with a selected weekly journal of general information and opinion.

H. 10. THE CONSTITUTION OF THE UNITED STATES. 2 units (1-0-1); third term.

A study of the principles and provisions of the national constitution in the light of present-day interpretation by the courts. Required of all seniors.

Instructor: Munro.

H. 14. HISTORY OF CHRISTIANITY. 9 units (3-0-6); third term.

Lectures and class work on the historical facts underlying the origin of Christianity, the rise and content of early Christian literature, and the growth of the Christian organization to the present time.

Text: Walker, History of the Christian Church.

Instructor: Thomson.

FIFTH-YEAR AND ADVANCED SUBJECTS

H. 100. SEMINAR IN AMERICAN HISTORY AND GOVERNMENT. 12 units (1-0-11); first, second and third terms.

Open only to fifth-year students and seniors who have attained honor grades.

First and Second terms: The Framing of the Federal Constitution (1786-1788), and the subsequent Development of Certain Constitutional Provisions, Farrand.

Third term: The Development of American Political Institutions During the Era Since the Civil War, Munro.

ECONOMICS

PROFESSOR: GRAHAM A. LAING

ASSISTANT PROFESSORS: HORACE N. GILBERT, CLYDE WOLFE

INSTRUCTOR: RAY E. UNTEREINER

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

UNDERGRADUATE SUBJECTS

EC. 2. GENERAL ECONOMICS. 6 units (3-0-3); first term.

The principles of economics governing the production, distribution, and consumption of wealth, with particular reference to some of the important business and social problems of the day.

Text: Economics, Vol. I, Fairchild.

Instructors: Laing, Untereiner.

EC. 3. ECONOMIC HISTORY. 2 units (1-0-1); second term.

The general purpose of the course is to show the dynamic nature of economic society. The various stages in the development of economic life from primitive beginnings to the industrial revolution are dealt with. The problems of economic organization that have arisen under a competitive and a quasi-competitive system are considered from the point of view of the causative and developmental influences which have produced them.

Text: Introduction to Economic History, Gras.

Instructor: Laing.

EC. 4. SELECTED ECONOMIC PROBLEMS. 4 units (2-0-2); second term.

Prerequisite: EC. 2.

A development of the course in General Economics, presenting a fuller treatment of specific problems such as: transportation, agriculture, labor legislation, socialism, present labor policies.

Text: Economics, Vol. II, Fairchild.

Instructors: Laing, Untereiner.

Ec. 10. MATHEMATICS OF FINANCE. 4 units (1-0-3); first term.

The mathematical theory underlying compound interest, annuities, and mathematical expectation, with application to such subjects as the accumulation of reserves, the amortization of debts, evaluation of bonds, partial payments, capitalized costs, and insurance.

Text: *Mathematics of Investment*, Hart.

Instructor: Wolfe.

Ec. 11. STATISTICS. 3 units (1-0-2); second term.

Statistical methods and the graphic portrayal of results, with their application to concrete business problems.

Text: *Elements of Statistical Method*, King.

Instructor: Wolfe.

Ec. 12. ECONOMIC HISTORY. 6 units (2-0-4); third term.

A more detailed treatment of the subjects discussed in Economics 3.

Text: *Introduction to Economic History*, Gras; and other reading to be assigned.

Instructor: Laing.

Ec. 14. TAXATION. 4 units (2-0-2); second term.

A study of the general principles of public expenditure and public revenues with special reference to American taxation methods.

Text: *Introduction to Public Finance*, Plehn.

Instructor: Untereiner.

Ec. 17. ACCOUNTING. 9 units (3-0-6); second 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: *Problems in Accounting Principles*, Walker.

Instructor: Gilbert.

Ec. 20. FINANCIAL ORGANIZATION. 8 units (3-0-5); third term.

Prerequisites: Ec. 2, 4.

A general study of the financial organization of society. The course includes a study of the following topics: Principles of money; nature and functions of credit; the varieties of credit instruments; the marketing of low and high grade securities; the functions of the corporation

and the stock exchange as capital-raising devices; the development of the banking system and the general principles of banking, including studies of commercial banking, the national banking system, and the Federal Reserve system.

Instructor: Laing.

Ec. 25. BUSINESS LAW. 6 units (3-0-3); third term.

The principles of law as applied to business affairs, including discussion of such fundamental topics as the definition of law, its sources, and a brief study of the law governing contracts, negotiable instruments, agency, partnership, corporations, and employer's liability.

Text: Business Law, Conyngton and Bergh.

Instructor: Untereiner.

Ec. 30 a, b. BUSINESS ADMINISTRATION. 8 units (3-0-5); first and second terms.

General consideration of the problems of business and more detailed study of the main problems, including location of industry and plant, scientific management, wage systems, labor relations, marketing and sales problems, financial organization and business risks, outlining principal forms of risk and methods of dealing with them. Discussion of the forms and varieties of business unit; individual producer, partnership, joint-stock company, and corporation. The principles and technique of foreign trade.

Instructor: Laing.

Ec. 34. CORPORATION FINANCE. 6 units (2-0-4); first term.

Corporation promotion; the issue and payment of securities; underwriting; the sale of speculative securities. Discussion of the principles of capitalization, the management of corporate income, and the relation of dividend to income. Financial problems of expansion, combination, and reconstruction of corporations.

Text: Corporation Finance, Dewing.

Instructor: Laing.

Ec. 45 a, b. SEMINAR IN SOCIAL AND ECONOMIC ORGANIZATION. 4 units (2-0-2); second and third terms.

This course consists in weekly lectures and discussions of the development of economic and social organization from a broad standpoint, and includes consideration of such subjects as primitive economic and political groupings and methods, development of gild and feudal systems, evolution of the competitive and quasi-competitive systems in economic life and democratic organization in political life. A considerable amount of outside reading is required from each student. The class

meets once a week for two hours, the first being devoted to lecture and the second to discussion of the problems treated in the lecture. The number of students is limited and the seminar is open to juniors and seniors.

Instructor: Laing.

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 in engineering.

This course presents the business aspects of engineering. There are four major divisions of the material: (a) a general description of the organization of business, with special attention to the activities which concern and offer opportunities to students trained in engineering; (b) the technology of business, including, more especially, accounting and statistics; (c) some principles of business economics, representing deduced generalizations based upon an observation of a large number of business situations; (d) an analysis of executive decisions in business to observe the executive point of view and to define the qualities exercised by business executives in the conduct of their affairs, as contrasted with the qualities used by engineers in the technical divisions of business. The case system of instruction developed by the Harvard Graduate Business School is employed throughout the course.

Text: An Introduction to Business, Gilbert and Gragg.

Instructor: Gilbert.

PHILOSOPHY, ETHICS AND SOCIOLOGY

ASSOCIATE: THEODORE G. SOARES

INSTRUCTOR: RAY E. UNTEREINER

UNDERGRADUATE SUBJECTS

Pl. 1. INTRODUCTION TO PHILOSOPHY. 9 units (3-0-6); second term.

A study of the development of Western thought and its issue in modern philosophy.

Text: John Herman Randall, *The Making of the Modern Mind*.

Instructor: Soares.

Pl. 4. ETHICS. 9 units (3-0-6); second term.

A study of the social experience exhibited in the Bible as a basis for a consideration of the evolution of morality. Modern problems of conduct in the light of this historical survey.

Texts: Soares, *Social Institutions and Ideals of the Bible*; Dewey and Tufts, *Ethics*.

Instructor: Soares.

Pl. 5. SOCIOLOGY. 9 units (3-0-6); third term.

The development of races, with a study of biological selection, physical adaptation, and the influence of climatic and geographical conditions. The genesis and evolution of the social organism, and the influence of the economic, religious, intellectual and political interests. A course in principles, with theses assigned for the application of these principles to specific social problems.

Instructor: Untereiner.

FIFTH-YEAR AND ADVANCED SUBJECTS

Pl. 100. A STUDY OF SOME ASPECTS OF PHILOSOPHICAL, ETHICAL OR SOCIAL DEVELOPMENT. 12 units; first, second and third terms.

Instructors: Soares, Judy.

Division of Physical Education

PHYSICAL DIRECTOR: WILLIAM L. STANTON

INSTRUCTOR: HAROLD Z. MUSSELMAN

ASSISTANTS: FRANK A. NICKELL, HARRISON S. THOMPSON (football), VAINO A. HOOVER, JOHN PRITCHETT (intramural sports), LAYTON STANTON (coach of freshmen), W. M. GOTTSCHALK (football and basketball), ARTHUR GRIFFITH (wrestling and boxing), OTTO SASS (wrestling), WILLIAM COGEN (boxing)

PHYSICIAN TO ATHLETES: DR. FLOYD L. HANES

ADVISER IN ATHLETICS: DAVID BLANKENHORN

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

The program of physical education is designed to give general physical development to all. When a student has completed the year's work he should exhibit some progress in attaining the following results: (1) strength and endurance, self-respecting and erect carriage of the body, and neuro-muscular control; (2) aggressiveness, self-confidence, courage, decision, perseverance, and initiative; (3) self-control, self-sacrifice, loyalty, cooperation, mental and moral poise, a spirit of fair play, and sportsmanship.

