VOLUME XL NUMBER 133

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, 1931

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for

1931-1932

PASADENA, CALIFORNIA

DECEMBER, 1931

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Calendar

1932

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International Relations

OTTO SCHMIDT, PH.D., DR.ENG.
Applied Chemistry

Staff of Instruction and Research

Robert Andrews Millikan, Ph.D., LL.D., Sc.D., Nobel Laureate
Professor of Physics
Director of the Norman Bridge Laboratory of Physics
Chairman of the Executive Council

A.B., Oberlin College, 1891; A.M., 1893; Ph.D., Columbia University, 1895. Assistant in Physics, University of Chicago, 1896-1897; Associate, 1897-1899; Instructor, 1899-1902; Assistant Professor, 1902-1907; Associate Professor, 1907-1910; Professor, 1910-1921. 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; University of Southern California, 1931; Ph.D. (hon.), King John Casimir University, Lwów, Poland, 1926; University of Ghent, 1927; Docteur Honoris Causa, University of Liege, 1930; Vice-President, American Association for the Advancement of Science, 1911; President, 1929; President, American Physical Society, 1916-1918; Lieutenant Colonel, U. S. A., and Chief, Science and Research Division of Signal Corps, 1917-1919; American Representative, Troisiême Conseil de Physique, Solvay, Brussels, 1921; Exchange Professor, Belgium, 1922; American Representative, Committee on Intellectual Cooperation, League of Nations, 1922-. Fellow of the Oberlaendar Trust, 1931. 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, Royal Accademia della Scienze Dell' Istituto Bologna, Accademie Lincei Rome. Hon. Member, Royal Institution of Great Britain, La Société Hollandaise des Sciences, Royal Irish Academy, Die Gesellschaft der Wissenschaften zu Göttingen, Bayeresche Akademie der Wissenschaften zu Muenchen, Association des Ingenieurs de Liege. Recipient of Comstock Prize, National Academy of Sciences, 1913; of Edison Medal of the American Institute of Electrical Engineers, 1922; of the Nobel Prize in Physics of the Royal Swedish Academy, 1923; of the Hughes Medal of the Royal Society of Great Britain, 1923; of the Faraday Medal of the London Chemical Society, 1924; of the Matteucci Medal of the Societa Italana della Scienze, 1925; of the Gold Medal of the American Society of Mechanical Engineers, 1926; of the Messel Medal of the Society of Chemical Industry of England, 1928; of the Gold Medal of the Society of Arts and Sciences, 1929, and of the Gold Medal of the Radiological Society of North America, 1930. Chevalier de l'Ordre National de la Legion d'Honneur, 1931. California Institute, 1916-

1640 Oak Grove Avenue

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., University of Kentucky, 1886; M.S., 1888; Ph.D., Johns Hopkins University, 1890. Professor of Biology, Bryn Mawr College, 1891-1904; Professor of Experimental Zoology, Columbia University, 1904-1928. LL.D., Johns Hopkins University, 1915; University of Kentucky, 1916; McGill University, 1921; University of Edinburgh, 1922; University of California, 1930; Sc.D., University of Michigan, 1924; Ph.D. (Dr. of Nat. Phil.), Heidelberg University, 1931. Fellow of the American Association for the Advancement of Science (President, 1930); Member, American Philosophical Society; President, National Academy of

Sciences, 1927-1931; Member, Linnean Society of London; Royal Society of Sciences of Denmark; Foreign Member, Royal Society of London; Finnish Society of Sciences; Associate Member, Société Royale des Sciences Medicales et Naturelles de Bruxelles; Society Belge de Biologie, Bruxelles; Société de Biologie de France; Corresponding Member, Zoological Society of London; Académie des Sciences de Russie; Bavarian Academy of Sciences; Honorary Member, Royal Irish Academy; Ordinary Member, Royal Society of Sciences of Upsala; Foreign Associate, Royal Accademia Nazionale dei Lincei, Rome; Correspondent, Academie des Sciences, Institut de France. California Institute, 1928-

1149 San Pasqual Street

William Bennett Munro, Ph.D., LL.D., Litt.D.