The required work is divided into three parts: (1) corrective exercises for those physically deficient; (2) group games; (3) fundamentals of highly organized athletics. This work is modified by various activities designed to encourage voluntary recreational exercises, including football, basketball, baseball, track and field athletics, boxing, swimming, wrestling, and other sports.

PE. 1, 2, 3, 4. PHYSICAL EDUCATION. 3 units; first, second and third terms.

The physical education program of the Institute is based on intramural and intercollegiate sports in which all students are required to participate during all four undergraduate years. The intramural sports comprise competition between classes, clubs, fraternities, in all sports, including football, cross-country running, track and field events, baseball, basketball, swimming, boxing, wrestling, tennis, handball, etc., and is required of all students not taking part in intercollegiate sports. The intercollege sports comprise competition with other members of the Southern California Intercollegiate Conference, of which the Institute is a member. Representative freshmen and varsity teams, trained by experienced coaches, in the major sports are developed. Fair-spirited and clean-cut athletic competition is encouraged as a part of the physical program for its social and physical values, and as a foundation for genuine college spirit. During the freshman and sophomore years, all students are given physical examinations and strength tests in the first and third terms. These tests are used as a basis of comparison with other men of the same weight and height. Corrective or special exercises are prescribed throughout the four years for those who cannot compete in intramural or intercollegiate sports.

Degrees Conferred, June 7, 1929

DOCTOR OF PHILOSOPHY

- MIGUEL ANTONIO BASOCO, B.A., University of California; M.S., University of Chicago
CHARLES ROBERT DAILY, A.B., Colorado College
ROBERT TROUTMAN DILLON, B.S. and M.S., California Institute of Technology
JESSE WILLIAM MUNROE DUMOND, B.S., California Institute of Technology; M.S. in E.E., Union College
JOHN DYER ELDER, B.S., University of Chicago
HAAKON MUUS EVJEN, E.E., Cornell University; M.S., California Institute of Technology
CLAUDE DEWAYNE HAYWARD, B.S. and M.S., California Institute of Technology
WILLIAM BERRARD HINCKE, B.S., University of Illinois
HOWARD BYINGTON HOLROYD, B.S., Iowa State College
H. DARWIN KIRSCHMAN, B.S. and M.S., California Institute of Technology
ROBERT TALBOT KNAPP, B.S., Massachusetts Institute of Technology
CHARLES CHRISTIAN LAURITSEN, Odense Tekniske Skole
WILLIAM ABBETT LEWIS, JR., B.S. and M.S., California Institute of Technology
MORRIS MUSKAT, B.A. and M.A., Ohio State University
NICOLAS MIKHAILOVICH OBROUKHOFF, University of Moscow; Technological Institute of Kharkov; E.E., Ecole Superieure d'Electricite de Paris
EMERSON MARTINDALE PUGH, B.S., Carnegie Institute of Technology; M.S., University of Pittsburgh
DUANE EMERSON ROLLER, B.A. and M.S., University of Oklahoma
RICHARD MANLIFFE SUTTON, B.S., Haverford College
ALBERT TITLEBAUM, A.B. and A.M., Columbia University
WILLY UYTERHOEVEN, C.E., University of Brussels
RALPH EDGAR WINGER, B.A., Baker University
WILLIAM GOULD YOUNG, B.A. and M.A., Colorado College

MASTER OF SCIENCE

PHYSICS

- THOMAS HENRY BRIGGS, JR., B.S., Wesleyan University
ROBLEY DUNGLISON EVANS, B.S., California Institute of Technology
EDWIN MATTISON McMILLAN, B.S., California Institute of Technology

CHEMISTRY

LEE REED BRANTLEY, A.B., University of California at Los Angeles
WILLIAM BRADLEY LEWIS, B.A., Williams College

GEOLOGY AND PALEONTOLOGY

THOMAS CLEMENTS, E.M., University of Texas
EDWARD CHARLES SANDBERG, B.S. and E.M., Michigan College of Mines
THOMAS SCOTT SOUTHWICK, B.S., California Institute of Technology

ELECTRICAL ENGINEERING

GEORGE RICHARD CRANE, B.S., California Institute of Technology
ANDREW VASILY HAEFF, E. and M.E., Polytechnic Institute of the Special Region of the Eastern Province, China
ROY FRIEND SLOCUM, B.A., University of Redlands
KARL MORGAN WOLFE, B.S., West Virginia University

MECHANICAL ENGINEERING

GUY LEWIS CHILBERG, B.S., California Institute of Technology
RICHARD GILMAN FOLSOM, B.S., California Institute of Technology
DOUGLAS GEORGE KINGMAN, B.S., California Institute of Technology
ALBERT EATON LOMBARD, JR., B.S., California Institute of Technology
ERNEST EDWIN SECHLER, B.S., California Institute of Technology

CIVIL ENGINEERING

RALPH WALDO CUTLER, B.S., California Institute of Technology
FERDINAND GUNNER GRAMATKY, B.S., California Institute of Technology
KENNETH HALL ROBINSON, B.S., California Institute of Technology
JOHN EGON SKAFTE, B.S., California Institute of Technology

Degrees Conferred—Continued

BACHELOR OF SCIENCE

(Stars indicate graduation with honor)

Science

ISADORE BERMAN
WILLIAM WALTER BOOTH
*JOHN WARLAUMONT DALY
*WILLARD ALEXANDER FINDLAY
KARL ALBERT GANSSE
MAURICE FRED HASLER
DONALD HALL JOHNSON
KENNETH EDWARD KINGMAN
KAM HU LAU
KENNETH ELMO LOHMAN
*STANLEY WILLIAM LOHMAN
WALLACE ANGUS McMILLAN
HOMER GORE MCWILLIAMS

*PHILIP GRIFFIS MURDOCH
*ALBERT EDWARD MYERS
WADSWORTH EGMONT POHL
RUSSELL WATSON RAITT
TRUE WILLIAM ROBINSON
ALFRED RUMMELSBURG
MILTON HEYER SPERLING
JOHN CLARK SUTHERLAND
GEORGE FREDERIC TAYLOR
LINTON PAUL EUGENE VON
BEROLDINGEN
ROBERT JAMES WHITE

Engineering

HARLAN ROBERT ASQUITH
EUGENE ATWATER
BILL BAKER
WILBERT WIESE BAUSTIAN
WILLIAM LITTEL BERRY
KNOWLTON ROOT BIRGE
CHARLES ASHTON BOSSERMAN
HORACE ALLEN CAMPBELL
DONALD SHERMAN CLARK
FREDERICK R. CLINE
DALLAS E. COLE
ALPHONSE CRAMER
*PHILIP CRAVITZ
HOWARD GRINDAL DODGE
JAMES WARING DUNHAM
ALLEN WINFIELD DUNN
THOMAS FARRER EDSON
JULIUS NELSON ESPINOSA
*THOMAS HAYHURST EVANS
*SIDNEY THOMAS EXLEY, JR.
BEVERLY FRANK FREDENDALL
ALBERT MUNROE GILMORE
WALTER BERT GRIMES
*LAWRENCE J. GRUNDER
VIVIAN LYMAN HOLDAWAY
ERNEST BRANCH HUGG
HAROLD MILTON HUSTON
HARRY JAMES KEELING
LEON KIBORT
*REYMOND JOHN KIRCHER
*ANTHONY JAMES LARRECQ

EDSON CHURCHILL LEE
LEONID VLADIMIR LEONARD
ROLAND WILLIAM LINDHURST
GEORGE SCHILD LUFKIN
LAURENCE EDWIN LYNN
DONALD BOOTH MILLIKEN
WILLIAM HENRY MOHR
MASAHIRO NAGASHI
JOSEPH ALLEN NILES
THOMAS JEFFERSON NOLAND, JR.
HUBERT MAURICE O'HAYER
SAMUEL OLMAN
FIRTH PIERCE
JOHN CLAY RAPP
*ALBERT CLARK REED
HOMER CHARLES REED
*BOLIVAR ROBERTS
RICHARD GOEBEL ROFELTY
KENNETH FREELS RUSSELL
KARL FRITZ SCHUMACHER
LESLIE OWEN SCOTT
JAMES CONRAD SCULLIN
CLYDE EMERSON SHIELDS
MORTON KINGMAN SHIELDS
MAURICE HAROLD SINRAM
FRANK WALDEN THOMPSON
ALFRED EDWARD TOWNE
GEORGE FRANCIS WEISMAN
KARL WILSON WESTLUND
FRED ASTON WHEELER
FREDERICK RUSSELL WILSON