Professor of History and Government

Member of the Executive Council

B.A., Queens University, 1895; M.A., 1896; LL.B., 1898; M.A., Harvard University, 1899; Ph.D., 1900, M.A. (hon.), Williams College, 1904; LL.D., Queens University, 1912; Litt.D., University of Southern California, 1930; Parker Traveling Fellow, Harvard University, 1900-1901; Instructor in History and Political Science, Williams College, 1901-1904; Instructor in Government, Harvard University, 1904-1906; Assistant Professor of Government, 1906-1912; Professor of Municipal Government, 1912-1925; Jonathan Trumbull Professor of American History and Government, 1925-1930; Chairman of the Division of History, Economics and Government, Harvard University, 1920-1928; Weil Foundation Lecturer, University of North Carolina, 1921; McBride Foundation Lecturer, Western Reserve University, 1925; Jacob H. Schiff Foundation Lecturer, Cornell University, 1926; Marfleet Lecturer, University of Toronto, 1929; President of the American Association of University Professors; 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.

Professor of Chemistry

Director of the Gates Chemical Laboratory

Member of the Executive Council

S.B., Massachusetts Institute of Technology, 1886; S.M., 1887; Ph.D., University of Leipzig, 1890; LL.D., University of Maine, 1908; Clark University, 1909; University of Pittsburgh, 1915; Sc.D. (hon.), Harvard University, 1909; Yale University, 1913. Assistant and 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

Edward Cecil Barrett, B.A.

Secretary of the Institute

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

942 North Chester Avenue

HARRY BATEMAN, PH.D.

Professor of Mathematics, Theoretical Physics, and Aeronautics

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

1101 San Pasqual Street

STUART JEFFERY BATES, PH.D.

Professor of Physical Chemistry

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

2011 Rose Villa Street

ERIC TEMPLE BELL, PH.D.

Professor of Mathematics

A.B., Stanford University, 1904; A.M., University of Washington, 1908; Ph.D., Columbia University, 1912. Instructor, Assistant Professor, Associate Professor, University of Washington, 1912-1922; Professor, 1922-1926. Bôcher Prize, American Mathematical Society, 1924; Vice-President, American Mathematical Society, 1926-; Colloquium Lecturer, American Mathematical Society, 1927. Professor, summer quarters, University of Chicago, 1924-1928; Visiting Lecturer, Harvard University, first half 1926. Vice-President, American Association for the advancement of Science, 1929-1930; President, Mathematical Association of America, 1931-. Member of National Academy of Sciences. California Institute, 1926-

434 South Michigan Avenue

JAMES EDGAR BELL, PH.D.

Professor of Chemistry

S.B., University of Chicago, 1905; Ph.D., University of Illinois, 1913. Graduate student, University of Chicago, 1908-1910. Instructor in Chemistry, University of Washington, 1910-1911, 1913-1916. Associate Professor, California Institute, 1916-1918; Professor, 1918-

R. D. 1, Box 639

IRA SPRAGUE BOWEN, PH.D.

Professor of Physics

A.B., Oberlin College, 1919; Ph.D., California Institute of Technology, 1926. Assistant in Physics, University of Chicago, 1920-1921. Instructor, California Institute, 1921-1926; Assistant Professor, 1926-1928; Associate Professor, 1928-1931; Professor, 1931-

1848 Keystone 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. Instructor, California Institute, 1911-1913; Assistant Professor, 1913-1914; Associate Professor, 1914-1918; Professor, 1918-

95 South Mentor Avenue

Robert L. Daugherty, M.E.

Professor of Mechanical and Hydraulic Engineering

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

373 South Euclid Avenue

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

Visiting Professor of Physiographic Geology

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

441 South Chester Avenue

Paul Sophus Epstein, Ph.D.

Professor of Theoretical Physics

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

359 South Michigan Avenue

Beno Gutenberg, Ph.D.

Professor of Geophysics

Technische Hochschule, Darmstadt, 1907; Universität Göttingen, 1908; Ph.D., 1911. Assistant Zentral Büro der Internationalen Seismologischen Vereinigung, Strassburg, 1913-1914; Reichszentrale fuer Erdbebenforschung, Strassburg, 1914-1919; Privatdozent fuer Geophysik, Universität Frankfurt A/M, 1924-1926; A. O. Professor, 1926-1930. Member of Committee on Physics of the Earth (subsidiary Committee on Internal Constitution of the Earth) of the National Research Council, Washington, 1927. California Institute, 1930-

131 Annandale Road

Frederic W. Hinrichs, Jr., M.A.

Professor of Mechanics

Dean of Upper Classmen

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

1071 Garfield Avenue

William Vermillion Houston, Ph.D.

Professor of Physics

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

2428 Ridgeway Road, San Marino

Clinton Kelly Judy, M.A.