Honors, 1929

JUNIOR TRAVEL PRIZES: HOWARD CARY, LOWELL GREEN, PHILIP JANSSEN,
FRANK MOYERS

SENIOR SCHOLARS: JOE FOLADARE, ROLAND HAWES, THEODORE STIPP, OSCAR
VAN BEVEREN

BLACKER JUNIOR SCHOLARS: LUCAS A. ALDEN, CARTER H. GREGORY,
ROBERT B. JACOBS, LAWRENCE E. KINSLER, RAYMOND A. PETERSON

BLACKER SOPHOMORE SCHOLARS: CLARK GOODMAN, CHAS. M. HARSII,
CHARLES W. JONES, WILLIAM L. KENT, J. G. SCHAAFSMA, CARL L.
THIELE

FRESHMAN SCHOLARS:

*THOMAS A. ANDREW, Brea Olinda High School

HARRIS STOUT BACKUS, Pasadena Junior College

EUGENE M. BRUNNER, Monrovia High School

CHARLES DuBOIS CORYELL, Alhambra City High School

SAMUEL YORKS JOHNSON, Pasadena Junior College

LAWRENCE JACKSON LASLETT, Santa Monica High School

WILLIAM ALVIN MERSMAN, Alhambra City High School

WALTER SCHOLTZ, Hollywood High School

REINHARDT SCHUHMAN, JR., Long Beach Polytechnic High School

ROBERT LESLIE SMALLMAN, Los Angeles High School

CONGER PEACE PRIZE:

WILLIAM CUTTS, RAYMOND A. CROMLEY

*Alumni Scholarship.

Graduate Students

NAME	MAJOR SUBJECT	HOME ADDRESS
AGER, RAYMOND WELLINGTON B.S., California Institute, 1922	E.E.	Pasadena
ANDERSON, ALFRED B. C. A.B., University of California at Los Angeles, 1928	Phys.	Los Angeles
ANDERSON, CARL DAVID B.S., California Institute, 1927	Phys.	Pasadena
ANDERSON, GEORGE HAROLD A.B., Stanford University, 1917; A.M., 1920	Geol.	Burbank
ARNQUIST, WARREN NELSON B.S., Whitman College, 1927	Phys.	Yakima, Washington
ATKINSON, RALPH BLAISDELL B.S., Massachusetts Institute of Technology, 1929	Phys.	Georgetown, Massachusetts
ATWATER, EUGENE B.S., California Institute, 1929	E.E.	Los Angeles
AVERILL, REX GILMAN B.S., Purdue University, 1905	E.E.	Pasadena
BAKER, BILL B.S., California Institute, 1929	A.E.	Piru
BARNES, DONALD PORTER B.S., Oregon State College, 1928	C.E.	Pasadena
BECK, DERWOOD ANTHONY B.A., Morningside College, 1929	A.E.	Sioux City, Iowa
BEELER, RAYMOND ARTHUR B.A., Pomona College, 1927	Phys.	Pasadena
BELKNAP, KENNETH ALBERT B.S., California Institute, 1927	Eng.	Los Angeles
BIDDLE, RUSSELL LEE B.S., University of Pittsburgh, 1925; M.A., Columbia University, 1928	Biol.	Crafton, Pennsylvania
BLACKBURN, JOHN FRANCIS B.S., University of Chicago, 1926	Phys.	Hollywood
BLEAKNEY, WILLIAM MCCHESENEY B.S., Whitman College, 1926	Phys.	Pasadena
BOREN, JACK SCARBOROUGH B.A., University of Redlands, 1927	E.E.	Los Angeles
BOTSFORD, JAMES LAWRENCE B.A., University of Washington, 1928	Phys.	Seattle, Washington
BOWEN, WILLIAM HAROLD B.S., University of California, 1928	A.E.	Pasadena
BOWMAN, JOHN RIDGWAY B.S., University of Pittsburgh, 1929	Phys.	Pittsburgh, Pennsylvania
BRAHTZ, JOHN HENRY AGUSTUS B.S., Royal Technical College in Copenhagen, 1911; M.S., 1914	Phys.	Copenhagen, Denmark
BRANTLEY, LEE REED A.B., University of California at Los Angeles, 1927 M.S., California Institute, 1929	Chem.	Los Angeles
BRASS, PHILIP DAVIS B.S., Yale University, 1928	Chem.	Elmwood, Connecticut
BROADWELL, SAMUEL JONATHAN B.S., Throop College of Technology, 1918; M.S., University of Chicago, 1920	Phys.	Los Angeles
BUCKLEY, EDMOND COLLINS E.E., Rensselaer Polytechnic Institute, 1927	Phys.	Pasadena

NAME	MAJOR SUBJECT	HOME ADDRESS
CAMPBELL, J. STUART B.S., California Institute, 1926	Phys.	Pasadena
CARTWRIGHT, CHARLES HAWLEY B.S., California Institute, 1926	Phys.	San Gabriel
CASSEN, BENEDICT A.R.C.S., Imperial College of Science and Technology, London, England, 1927 M.S., California Institute, 1928	Phys.	Long Beach
CHAO, CHUNG-YAO B.S., National Southeastern University, Nanking, China, 1927	Phys.	Chu-Ki, Chekiang, China
CHENG, YU-FUNG B.S., National Central University, Nanking, China, 1925	Phys.	Tze, Chekiang, China
CLARK, DONALD SHERMAN B.S., California Institute, 1929	M.E.	Bakersfield
CLEMENTS, THOMAS E.M., University of Texas, 1922; M.S., California Institute, 1929	Geol.	Hollywood
CLIFFORD, ALFRED HOBLITZELLE B.A., Yale University, 1929	Phys.	Pasadena
CLINE, FREDERICK R. B.S., California Institute, 1929	C.E.	Covina
CRAIN, JOHN JAY M.E., Cornell University, 1896	Phys.	Wallingford, Connecticut
DALY, JOHN WARLAUMONT B.S., California Institute, 1929	Geol.	Buena Park
ENGEL, RENE L. H. B.S., University of Paris, 1909; M.S., 1912	Geol.	Pasadena
ERICKSON, ELLIS OSMON B.S., University of North Dakota, 1923	E.E.	Pasadena
EVANS, ROBLEY DUNGLISON B.S., California Institute, 1928; M.S., 1929	Phys.	Pasadena
EVANS, THOMAS HAYHURST B.S., California Institute, 1929	C.E.	Los Angeles
EWING, FREDERICK JUNIOR B.S., California Institute, 1927	Chem.	Pasadena
FINDLAY, WILLARD ALEXANDER B.S., California Institute, 1929	Geol.	Avalon
FOCKE, ALFRED BOSWORTH B.S., Case School of Applied Science, 1928	Phys.	Pasadena
FOLSOM, RICHARD GILMAN B.S., California Institute, 1928; M.S., 1929	M.E.	Pasadena
GAZIN, CHARLES LEWIS B.S., California Institute, 1927; M.S., 1928	Geol.	Pasadena
GOTTSCHALK, WINSTON MALCOLM B.S., Princeton University, 1929	Phys.	Washington, D. C.
HABLUTZEL, CHARLES EDWARD A.B., Stanford University, 1925; A.M., 1926	Phys.	San Jose
HAEFF, ANDREW VASILY Electrical and Mechanical Engineer, Polytechnic Institute of the Special Region of the Eastern Province, 1928; M.S., California Institute, 1929	E.E.	Harbin, China
HARTMAN, EDWIN PHELPS M.E., Marquette University, 1929	A.E.	Waupaca, Wisconsin
HASLER, MAURICE FRED B.S., California Institute, 1929	Phys.	West Hollywood
HASSLER, GERALD L. B.A., Washington University, 1926; M.S., 1928	Phys.	St. Louis, Missouri
HERGENROTHER, RUDOLF CLEMENS B.S., Cornell University, 1925; M.S., Pennsylvania State College, 1928	Phys.	Pasadena
HETHERINGTON, WILLIAM ALFORD A.B., Columbia College, 1926; M.A., Columbia University, 1927	Biol.	Walnut Creek