Professor of English Language and Literature

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

1325 Woodstock Road, San Marino

Theodor von Kármán, Ph.D., Dr. Ing.

Professor of Aeronautics

Director of the Daniel Guggenheim Laboratory

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

1620 East California Street

William Noble Lacey, Ph.D.

Professor of Chemical Engineering

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

334 South Berkeley Avenue

Graham Allan Laing, M.A.

Professor of Economics and Business Administration

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

1081 Elizabeth Street

John Robertson Macarthur, Ph.D.

Professor of Languages

Dean of Freshmen

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

866 South Pasadena Avenue

Romeo Raoul Martel, S.B.

Professor of Structural Engineering

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

690 South Mentor Avenue

Linus Pauling, Ph.D.

Professor of Chemistry

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

1245 Arden Road

Frederick Leslie Ransome, Ph.D.

Professor of Economic Geology

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

543 South San Marino Avenue

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

Professor of Ethics

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

1542 Morada Place, Altadena

Royal Wasson Sorensen, E.E.

Professor of Electrical Engineering

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

384 South Holliston Avenue

Chester Stock, Ph.D.

Professor of Paleontology

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

1633 Linda Vista Avenue

Alfred Henry Sturtevant, Ph.D.

Professor of Genetics

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

410 South Oakland 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-. Associate Professor, California Institute, 1913-1914; Professor, 1914-

685 South El Molino Avenue

Richard Chace Tolman, Ph.D.

Professor of Physical Chemistry and Mathematical Physics

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

345 South Michigan Avenue

Harry Clark Van Buskirk, Ph.B.

Professor of Mathematics

Registrar

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

390 South Holliston Avenue

Earnest Charles Watson, Ph.B.

Professor of Physics

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

1124 Mar Vista Avenue

John August Anderson, Ph.D.

Research Associate in Astrophysics*

Executive Officer of the Observatory Council

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

994 Poppy Street, Altadena

Samuel Jackson Barnett, Ph.D.

Research Associate in Physics

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

900 Malcolm Avenue, Westwood Hills, Los Angeles

Avery Craven, Ph.D.

Associate in American History

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

1215 Boston Street, Altadena

Godfrey Davies, M.A.

Associate in English History

Resident Associate in Ricketts House

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

Ricketts House

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

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

Jesse William Monroe DuMond, Ph.D.

Research Associate in Physics

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

1585 Homewood Street, Altadena

Max Farrand, Ph.D., L.H.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; L.H.D., Wesleyan University, 1928; LL.D., Occidental College, 1928, Pomona College, 1928; University of Southern California, 1930; University of Michigan, 1931. 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-

1650 Orlando Road, San Marino

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-

Seeley G. Mudd, M.D.

Research Associate in Radiation

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

415 South Grand 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

Russell Williams Porter, M.S.

Associate in Optics and Instrument Design

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

615 South Mentor Avenue

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

HENRY SWAIN SIMMS, PH.D.

Associate in Biochemistry of the Rockefeller Institute

B.S., Massachusetts Institute of Technology, 1920; Ph. D., Columbia University, 1922. Fellow, Assistant, and Associate in Chemistry of the Rockefeller Institute, New York, 1920-1926; Associate in Chemistry of the Rockefeller Institute, Princeton, N. J., 1926-1931. California Institute, 1931-

1660 Loma Vista Street

CARL CLAPP THOMAS, M.E.

Associate in Engineering Research

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

165 Linda Vista Avenue

HARRY OSCAR WOOD, M.A.

Research Associate in Seismology

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

220 North San Rafael Avenue

LOUIS BOOKER WRIGHT, PH.D.

Associate in English Literature

A.B., Wofford College, 1920; M.A., University of North Carolina, 1924; Ph.D., 1926. Instructor in English, University of North Carolina, 1925-1927; Research Scholar, Johns Hopkins University, 1927-1928; Guggenheim Research Fellow in England and Italy, 1928-1929; Visiting Professor, Emory University, winter quarter, 1929; Assistant Professor of English, University of North Carolina, 1929-. Visiting Scholar of the Huntington Library, 1931-. California Institute, 1931-

6 Sierra Bonita Place

ERNEST GUSTAF ANDERSON, PH.D.

Associate Professor of Genetics

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

831 Sunset Boulevard, Arcadia

Roscoe Gilkey Dickinson, Ph.D.

Associate Professor of Physical Chemistry

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

530 Bonita Avenue

Horace Nathaniel Gilbert, M.B.A.

Associate Professor of Business Economics

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

4 Terrace Villa

Alexander Goetz, Ph.D.

Associate Professor of Physics

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

1185 Banyon Street

Charles Christian Lauritsen, Ph.D.

Associate Professor of Physics

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

1671 Oakdale Street

Howard Johnson Lucas, M.A.

Associate Professor of Organic Chemistry

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

97 North Holliston Avenue

Samuel Stuart Mackeown, Ph.D.

Associate Professor of Electrical Engineering

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

1240 Arden Road

George Rupert MacMinn, A.B.

Associate Professor of English Language and Literature

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

255 South Bonnie Avenue

William W. Michael, B.S.

Associate Professor of Civil Engineering

B.S., in Civil Engineering, Tufts College, 1909. With New York City on topographic surveys, 1909-1911; with The J. G. White Engineering Corporation, 1912-1913 and 1915; Instructor, Department of Drawing and Design, Michigan Agricultural College, 1914; Office Engineer with The Power Construction Company of Massachusetts, 1914-1915; in private engineering practice, 1916-1918. Engineer, Palos Verdes Estates, summer of 1922; Associate and Consulting Engineer with County Engineer, Ulster County, N. Y., summers of 1925, 1928-1931. 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, No. 5

William L. Stanton, B.A.

Physical Director

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

515 Manzanita Avenue, Sierra Madre

Luther Ewing Wear, Ph.D.

Associate Professor of Mathematics

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

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 of International Education Board, California Institute, 1925-1927; Assistant Professor, 1927-1929; Associate Professor, 1929-

Athenæum

Richard McLean Badger, Ph.D.

Assistant Professor of Chemistry

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

215 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. Teaching Fellow, California Institute, 1923-1924; 1926-1928; Instructor, 1928-1929; Assistant Professor, 1929-

1301 Topeka Street

William Noel Birchby, M.A.

Assistant Professor of Mathematics
Assistant Registrar

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

251 South Catalina Street

Henry Borsook, Ph.D.

Assistant Professor of Biochemistry

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

154 Marion Avenue

Ian Campbell, Ph.D.

Assistant Professor of Petrography

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

627 Drexel Place

THEODOSIUS DOBZHANSKY
Assistant Professor of Genetics

Diploma, University of Kiev, 1921. Assistant in Zoology, Polytechnic Institute of Kiev, 1921-1924. Lecturer in Genetics, University of Leningrad, 1924; Research Fellow, Bureau of Genetics, Russian Academy of Sciences, 1926. Research Fellow in Biology of the International Education Board, California Institute, 1928-1929; Assistant Professor, 1929-

680 Santa Barbara Street

HERMAN ELISA DOLK, PH.D.
Assistant Professor of Plant Physiology

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

328 Palmetto Drive

HARVEY EAGLESON, PH.D.
Assistant Professor of English Language and Literature
Resident Associate in Blacker House

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

Blacker House

ROBERT EMERSON, PH.D.
Assistant Professor of Biophysics

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

1742 North Holliston 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-

541 South Madison Avenue

PHILIP SHEARER FOGG, M.B.A.
Assistant Professor of Business Economics
Resident Associate in Fleming House

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

Fleming House

EDWARD LEON HARVEY, M.A.
Assistant Professor of History

B.A., Oxford University, Final Honour School of Modern History, 1915; M.A., 1921. Senior Assistant Master (History), The Heath School, Halifax, Yorkshire, 1915. Military Service in France and India, 1915-1919. Professor of English and Modern History, University of New Brunswick, Canada, 1919-1927; Acting Professor of European History, University of Washington, 1927-1928; Professorial Lecturer in European History, University of Minnesota, 1928-1929; Visiting Professor of European History, University of Washington Summer School, 1929; Acting Assistant Professor of History, Stanford University, 1929-1930. Fellow of the Royal Historical Society, 1921. Visiting Scholar, Huntington Library, 1930-. California Institute, 1930-

1124 East Del Mar Street

Hugh Martin Huffman, Ph.D.

Assistant Professor of Biochemistry

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

1872 Wagner Street

William Huse, Jr., M.A.

Assistant Professor of English Language and Literature
Resident Associate in Dabney House

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-

Dabney House

Arthur Louis Klein, Ph.D.

Assistant Professor of Aeronautics

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

Athenæum

Robert Talbot Knapp, Ph.D.