NAME	MAJOR SUBJECT	HOME ADDRESS
HO, TSENG-LOH B.S., National Central University, Nanking, China, 1927	Phys.	Patow, Chuki, Chekiang, China
HOARD, JAMES LYNN B.S., University of Washington, 1927; M.S., 1929	Chem.	Seattle, Washington
HOLDAWAY, VIVIAN LYMAN B.S., California Institute, 1929	E.E.	Los Angeles
HOOVER, VAINO ALEX B.S., California Institute, 1927; M.S., 1928	E.E.	Pasadena
HOYT, ARCHER B.A., Whitman College, 1927	Phys.	Berkeley
HUFF, LORENZ DITMAR A.B., University of Oklahoma, 1927; M.S., 1928	Phys.	Norman, Oklahoma
HUGG, ERNEST BRANCH B.S., California Institute, 1929	C.E.	Huntington Park
HULTGREN, RALPH RAYMOND B.S., University of California, 1928; M.S., University of Utah, 1929	Chem.	Los Angeles
JEFFREYS, CECIL E. P. B.A., University of Texas, 1925; M.A., 1927	Chem.	San Angels, Texas
KEELING, HARRY JAMES B.S., California Institute, 1929	M.E.	Los Angeles
KENNISON, LAWRENCE SANFORD A.B., Dartmouth College, 1926; A.M., Brown University, 1928	Math.	Ayer, Massachusetts
KEYES, RAYMOND STEDMAN M.E., United States Naval Academy, 1929	A.E.	San Diego
KINNEY, EDWARD EVERETT B.S., Michigan State College, 1915	E.E.	Lansing, Michigan
KIRKPATRICK, HARRY ALLISTER B.S., Occidental College, 1914	Phys.	Eagle Rock
LASH, CHARLES COYLE B.S., California Institute, 1928	E.E.	Los Angeles
LEE, EDSON CHURCHILL B.S., California Institute, 1929	Phys.	Petoskey, Michigan
LEERMAKERS, JOHN ANDREWS B.S., Iowa State College, 1928; M.S., 1929	Chem.	Omaha, Nebraska
LEWIS, CHARLTON MINER B.A., Yale University, 1929	Phys.	New Haven, Connecticut
LEWIS, WILLIAM BRADLEY B.A., Williams College, 1927; M.S., California Institute, 1929	Chem.	Los Angeles
LINDEGREN, CARL CLARENCE B.S., University of Wisconsin, 1922; M.S., 1923	Biol.	Pasadena
LOHMAN, KENNETH ELMO B.S., California Institute, 1929	Geol.	Pasadena
LOHMAN, STANLEY WILLIAM B.S., California Institute, 1929	Geol.	Pasadena
LUFKIN, GEORGE SCHILD B.S., California Institute, 1929	A.E.	Los Angeles
LUPHER, RALPH LEONARD B.A., University of Oregon, 1926; M.A., 1927	Geol.	Eugene, Oregon
MARTIN, ROBERT SAMUEL A.B., University of Pittsburgh, 1929	Math.	Gary, Indiana
MAXSON, JOHN HAVILAND B.S., California Institute, 1927; M.S., 1928	Geol.	Pasadena
MAXSTADT, FRANCIS WILLIAM M.E., Cornell University, 1916; M.S., California Institute, 1925	E.E.	Pasadena
McRAE, DANIEL BRENT B.S., University of Utah, 1926	Chem.	Alhambra

NAME	MAJOR SUBJECT	HOME ADDRESS
MICHEL, WALTER CHRISTIAN B.S., Rensselaer Polytechnic Institute, 1927	Phys.	Pasadena
MILLS, ROSCOE HARLAN B.A., Pomona College, 1928	A.E.	Hollywood
MOHR, WILLIAM HENRY B.S., California Institute, 1929	C.E.	Santa Monica
MOORE, BERNARD NETTLETON B.S., California Institute, 1927	Geol.	Los Angeles
MOSLEY, LOUIE WARREN B.A., University of Texas, 1926	A.E.	Lubbock, Texas
MOUZON, JAMES CARLISLE A.B., Southern Methodist University, 1927	Phys.	Abilene, Texas
MUNRO, GEORGE CLARKSON A.B., University of California at Los Angeles, 1929	Phys.	Rifle, Colorado
MURDOCH, PHILIP GRIFFIS B.S., California Institute, 1929	Chem.	Pasadena
NAGASHI, MASAHIRO HOWARD B.S., California Institute, 1929	A.E.	Delta, Utah
NEHER, HENRY VICTOR B.A., Pomona College, 1926	Phys.	Pasadena
NICKELL, FRANK ANDREW B.S., California Institute, 1927; M.S., 1928	Geol.	Los Angeles
OLMAN, SAMUEL B.S., California Institute, 1929	C.E.	Los Angeles
OSWALD, W. BAILEY B.A., University of California at Los Angeles, 1927	A.E.	Los Angeles
PLEASANTS, JOHN GIBSON B.S., University of Southern California, 1929	E.E.	Los Angeles
POHL, WADSWORTH EGMONT B.S., California Institute, 1929	Chem.	Redlands
POMEROY, RICHARD DURANT B.S., California Institute, 1926	Chem.	Pasadena
POSNER, EZRA C. M.E., Cornell University, 1924	A.E.	Rochester, New York
PUGH, ROBERT EUGENE, JR. B.A., Lake Forest College, 1929	Phys.	Lake Forest, Illinois
RAVITZ, SOL FREDERICK B.A., University of Utah, 1927; M.A., 1928	Chem.	Salt Lake City, Utah
REED, HOMER CHARLES B.S., California Institute, 1929	A.E.	Glendale
REVELLE, ROGER B.A., Pomona College, 1929	Geol.	Claremont
RHOADES, MARCUS MORTON B.S., University of Michigan, 1927; M.S., 1928	Biol.	Manhattan, Kansas
RICE, STEPHEN OSWALD B.S., Oregon State Agricultural College, 1929	Math.	Waldport, Oregon
RICHARDSON, BURT Ph.B., Yale University, 1919	Phys.	Glendale
ROMER, ALFRED B.A., Williams College, 1928	Phys.	Brooklyn, New York
RUMBAUGH, LYNN HAMILTON A.B., Miami University, 1928	Phys.	Carthage, Missouri
SAGE, BRUCE HORN BROOK B.S., New Mexico College of Agriculture and Mechanical Arts, 1929	Chem.	State College, New Mexico
SCHOTT, HERMANN FRANZ B.S., California Institute, 1926	Chem.	Pasadena
SCOVILLE, LOREN P. A.B., University of Redlands, 1928	Ch.E.	Pasadena

NAME	MAJOR SUBJECT	HOME ADDRESS
SECHLER, ERNEST EDWIN B.S., California Institute, 1928; M.S., 1929	A.E.	Pasadena
SHAPELL, MAPLE DELOS B.S., University of Arizona, 1921	Geol.	Temple City
SHERMAN, JACOB HENRY B.S., University of California, 1929	Chem.	San Francisco
SKINNER, SELBY MILLMORE B.S., University of Washington, 1928	Phys.	Seattle, Washington
SMITH, HUBERT HENRY A.B., University of Redlands, 1928	M.E.	Phoenix, Arizona
STANTON, W. LAYTON B.S., California Institute, 1927	Geol.	Sierra Madre
STAPP, FREDERICK PEARCE A.B., Stanford University, 1927	Ch.E.	Pasadena
STENZEL, RICHARD WERNER B.S., California Institute, 1921	Chem.	Pasadena
STURDIVANT, JAMES HOLMES B.A., University of Texas, 1926; M.A., 1927	Chem.	Greenville, Texas
SUTHERLAND, JOHN CLARK B.S., California Institute, 1929	Geol.	Pasadena
SWARTZ, CHARLES ALBERT B.S., California Institute, 1927	Phys.	Pasadena
TAYLOR, DANIEL DWIGHT A.B., Colorado College, 1924	Phys.	Pasadena
TAYLOR, GEORGE FREDERIC B.S., California Institute, 1929	Geol.	Los Angeles
THORNDIKE, EDWARD MOULTON B.S., Wesleyan University, 1926; A.M., Columbia University, 1927	Phys.	Montrose, New York
URMSTON, JOSEPH WINCHESTER A.B., University of California at Los Angeles, 1928	Chem.	San Marino
VAN DEN AKKER, JOHANNES ARCHIBALD B.S., California Institute, 1926	Phys.	Los Angeles
WADDINGTON, GUY B.A., University of British Columbia, 1928	Chem.	Victoria, B. C., Canada
WAITE, HOWARD WINFRED B.S., California Institute, 1929	A.E.	Burbank
WELLMAN, HOMER BIGELOW B.A., Carleton College, 1926; M.S., University of Michigan, 1927	Chem.	Cape Town, South Africa
WENNER, RALPH RICHTER B.S., Cooper Union Institute of Technology, 1926; M.S., Northwestern University, 1927	Chem.	Pasadena
WILLIAMSON, ROBERT POLLOCK B.S., Virginia Military Institute, 1927	E.E.	Greenville, Kentucky
WOLF, JOHN RICHARD B.A., Yale University, 1929	Phys.	New York, New York
WOLFE, KARL MORGAN B.S., West Virginia University, 1925; M.S., California Institute, 1929	E.E.	Kingwood, West Virginia
WOO, SHO-CHOW B.S., National Central University, Nanking, China, 1925	Chem.	Ping-Hsiang, Kiangsi, China
WORRALL, GEORGE HOBSON A.B., Temple University, 1929	Phys.	Collingswood, New Jersey
YUAN, HAN-CHING B.S., Tsing Hua University, Peiping, China	Chem.	Nantuangchow, Kiangsu, China
ZAHORSKI, ADAM TEODOR B.S.E., University of Michigan, 1928	A.E.	