Assistant Professor of 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; Consulting Engineer, Riverside Cement Company, 1927-1929; American Society of Mechanical Engineers Freeman Scholar in Europe, 1929-1930. Instructor, California Institute, 1922-1930; Assistant Professor, 1930-

2526 North Roosevelt Avenue

Frederick Charles Lindvall, Ph.D.

Assistant Professor of Electrical Engineering

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

262 South Sierra Bonita Avenue

Clark Blanchard Millikan, Ph.D.

Assistant Professor of Aeronautics

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

2700 Inverness Drive

J. ROBERT OPPENHEIMER, PH.D.
Assistant Professor of Theoretical Physics

B.A., Harvard University, 1925; Ph.D., University of Göttingen, 1927. Associate Professor of Theoretical Physics, University of California, 1930-. California Institute, 1928-

HERMAN C. RAMSPERGER, PH.D.
Assistant Professor of Organic 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, Stanford University, 1927-1928. National Research Fellow, California Institute, 1928-1930; Assistant Professor, 1930-

286 South Chester Avenue

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; Assistant Professor, 1927-

120 North Chester Avenue

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

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

Athenæum

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. Teaching Fellow, California Institute, 1919-1920; Instructor, 1920-1928; Assistant Professor, 1928-

1131 Lura Street

S. HARRISON THOMSON, PH.D.*
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. California Institute, 1929-

8756 Bonner Drive, Los Angeles

*On leave of absence, 1931-32.

Ray Edward Untereiner, A.M.*

Assistant Professor of 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. Instructor, California Institute, 1925-1930; Assistant Professor, 1930-

Morgan Ward, Ph.D.

Assistant Professor of Mathematics

A. B., University of California, 1924; Ph.D., California Institute of Technology, 1928. Assistant in Mathematics, California Institute, 1925-1926; Teaching Fellow, 1926-1928; Research Fellow, 1928-1929; Assistant Professor, 1929-

241 South Holliston 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. Dean, Santa Rosa Junior College, 1919-1920. Instructor, California Institute, 1920-1921; Assistant Professor, 1921-

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; duPont Fellow, California Institute, 1924-1925; Teaching Fellow, 1925-1926; Research Fellow, 1926-1927; Instructor, 1927-1929; Fellow of the International Education Board, 1928-1929. Assistant Professor, 1929-

360 South Wilson Avenue

Edward Dunster Kremers, M.D.

Consulting Physician

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

2315 Mar Vista Avenue, Altadena

William Beard, B.S.

Instructor in Government

B.S., in Sanitary and Municipal Engineering, Massachusetts Institute of Technology, 1928. Research Assistant to the Joint Committee on Taxation and Retrenchment of the New York State Legislature, 1928-1929. California Institute, 1931-

Athenæum

*On leave of absence, 1931-32.

REGINALD BLAND
Director of Orchestra

California Institute, 1926-

609 North Hill Avenue

MARTIN LUDWIG DETLOFF BUNGE, LIC.TH.
Instructor in Modern Languages

Lic.Th., Wartburg Seminary, Dubuque, Iowa, 1899; Pastor and principal of private schools near Marshfield and Green Lake, Wisconsin, 1899-1909. Teacher of Latin and German at Green Lake Public High School, 1909-1911. Teacher of German, Milwaukee Public Schools, 1911-1913. Editor of German and English periodicals of Turner Publishing Company, 1913-1918. Private Teacher and Translator, 1919-1930. California Institute, 1930-

2068 Summit Avenue

FRED J. CONVERSE, B.S.
Instructor in Civil Engineering

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

239 South Sierra Bonita Avenue

RENE ENGEL, M.S.
Instructor in Mineralogy

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

1148 Constance Street

EUSTACE L. FURLONG
Curator in Vertebrate Paleontology

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

270 South Roosevelt Avenue

FLOYD L. HANES, D.O.
Physical Trainer

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

1637 North Holliston Avenue

Herbert Hoover, Jr., M.B.A.

Instructor in Business Administration

B.A., Stanford University, 1925; M.B.A., Harvard University, 1927. California Institute, 1931-

1890 East California Street

Louis Winchester Jones, A.B.

Instructor in English Language and Literature

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

351 California Terrace

Allyn Campbell Loosley, Ph.D.

Instructor in Economics

B.S., University of California, 1927; M.A., 1928; Ph.D., 1931. Assistant in Economics, University of California, 1928-1931. California Institute, 1931-

Athenæum

John Haviland Maxson, Ph.D.