Undergraduate Students

Abbreviations: Eng., Engineering; Sci., Science; E.E., Electrical Engineering; M.E., Mechanical Engineering; C.E., Civil Engineering; Ch., Chemistry; Ch.E., Chemical Engineering; Ph., Physics; Ge., Geology; Ma., Mathematics; A.E., Aeronautical Engineering.

Students whose names are starred attained honor standing during the preceding year, obtaining 145 credits in any one or more terms, 130 of which resulted from grades of three and four in non-italicized subjects.

SENIOR CLASS

NAME	COURSE (OPTION)	HOME ADDRESS
Alderman, Frank Edward	Eng.(C.E.)	Santa Ana
Allison, Donald Kreeck	Sci.(Ch.E.)	Los Angeles
Anderson, John Edward	Eng.(E.E.)	Pasadena
Ayers, Wilbur Walter	Eng.(A.E.)	Highgrove
Baker, Howard Eugene	Eng.(C.E.)	Los Angeles
Bechtold, Ira Christian	Sci.(Ch.E.)	Anaheim
*Bernhardi, Tom George	Sci.(Ch.E.)	Los Angeles
Blohm, Clyde Lehnhard	Sci.(Ch.E.)	Los Angeles
Bode, Francis Dashwood	Sci.(Ge.)	South Pasadena
Boyle, James Robert Lester	Eng.(M.E.)	Santa Ana
Brasher, Bert Vessie	Sci.(Ch.E.)	Walnut Park
*Bungay, Robert Henry, Jr.	Eng.(M.E.)	Glendale
Butler, Albert	Eng.(E.E.)	Santa Barbara
Carberry, Deane Edwin	Eng.(C.E.)	Pasadena
*Carlson, Chester Floyd	Sci.(Ph.)	Pasadena
Cary, Henry Howard	Eng.(C.E.)	Los Angeles
*Chamberlain, Glenn John	Eng.(E.E.)	San Diego
Clark, John Drury	Sci.(Ch.)	Fairbanks, Alaska
Coupland, Bert Russell	Eng.(E.E.)	Los Angeles
Crane, Horace Richard	Sci.(Ph.)	Turlock
*Crawford, Franklin Goodrich	Eng.(M.E.)	Pasadena
*Cromley, Raymond Avalon	Sci.(Ph.)	Long Beach
Deardorff, Herbert Hadley	Eng.(C.E.)	Pasadena
de Camp, Lyon Sprague	Eng.(A.E.)	Los Angeles
Doherty, Norman Frederick	Sci.(Ch.E.)	Los Angeles
Downs, Roscoe Phillips	Eng.(C.E.)	North Hollywood
*Eastman, Harvey Selden	Sci.(Ch.E.)	Pasadena
Effmann, Karl Herman	Eng.(M.E.)	Los Angeles
Elliott, Orrin Mathews	Eng.(M.E.)	San Diego
Ellis, Emory Leon	Sci.(Ch.)	San Diego
Ellis, Eugene Vance	Eng.(E.E.)	Okmulgee, Oklahoma
Foladare, Joe	Sci.(Ph.)	Los Angeles
Fracker, Henry Edward	Eng.(E.E.)	Pasadena
Gates, Clinton Eugene	Eng.(E.E.)	Pasadena
Gaylord, John Wallace	Sci.(Ch.E.)	Pasadena
Giebler, Clyde Edgar	Eng.(E.E.)	Los Angeles
Grant, Edmund Glen	Eng.(M.E.)	Long Beach
Green, Lowell Forrest	Sci.(Ph.)	Santa Ana

NAME	SUBJECT	HOME ADDRESS
*Groch, Fred Reston	Eng.(E.E.)	Los Angeles
Hall, John Leland	Eng.(E.E.)	Los Angeles
*Hamilton, John Douglas	Sci.(Ch.E.)	Sawtelle
Hatch, William Bell, Jr.	Eng.(C.E.)	Ypsilanti, Michigan
Hawes, Roland Cyril	Sci.(Ch.)	Rapid City, South Dakota
Hesse, John Fred, Jr.	Eng.(E.E.)	Las Vegas, Nevada
Hillman, Ernest Christian	Eng.(C.E.)	Los Angeles
Hiyama, Thomas Tamotsu	Eng.(E.E.)	Pasadena
Hoch, Winton Christoph	Sci.(Ph.)	Pacific Palisades
Hodder, Roland Frederick	Sci.(Ge.)	Glendale
*Hoeppel, Raymond Winfield	Sci.(Ch.E.)	Arcadia
Hopper, Rea Earl	Eng.(A.E.)	Riverside
Howse, Samuel Eric	Eng.(E.E.)	West Hollywood
Ignatieff, Alex Ivan	Eng.(E.E.)	Pasadena
Imus, Henry Oscar	Sci.(Ph.)	Los Angeles
Janssen, Otto Philip	Sci.(Ch.)	Pomona
Johnson, Josef Jerome	Sci.(Ph.)	Altadena
Jones, Harlen R. E.	Eng.(M.E.)	Fresno
Kelley, William Francis	Eng.(E.E.)	Santa Monica
Kleinbach, Hugo Otto	Eng.(M.E.)	Glendale
Koehm, Edward	Eng.(C.E.)	Los Angeles
Kuhn, Truman Howard	Sci.(Ge.)	Glendora
Leppert, Melvin Lawrence	Eng.(E.E.)	Monrovia
Levine, Ernest	Eng.(C.E.)	Los Angeles
Liedholm, George Edward	Sci.(Ch.E.)	Long Beach
Lord, Roy Stanley	Eng.(C.E.)	Pasadena
MacDonald, James H.	Eng.(C.E.)	Pasadena
Maitland, William Blackstock	Sci.(Ge.)	Glendale
Mason, Harry Shattuck	Eng.(C.E.)	Los Angeles
Mauzy, Harris Kenneth	Eng.(C.E.)	South Pasadena
*McLean, Ralph Stewart	Eng.(C.E.)	Brea
McMillan, John Robertson	Eng.(M.E.)	Los Angeles
*Miles, Kenneth Leonard	Eng.(C.E.)	Santa Barbara
Mitchell, Gordon Sylvester	Eng.(E.E.)	Hollywood
Moss, Harland Ray	Sci.(Ch.E.)	Los Angeles
Moyers, Frank Neff	Eng.(M.E.)	Highgrove
Muff, Elmer Mason	Eng.(M.E.)	Glendale
Murray, John Stalker	Sci.(Ph.)	Pasadena
Myers, Henry Glysson	Eng.(M.E.)	Artesia
Nelson, Warren Campbell	Sci.(Ch.E.)	Los Angeles
Nomann, Arthur Behrend	Eng.(E.E.)	Whittier
Nye, Lawrence Carlton	Sci.(Ph.)	Pacific Palisades
Pritchett, Jack Dean	Eng.(E.E.)	Cabazon
*Read, George Wilber	Eng.(E.E.)	Glendale
Reilly, James Thomas	Sci.(Ge.)	Pasadena
*Reynard, Willard Grant	Sci.(Ch.E.)	Los Angeles
Reynolds, George Lawrence	Eng.(C.E.)	Glendale
Riggs, William Christopher	Eng.(A.E.)	Pasadena
Ross, George Arthur	Eng.(E.E.)	Fillmore
Russell, Lloyd Wallace	Eng.(E.E.)	Pasadena
*Sass, Otto	Sci.(Ch.)	Los Angeles