Instructor in Geology

B.S., California Institute, 1927; M.S., 1928; Ph.D., 1931. Assistant in Geology, California Institute, 1927-1928; Teaching Fellow, 1928-1931; Instructor, 1931-

380 South Chester Avenue

Francis William Maxstadt, Ph.D.

Instructor in Electrical Engineering

M.E., Cornell University, 1916; Certificate of E.E., 1916; M.S., California Institute of Technology, 1925; Ph.D., 1931. Draftsman and Designer, Otis Elevator Company, 1916-1917. Assistant in the Electrical Research Division, Interborough Rapid Transit Company, 1917-1919. Assistant in the Thomas A. Edison Laboratories, 1919. California Institute, 1919-

3782 Elma Road

Harold Z. Musselman, A.B.

Instructor in Physical Education and Manager of Athletics

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

834 East California Street

John L. Ridgway

Scientific Illustrator in Vertebrate Paleontology

Chief Illustrator, United States Geological Survey, 1898-1920; Artist, Carnegie Institution of Washington, 1910-. California Institute, 1929-

501 Fairmont Street, Glendale

Ernest Edwin Sechler, M.S.

Instructor in Engineering Drawing

B.S., California Institute, 1928; M.S., 1929. Assistant in Engineering, California Institute, 1928-1930; Instructor, 1930-

1109 North Lake Avenue, No. 9

FRANCES HALSEY SPINING

Librarian

California Institute, 1914-

1067 North Catalina Avenue

KENNETH VIVIAN THIMANN, PH.D.

Instructor in Biochemistry

B.Sc., University of London (Imperial College), 1924; A.R.C.S., 1924; Ph.D., 1928. Frank Hatton Prizeman in Chemistry, 1924. Demonstrator in Bacteriology, London University, 1925-1927. Beit Memorial Research Fellow in Biochemistry, 1927-1929. California Institute, 1930-

328 Palmetto Drive

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. Teaching Fellow in Biology, California Institute, 1928-1929; Instructor, 1929-

1067 San Pasqual Street

RESEARCH FELLOWS

CARL DAVID ANDERSON, PH.D.

Research Fellow in Physics

B.S., California Institute, 1927; Ph.D., 1930. California Institute, 1927-

520 South Lake Avenue

GEORGE W. BEADLE, PH.D.

National Research Fellow in Biology

B.Sc., University of Nebraska, 1926; M.Sc., 1927; Ph.D., Cornell University, 1930; Assistant in Agronomy, Cornell University, 1926-27; Experimentalist in Plant Breeding, 1928-30. California Institute, 1930-

204 South Wilson Avenue

OTTO BEECK, DR.ENG.

Foreign Exchange Fellow in Physics

Diploma in Engineering, Danzig University, 1928; Dr. Eng., 1930. Assistant in Physics, Danzig University, 1927-1930. California Institute, 1930-

Dormitory

MAURICE BIOT, DR. SC.

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

Ing. Civ. des Mines, University of Louvain, 1929; Ing. Electricien, 1930; Docteur en Sciences, 1931. California Institute, 1931-

Athenæum

ARNOLD EPHRAIM ROSS, PH.D.

National Research Fellow in Mathematics

B.S., University of Chicago, 1928; M.S., 1929; Ph.D., 1931. California Institute, 1931-

Athenæum

RAYMUND SANGER, PH.D.

Research Fellow in Physics of the Rockefeller Foundation

Ph.D., Eidgenössische Technische Hochschule, Zürich, 1926. Privat Dozent für Physik, Eidgenössische Technische Hochschule, 1930-. California Institute, 1931-

Athenæum

HANS DIETRICH SCHMIDT-OTT, PH.D.

Foreign Exchange Fellow in Physics

Ph.D., University of Göttingen, 1931. California Institute, 1931-

Athenæum

REINHOLD KARL THEODOR SEIFERTH

Research Fellow in Aeronautics

Dipl.-Ing., Technische Hochschule of Dresden, 1923. Research Fellow, Aerodynamische Versuchsanstalt zu Göttingen, 1923-1930. California Institute, 1930-

1006 Del Mar Street

WILLIAM LAYTON STANTON, PH.D.

Research Fellow in Geology

B.S., California Institute of Technology, 1927; Ph.D., 1931. California Institute, 1927-

515 Manzanita Avenue, Sierra Madre

WILHELM OTTO STIERSTADT, PH.D.