NAME	SUBJECT	HOME ADDRESS
Sawyer, Herbert Goodman	Sci.(Ph.)	Napa
*Scharf, David Walter	Sci.(Ge.)	Los Angeles
Scott, Frederick Schell	Sci.(Ch.E.)	Pasadena
*Sheffet, David	Eng.(E.E.)	Venice
*Shields, John Charles	Eng.(A.E.)	Pasadena
Shuey, Clyde Wellar	Eng.(E.E.)	St. Bernice, Indiana
Silverman, Michael Morris	Eng.(M.E.)	Los Angeles
Smith, Richard Hale	Sci.(Ph.)	South Pasadena
Springsholz, Charles Adolph	Eng.(C.E.)	Santa Barbara
Stein, Myer Samuel	Eng.(E.E.)	Los Angeles
*Stipp, Theodore Frank	Eng.(E.E.)	Glendale
*Stirton, Robert Ingersoll	Sci.(Ch.)	Los Angeles
*Strong, Austin Webber	Eng.(E.E.)	San Diego
Sturgess, Jack Bainbridge	Eng.(M.E.)	Glendale
*Suzuki, Katsunoshin	Eng.(M.E.)	Kanagawa, Ken, Japan
Swift, Frederick Thayer, Jr.	Eng.(E.E.)	Altadena
Thayer, Eugene Merlin	Eng.(E.E.)	Huntington Park
*Towler, John William	Eng.(A.E.)	Santa Barbara
*Trostel, Everett G.	Sci.(Ph.)	Santa Ana
Tucker, Merrill Douglas	Sci.(Ge.)	Alhambra
Van Beveren, Oscar Franz	Sci.(Ge.)	Hollywood
Weise, Carl Arthur	Eng.(A.E.)	Tustin
*West, Samuel Stewart	Sci.(Ph.)	Pasadena
*Wheeler, George Richard	Eng.(E.E.)	Richgrove
White, Dudley Lawton	Eng.(A.E.)	Los Gatos
Whitman, Nathan Davis, Jr.	Eng.(C.E.)	South Pasadena
*Wilkinson, Walter Dunbar	Sci.(Ch.)	Santa Barbara
Wilmot, Charles Alfred	Sci.(Ch.)	Imperial
*Wilson, Robert Warren	Sci.(Ge.)	Los Angeles
Zahn, Oswald Francis	Eng.(M.E.)	Coronado
*Zipser, Sidney	Eng.(E.E.)	Los Angeles

JUNIOR CLASS

NAME	COURSE	HOME ADDRESS
*Alden, Lucas Avery	Sci.(Ch.)	Montrose
*Amann, Jack Huber	Eng.	Pasadena
*Anderson, Maynard Marion	Eng.	San Diego
Atwood, Albert William, Jr.	Eng.	Washington, D. C.
Axline, Rea Andrew	Eng.	Norwalk
Babcock, William Chapman	Sci.(Ge.)	Los Angeles
Barnett, Richard James	Eng.	Temecula
Bell, Thomas William	Eng.	Whittier
Bennett, Elliott Powell	Eng.	Los Angeles
Biggers, John Carter	Eng.	Alhambra
Bolles, Lawrence William	Sci.(Ge.)	Santa Ana
Boothe, Perry Mattison	Eng.	Los Angeles
Bovee, John Leroy, Jr.	Eng.	Anaheim
Bowen, George Henry	Sci.(Ch.E.)	Los Angeles
Brooks, Arthur Clinton	Eng.	Balboa
Bruce, Philip Lester	Sci.(Ch.E.)	Newtonville, Massachusetts
*Buffum, Charles Emery	Sci.(Ph.)	Long Beach
Bussey, George Leland	Eng.	Los Angeles
*Cate, Paul Herman	Sci.(Ch.E.)	Los Angeles
Cogen, William Maurice	Sci.(Ge.)	Los Angeles
*Coleman, Robert Prewitt	Sci.(Ph.)	Pasadena
Connable, Harry Stanton	Eng.	Hollywood
Cordes, Nelson Myers	Eng.	Los Angeles
*Crawford, Albert Thomas	Sci.(Ch.E.)	Santa Ana
Crawford, John Henry	Eng.	Los Angeles
Crossman, Edward Bishop	Sci.(Ge.)	Brentwood Heights
Detweiler, John Struss	Sci.(Ch.)	Los Angeles
Dickerman, Charles Edwin	Eng.	Altadena
Dickey, Walter Linn	Eng.	Eagle Rock
*Dorman, Stephen Charles	Sci.(Ch.E.)	San Bernardino
Eastman, Samuel Clare	Eng.	Los Angeles
*Eberz, William Ferdinand	Sci.(Ch.E.)	Altadena
*Ferguson, Lawrence LaVerne	Eng.	Glendale
Folsom, Theodore Robert	Sci.(Ph.)	San Diego
Ford, Frank Hubert	Eng.	Porterville
Frye, Calvin Barton	Eng.	San Diego
Futcher, Ralph Allan	Eng.	Vancouver, B. C., Canada
Girard, John Emile	Eng.	Los Angeles
Grafman, Abraham Jack	Eng.	Hollywood
Green, Edwin Francis	Eng.	Los Angeles
*Gregory, Carter Holt	Sci.(Ch.)	San Marino
*Griffin, Robert Hardy	Eng.	San Diego
Guhl, Robert Hills	Eng.	Los Angeles
Gunderson, Norman Robert	Sci.(Ch.)	Randsburg
Hacker, William Dillon, Jr.	Eng.	Pasadena
Hall, Marvin William	Eng.	Los Angeles
*Hatcher, John Burton	Sci.(Ch.)	Los Angeles
Holman, Emmette Rudolph	Sci.(Ch.)	Pasadena
Holzman, Benjamin	Sci.(Ch.E.)	Los Angeles

NAME	SUBJECT	HOME ADDRESS
Horton, Warren Birch	Eng.	Fargo, North Dakota
Humphreys, Wendell Lewis	Eng.	Huntington Park
Hutchinson, Francis	Eng.	Crockett
Ingham, Herbert Smith	Eng.	Los Angeles
*Jacobs, Robert Byron	Sci.(Ph.)	Santa Monica
*Jecker, Duroc Albert	Sci.(Ch.E.)	Los Angeles
Johnson, Byron Bethune	Eng.	St. Louis, Missouri
Johnston, William Elmore, Jr.	Eng.	Van Nuys
*Jurling, Theodore Waldemar	Eng.	Los Angeles
Keachie, Edward Chester	Eng.	Los Angeles
*Kinsler, Lawrence Edward	Sci.(Ph.)	Los Angeles
*Kircher, Charles Edmund, Jr.	Sci.(Ch.E.)	El Paso, Texas
Kuykendall, Charles Edwin	Sci.(Ch.E.)	South Pasadena
Labory, Raymond Frary	Eng.	Los Angeles
Laird, Francis Neil	Sci.(Ch.E.)	Alhambra
Leeper, Laverne	Eng.	San Bernardino
Lehman, Robert Marshall	Eng.	Pasadena
Levine, Alex Herbert	Sci.(Ma.)	Long Beach
Lewis, Charles Kimmel	Eng.	Santa Ana
Lewis, George Edward	Eng.	Pasadena
Longyear, Edmund Joseph, Jr.	Eng.	Altadena
*Matison, Harry	Sci.(Ph.)	Pasadena
McGarry, Jack Felbert	Eng.	Hermosa Beach
Mehl, John Wilbur	Sci.(Ch.)	Upland
Merrithew, William Sterling	Eng.	Los Angeles
Miller, Glen Wellington	Eng.	Glendale
Montgomery, John Cochran	Sci.(Ph.)	Pasadena
*Morris, Ross Elliott	Sci.(Ch.E.)	Hollywood
Murdock, DeWolfe	Eng.	Santa Ana
Nelson, Theron Lyle	Sci.(Ph.)	Sacramento
Newby, Oscar McMullin	Eng.	Glendale
Newcomb, Daniel Albert	Sci.(Ch.E.)	Corona
Olmsted, Ennis Gunning	Eng.	Glendale
*Overhage, Carl F. J.	Sci.(Ph.)	Weida, Thüringen, Germany
Peer, Edward Stephen	Sci.(Ch.)	Long Beach
*Peterson, Raymond Alfred	Sci.(Ge.)	Denver, Colorado
Pratt, Leland DeWitt	Sci.(Ch.E.)	Huntington Park
Rice, George Skidmore	Eng.	Alhambra
Robinson, Roger Theophilus	Sci.(Ch.E.)	Altadena
Sarno, Dante Hector	Sci.(Ch.E.)	Pasadena
*Shull, George Orval	Sci.(Ch.)	Los Angeles
Sinnette, John T.	Sci.(Ch.)	Pasadena
*Smith, Robert Graves	Eng.	Riverside
Smits, Howard Gardner	Eng.	Glendale
*Stipp, Charles Klopp	Eng.	Glendale
Sweet, Carl Herbert	Sci.(Ch.)	Minneapolis, Minnesota
Tarbet, Thomas Vernon	Eng.	Pasadena
Thompson, Isadore	Eng.	Los Angeles
Townsend, Arthur Ornes	Eng.	Sedalia, Missouri
Tutschulte, Alvin Carl	Eng.	Los Angeles
*Ugrin, Nick Thomas	Eng.	Los Angeles