Research Fellow in Physics of the Rockefeller Foundation

Ph.D., University of Göttingen, 1928. Assistant in Physics, University of Göttingen, 1928-1931. California Institute, 1931-

Athenæum

JOHN DONOVAN STRONG, PH.D.

National Research Fellow in Physics

A.B., Kansas University, 1926; M.S., Michigan University, 1928; Ph.D., 1930. California Institute, 1930-

155 South Bonnie Avenue

JAMES HOLMES STURDIVANT, PH.D.

Research Fellow in Chemistry

B.A., University of Texas, 1926; M.A., 1927; Ph.D., California Institute, 1930. California Institute, 1930-

Athenæum

WALTER GUSTAV JOHANNES TOLLMIEN, DR. PHIL.

Research Fellow in Aeronautics

Dr. Phil., University of Göttingen, 1924. Research Fellow, Kaiser Wilhelm Institut für Strömungsforschung Göttingen, California Institute, 1930-

384 North Chester Avenue

ADRIAAN JOSEPH VAN ROSSEM
Research Fellow in Vertebrate Zoology

Assistant, California Institute, 1926-1931; Research Fellow, 1931-

2656 Foothill Boulevard, Altadena

HARRY VERNEY WARREN, D.PHIL.
Commonwealth Fund Fellow in Geology

B.A., University of British Columbia, 1926; B.A.Sc., 1927; B.Sc., Oxford University, 1928; D.Phil., 1929. British Columbia's Rhodes Scholar at Oxford University, 1926-1929. California Institute, 1929-

392 South Catalina Avenue

EVAN GWYN WILLIAMS, M.A.
Commonwealth Fund Fellow in Astronomy

B.A., Cambridge University, 1927; M.A., 1931. Isaac Newton Student, Trinity College, Cambridge, 1929. California Institute, 1931.

Athenæum

EVERLY JOHN WORKMAN, PH.D.
National Research Fellow in Physics

B.S., Whitman College, 1924; Ph.D., University of Virginia, 1930. Instructor in Physics, Whitman College, 1924-1926; Instructor in Physics, North Dakota State College, 1927-1928; National Research Fellow, Bartol Foundation of the Franklin Institute, 1930-1931. California Institute, 1931-

538 South Hudson Avenue

WLADIMIR M. ZAIKOWSKY
Research Fellow in Physics and in Mechanical Engineering

Graduate of Michel's Artillery Academy, 1911. Research Officer of Main Artillery Board (Russia), 1911-1914. Repetitor of Michel's Artillery Academy, 1914-1915. Captain of Russian Artillery, 1914- Member of Russian Artillery Commissions in the United States, 1915-1921. California Institute, 1923-

346 South Michigan Avenue

TEACHING FELLOWS AND GRADUATE ASSISTANTS

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B.S., California Institute, '22.

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B.S., California Institute, '31.

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A.B., Stanford Univ., '17; A.M., '20.

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B.S., Carnegie Institute of Technology, '29; M.S., '30.

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A.B., Stanford Univ., '27; M.S., Univ. of Pittsburgh, '29.

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B.A., Pomona College, '27.

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B.S., California Institute, '28.

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B.S., Massachusetts Institute of Technology, '30.

John Francis Blackburn . . . . Physics
B.S., Univ. of Chicago, '26.

William McChesney Bleakney* . . . . Physics
B.S., Whitman College, '26.

Francis Dashwood Bode . . . . Geology
B.S., California Institute, '30; M.S., '31.

Lawrence William Bolles . . . . Geology
B.S., California Institute, '31.

James Frederick Bonner . . . . Biology
A.B., Univ. of Utah, '31.

Perry Mattison Boothe . . . . Engineering
B.S., California Institute, '31.

James Lawrence Botsford . . . . Mathematics
A.B., Univ. of Washington, '28.

John Henry August Brahtz . . . . Engineering
B.S., Royal Technical College, Copenhagen, '11; M.S., '14.

Richard Hoover Brandon . . . . Physics
A.B., Miami Univ., '31.

Philip Davis Brass . . . . Chemistry
B.S., Yale Univ., '28.

Lawrence Olin Brockway . . . . Chemistry
B.S., Univ. of Nebraska, '29; M.S., '30.

Vinton Austin Brown . . . . Mathematics
B.S., Univ. of Arizona, '29; M.S., '31.