NAME	COURSE (OPTION)	HOME ADDRESS
Ung, Philip Fay	Eng.	Los Angeles
Van Reed, Mabry	Eng.	San Diego
Voak, Alfred Suter	Eng.	Atascadero
*Webb, Glenn Miller	Sci.(Ch.E.)	Los Angeles
West, William Textor	Eng.	Hollywood
White, Thomas Robert	Sci.(Ch.)	Redlands
Wiling, Arnold Philip	Sci.(Ch.)	Pasadena
Wilson, Roger Montgomery	Sci.(Ph.)	Pasadena
Wineland, Jeff Andrew	Eng.	Durham
Yoshioka, Carl Kaorn	Eng.	Los Angeles
*Zabaro, David	Eng.	Los Angeles

SOPHOMORE CLASS

NAME	COURSE	HOME ADDRESS
Adams, William Avanzino	Eng.	Long Beach
*Anderson, David William	Eng.	Alhambra
*Anderson, Thomas Foxen	Sci.	Glendale
Arnerich, Paul Frank	Eng.	Pasadena
Arnold, Emmer Joseph	Sci.	Los Angeles
Ayers, John Kimball	Eng.	Los Angeles
Barton, Millard Vernon	Eng.	Hollywood
Bascom, John Dwight	Sci.	Pasadena
*Bates, Dana Barker	Eng.	Santa Monica
Beckman, Harold Porter	Eng.	Santa Ana
Behlow, Lewis Bushnell	Eng.	Alhambra
Bergren, William Raymond	Sci.	Pasadena
Berry, William Ladew	Eng.	Yonkers, New York
Bland, Reginald Barrett	Sci.	Pasadena
Bonner, James Fredrick	Sci.	Salt Lake City, Utah
Bonner, Lyman Gaylord	Sci.	Salt Lake City, Utah
Bowden, Frederick William	Eng.	San Luis Obispo
Bowler, Gordon E.	Eng.	Pomona
Braasch, Albert Carl	Sci.	Eagle Rock
*Bradburn, James Rupert	Eng.	Los Angeles
Brakesman, Gordon	Eng.	Los Angeles
*Brown, Rupert Arthur	Sci.	Pasadena
Bruderlin, Henry Hurst	Eng.	Los Angeles
Burman, Paul Gustav	Eng.	San Gabriel
*Carey, Robert VanPelt	Eng.	South Pasadena
*Cawley, Clifford Comer	Eng.	Los Angeles
Chambers, John Voris	Eng.	Redondo
*Claussen, William Hammerich	Sci.	Altadena
Cline, Franklin Joseph, Jr.	Sci.	Covina
Cogen, Sol	Sci.	Los Angeles
Cox, John Luther	Eng.	Alhambra
Crater, Myron Lee	Eng.	Pasadena
Dean, Arthur Malcolm	Sci.	Chula Vista
*Elconin, Victor	Sci.	Los Angeles
Feely, Martin Gerald	Eng.	Los Angeles
Finney, Howard William	Sci.	Los Angeles
Foss, Robert Edwin	Eng.	Rivera

NAME	COURSE	HOME ADDRESS
Freeman, Orville Wallace	Eng.	Pasadena
Freeman, Robert Braman	Eng.	Pasadena
Gelber, Murray Samuel	Sci.	Los Angeles
Giddings, Sylvester Nahum	Eng.	Riverside
*Goodman, Clark	Sci.	Los Angeles
Gould, Laurence Keeney	Eng.	Alhambra
Graff, Donald Badger	Eng.	Pasadena
Gregory, Jackson, Jr.	Sci.	Altadena
Grieger, John Miller	Sci.	Pasadena
Griswold, Edward Allen	Sci.	Alhambra
Groat, William	Sci.	Whittier
Hamlin, Charles Frederick	Eng.	San Luis Obispo
Hanson, Henry Foster	Eng.	Oklahoma City, Oklahoma
Harmon, Cliver	Eng.	San Diego
*Harsh, Charles Maxfield	Sci.	Eagle Rock
Harshman, Elbert Nelson	Sci.	Los Angeles
Hastings, Allen	Eng.	Pasadena
Hayes, Edward Adams	Eng.	El Monte
Haymaker, Herbert Eugene	Sci.	Van Nuys
Haynes, Benarthur Castle	Eng.	Pasadena
Hegardt, Karl Edward	Eng.	Downey
Hibbs, Frank John, Jr.	Eng.	Los Angeles
Hill, James W.	Eng.	Los Angeles
Horn, Aubrey	Eng.	South Pasadena
*Huntley, Walter Palmer	Eng.	Tustin
Iwasaki, Tetsuo	Eng.	Los Angeles
James, George Hall	Eng.	Denair
*Jones, Charles Wright	Eng.	Long Beach
Josenhans, John Frederick	Sci.	Chicago, Illinois
Keeley, Kedric Vincent	Eng.	El Monte
*Kent, William Lyon	Sci.	Covina
Killgore, Cecil Lloyd	Eng.	Hollywood
Lani, Leslie Vincent	Eng.	Elko, Nevada
*Larsen, Delmar Herman	Sci.	Sherman
Lind, Carl Frank	Eng.	Los Angeles
*Lipp, James Everett	Eng.	Eagle Rock
Love, James Herman	Eng.	Chatsworth
Maass, Randal Oscar	Sci.	Anaheim
Maes, Alvin James	Eng.	Los Angeles
Mathews, Thomas Edwin	Eng.	Glendale
*McKinley, John Daniel	Eng.	Alhambra
McLaughlin, James Patrick	Eng.	Redondo Beach
Morgan, Richard David	Sci.	Meacham, Oregon
Morse, Barnard Alexander	Eng.	Altadena
Nicholson, Hunter, Jr.	Sci.	Los Angeles
Noble, Robert James	Eng.	San Diego
*Oelschlager, Ray Troy	Eng.	Kaweah
Oulton, Thomas Dixon	Sci.	Pasadena
Packer, Walter Hamilton	Sci.	Philadelphia, Pennsylvania
Page, Hollis Bem	Sci.	Sawtelle
Parsons, Paul Gates	Eng.	Hermosa Beach

NAME	SUBJECT	HOME ADDRESS
Paulson, Walter Henderson	Eng.	Pasadena
Pelzel, Robert E.	Sci.	Los Angeles
Persson, Sture Henning	Eng.	Halsingborg, Sweden
*Pickering, William Hayward	Eng.	Christchurch, New Zealand
Pier, Everett Harry	Eng.	Monrovia
*Polk, Wendell Robert	Eng.	Los Angeles
Pownall, Henry Bland	Eng.	Santa Monica
Prudames, Edwin Mott	Eng.	Los Angeles
Pruden, Worrell Franzoni	Eng.	Los Angeles
Rau, William Charles	Sci.	Las Vegas, Nevada
Ritter, John	Eng.	Whittier
Roach, Harold	Eng.	Los Angeles
Rockefeller, William Curtis	Eng.	Salt Lake City, Utah
Rossall, Kenneth Brown	Eng.	Glendale
Rule, Bruce Herbert	Eng.	Los Angeles
Saylor, William Henry	Eng.	Covina
*Schaafsma, Jan Gerard	Sci.	Honolulu, T. H.
Schoeller, Charles Philip	Sci.	Palmdale
Schuhart, Mervin Arno	Eng.	Pasadena
*Schultz, Behrend Carl	Eng.	Los Angeles
*Schultz, Henry William	Eng.	Pasadena
Schultz, William Francis	Eng.	Los Angeles
Searle, Richard Allen	Eng.	Los Angeles
Seavey, Walter Kelley	Eng.	Pasadena
*Sheffet, Joseph	Eng.	Venice
Shockley, William	Sci.	Los Angeles
Shuler, William Reeves	Eng.	El Monte
Simpkinson, Arthur Albert	Sci.	Pasadena
Skaredoff, Nicolai Nicolaevich	Eng.	Yokahama, Japan
Skoog, Folke Karl	Sci.	Alhambra
Smith, Alvin Joseph	Eng.	Pasadena
Solomon, Hyman	Sci.	Los Angeles
Sparling, Jack Norman	Eng.	Glendale
St. Clair, Robert Woodland	Eng.	Glendale
Taylor, James Benjamin	Sci.	Wildomar
*Thiele, Carl Leslie	Sci.	Hollywood
Thomas, Richard Notley	Eng.	Riverside
Tickner, Alvin Joseph	Sci.	Pasadena
Vander Goot, Herbert Albert	Eng.	Glendora
Van Wingen, Nico	Eng.	Pasadena
Venerable, Grant Delbert	Eng.	Los Angeles
Warfel, John Spencer	Eng.	Los Angeles
Watson, George Gilbert	Eng.	Torrance
Wengren, Frank Eric	Eng.	Pasadena
Wheeler, George	Eng.	Oceano
Wherritt, Robert Glay	Eng.	Los Angeles
*White, Wayne Bertrand	Sci.	Los Angeles
*Wilson, Chester Eugene	Sci.	North Hollywood
Wilson, William Wayne	Eng.	Pasadena
Wofford, George	Eng.	Los Angeles
*Wolfe, Halley	Sci.	Porterville
*Zuckerman, Herbert Samuel	Sci.	Berkeley

FRESHMAN CLASS

NAME	HOME ADDRESS
Allen, Robert James	Fullerton
Anderson, Henry Fredrik	Pasadena
Andrew, Thomas Adelbert	Brea
Backus, Harrison Stout	Pasadena
Bamberger, Sidney Francis	Venice
Barker, Neal Dow	Altadena
Barlow, Wilson Howell	Long Beach
Barnett, Earl Edgar	Pasadena
Beach, Elbert Hubbard	Glendale
Beckerlegge, Bernard Drake	Los Angeles
Bender, David Fulmer	Spokane, Washington
Berkley, George Merrill	Pasadena
Bernstein, Theodore Isra	Los Angeles
Blossom, Howard Clifford	St. Louis, Missouri
Bly, Victor Earl	Santa Barbara
Bonillas, Ygnacio	Hollywood
Bower, Evan George	Long Beach
Braun, Carl Allan	Pasadena
Brown, Everett Francis	Ventura
Brunner, Eugene Mittell	Monrovia
Buckingham, Norman Claggett	Glendale
Bulnes, Alfonso Carlos	Durango, Dgo., Mexico
Burch, Kenyon Colburn	Los Angeles
Burk, Thomas Copeland	Hollywood
Byrne, Ralph Edward, Jr.	Kansas City, Missouri
Carleton, Lee Thurston	Los Angeles
Clark, Dave Lewis	Pasadena
Cole, Robert William	Los Angeles
Colodny, Mortimer Doris	Hollywood
Cook, David Arthur	Hollywood
Core, Edwin John	Glendale
Coryell, Charles DuBois	Wilmar
Craig, Philip Henry	Burbank
Crawford, Edgar Grenfelle	Pasadena
Dack, Bruce M.	Hollywood
Dames, Trent Raysbrook	San Diego
Davis, III, Madison Thenton	Pasadena
DeFoe, Gordon Frank	Spokane, Washington
DeMilita, Joseph	Los Angeles
Dessery, Gerald Morrison	Los Angeles
Detmers, Fred Henry	Los Angeles
Doolittle, Kenneth Everett	Oakland
Downie, Arthur James	Los Angeles
Earle, Halford	Berkeley
Efromson, Philip Charles	Los Angeles
Eisen, Nathan	Los Angeles
Emerich, Robert Lee	Hollywood
Fletcher, Robert Dawson	Santa Ana
Fort, Robert Oscar	Los Angeles
Foster, Robert Warren	Pasadena

NAME	HOME ADDRESS
Franklin, Elmer Sherwood	Los Angeles
Gardener, Cornelius Allen	Los Angeles
Getzman, Edwin Samuel, Jr.	Claremont
Gordy, George Baxter, Jr.	Pasadena
Goss, Louis Harold	San Gabriel
Graham, Alexander Joseph	Long Beach
Greene, Clarence Kirk	Hollywood
Grimes, Joseph Wilbur	Glendale
Grossman, Robert Brown	Beverly Hills
Hallinger, Lawrence	Alhambra
Hartmann, Gregory Kemenyi	Pasadena
Heinrich, Albert	Pasadena
Hess, Marion	Atascadero
Hinshaw, Meral William	Pasadena
Hofmann, Oliver Dimmitt	Bell
Hogan, Robert Charles	Durango, Colorado
Hohneck, Wallace Robert	Hollywood
Hooks, Thomas William	Edinburg, Texas
Ingels, Julius Girard	Huntington Park
Johnson, James Stanley	Pasadena
Johnson, Norman Stanley	Pasadena
Johnson, Samuel Yorks	Pasadena
Judd, David Stuart	Honolulu, T. H.
Judson, Jack Finlay	Pasadena
Keim, Gordon Bartlett	Los Angeles
Kelso, Albert P.	Los Angeles
Kennedy, Edwin Russell	Los Angeles
Kenny, Allen Ross	Pasadena
Kullberg, John Earl	Kingsburg
Kurata, Fred	Rialto
Laslett, Lawrence Jackson	San Marino
Lawton, Watson Freeman	Sheffield, Illinois
Lentz, John Adolph	Phoenix, Arizona
Lewis, Wyatt Hunter	Glendora
Lindeborg, Abner Benjamin	Norway, Michigan
Lloyd, James Stanley	Los Angeles
Lyon, Charles Gersham	Los Angeles
Lyon, Frederick William	Los Angeles
Macdonald, Robert George	Hollywood
MacKay, Robert William	Hollywood
Madden, Albert Spencer	Pasadena
Margiot, Loring Kirby	Los Angeles
Marlow, Douglas George	Newport Beach
Mathewson, Arthur Adelbert, Jr.	Coronado
Matson, Edward Jean	Altadena
McCleery, Walter Lyde	Honolulu, T. H.
McCord, Charles Joseph	Ojai
McGirk, Lon Soland	El Monte
Mead, Robert Rufus	Pasadena
Mehm, Joseph Aloysius	Altadena
Mendenhall, John Dale	Van Nuys

NAME	HOME ADDRESS
Mersman, William Alvin	Alhambra
Monning, John Chester	Los Angeles
Moore, William Wallace	Pasadena
Morgan, Wendal Alton	Los Angeles
Muller, Jerome Joseph	Los Angeles
Munson, Frank Herbert	Puente
Nelson, Wesley Walter	Turlock
Newcombe, Dennis Arthur	Hollywood
Nixon, John Whitney	San Rafael
Olds, Earl Mortimer	Los Angeles
Osborne, LeRoy Robert	Hollywood
Palm, Bernhard Nelson	Pasadena
Palmer, Durward Harry	Fullerton
Parker, Eugene Vail	Los Angeles
Parker, Richard Tudor	Los Angeles
Pauly, William Charles	Los Angeles
Pearson, Harold E.	Pasadena
Perrine, Charles Dillon	Hermosa Beach
Pickett, George Henry	Pasadena
Pierce, John Robinson	Pasadena
Pipes, Louis Albert	South Pasadena
Poulson, Donald Frederick	Idaho Falls, Idaho
Prior, Christian Henry	Santa Monica
Ransome, Alfred Leslie	Pasadena
Robbins, Henry Walter	Los Angeles
Robinette, Willard Clement	Prescott, Arizona
Roeding, Fred Charles	Berkeley
Russell, Richard Lord	Long Beach
Scholtz, Walter	Los Angeles
Schuhmann, Reinhardt, Jr.	Gunnison, Colorado
Schulz, Clarence G.	Los Angeles
Sharp, John Wilfred	Pasadena
Sharp, Robert Chapin	Alhambra
Simpson, Winchell Heath	South Pasadena
Smallman, Robert Leslie	Los Angeles
Smith, Arthur Lamont Bill	Kansas City, Missouri
Smith, Apollo Milton Olen	Long Beach
Smith, Warren Howard	Pasadena
Snearly, James Edmund	Long Beach
Spade, James Clifton	Huntington Park
Spicer, Charles Bryson	Los Angeles
Stewart, Harry Edwin	Globe, Arizona
Stirling, Cedric Warren	Pasadena
Suhr, Henry Bruno	Deep Springs
Sullwold, John	Pacific Palisades
Terrill, Thomas Starr	Pasadena
Thompson, Alverdo Earnest	Los Angeles
Tillman, Charles Emil	San Pedro
Tucker, Kenneth Hugh	Pasadena
Vogt, John Thompson	Hemet
Waterhouse, Richard Seymour	San Jose

NAME	HOME ADDRESS
Webber, John Tufts	Pasadena
Weinstein, Nicholas	Palms
Welton, Francis Graves	Alhambra
Wheeler, William Thornton	Richgrove
Whipple, Galt Levi	Idaho Falls, Idaho
Whittaker, William Robert	Los Angeles
Widess, Moses	Pasadena
Wisher, Franklin Rudolph	San Diego
Wright, Norman Hall	Pasadena

SPECIAL STUDENT

NAME	COURSE	HOME ADDRESS
Wynkoop, Stratton	Eng.	Pasadena

SUMMARY

GRADUATE SCHOOL

National and International Research Fellows.....	12	
Commonwealth Fund Fellows.....	4	
Guggenheim Fund Fellow.....	1	
Japanese Foreign Research Scholar.....	1	
Research Fellows of the Institute.....	8	
Graduate Students: Physics.....	47	
Chemistry and Chemical Engineering	26	
Mathematics	3	
Geology	17	
Biology	4	
Engineering	40	
	163	163

UNDERGRADUATE SCHOOL

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