Charles Russel Burnham . . . . Biology
B.A., Univ. of Wisconsin, '24; M.S., '25; Ph.D., '29.

Donald Sherman Clark . . . . Engineering
B.S., California Institute, '29; M.S., '30.

William Maurice Cogen . . . . Geology
B.S., California Institute, '31.

Everett Franklin Cox . . . . Physics
A.B., Miama Univ., '30.

*Henry Laws Fellow.

CLYDE B. CRAWLEY . . . . Physics
A.B., Univ. of Kentucky, '30; M.S., '31.

BERNARD NEIL DICKINSON . . . . Chemistry
B.A., Univ., of Oklahoma, '29; M.S., '31.

MAURICE GHIRRAR DONNELLY . . . . Geology
E.M., Colorado School of Mines, '29.

WILLIAM FERDINAND EBERZ . . . . Chemistry
B.S., California Institute, '31.

EMORY LEON ELLIS . . . . Biochemistry
B.S., California Institute, '29.

ROBLEY DUNGLISON EVANS . . . . Physics
B.S., California Institute, '28; M.S., '29.

RICHARD GILMAN FOLSOM . . . . Engineering
B.S., California Institute, '28; M.S., '29.

MELVIN EARNEST GAINDER . . . . Electrical Engineering
B.S., California Institute, '26; M.S., Univ. of Pittsburgh, '31.

JOSEPH BOYD GROSE . . . . Engineering
B.S., Univ. of Utah, '31.

NORMAN ROBERT GUNDERSON* . . . . Chemistry
B.S., California Institute, '31.

CHARLES EDWARD HABLUTZEL, JR. . . . . Physics
B.A., Stanford Univ., '25; M.A., '26.

ANDREW VASILY HAEFF . . . . Electrical Engineering
E.E. and M.E., Polytechnic Institute of the Special Region of the Eastern Province, China, '28; M.S., California Institute, '29.

GEORGE THOMAS HARNESS, JR. . . . . Electrical Engineering
B.S., California Institute, '28.

MAURICE FRED HASLER . . . . Physics
B.S., California Institute, '29; M.S., '30.

EARL S. HILL** . . . . Engineering
B.S., Oregon State Agricultural College, '30; M.S., California Institute, '31.

JAMES LYNN HOARD . . . . Chemistry
B.S., Univ. of Washington, '27; M.S., '29.

BENJAMIN HOLZMAN . . . . Geology
B.S., California Institute, '31.

RALPH RAYMOND HULTGREN . . . . Chemistry
B.S., Univ. of California, '28; M.S., Univ. of Utah, '29.

*American Potash and Chemical Corporation.
**American Petroleum Institute.

Robert Byron Jacobs . . . . History
B.S., California Institute, '31.

Cecil Edward Pruitt Jeffreys . . . . Chemistry
B.A., Univ. of Texas, '25; M.A., '27; Ph.D., California Institute, '31.

Walter Harrison Jordan . . . . Physics
B.A., Univ. of Oklahoma, '30; M.S., '31.

Geoffrey Lorrimer Keighley . . . . Biology
B.A., Univ. of Toronto, '26.

Lawrence Edward Kinsler . . . . Physics
B.S., California Institute, '31.

Charles Edmund Kircher* . . . . Chemistry
B.S., California Institute, '31.

Arnold Martin Kuethe . . . . Mathematics
Ph.B., Ripon College, '26.

Edson Churchill Lee** . . . . Physics
B.S., California Institute, '29.

Laverne Leeper . . . . Engineering
B.S., California Institute, '31.

John Andrews Leermakers*** . . . . Chemistry
B.Sc., Iowa State College, '28; M.Sc., '29.

Charles Kimmel Lewis . . . . Engineering
B.S., California Institute, '31.

Carl Clarence Lindegren . . . . Biology
B.Sc., Univ. of Wisconsin, '22; M.S., '23; Ph.D., California Institute, '31.

Ernest Herbert Lyons, Jr. . . . . Chemistry
B.S., Massachusetts Institute of Technology, '31.

Robert S. Martin*** . . . . Mathematics
B.A., Univ. of Pittsburgh, '29.

Harry Matison . . . . Mathematics
B.S., California Institute, '31.

John Felbert McGarry . . . . Engineering
B.S., California Institute, '31.

John McMorris . . . . Chemistry
A.B., College of Emporia, '24.

Roscoe H. Mills . . . . Aeronautics
B.A., Pomona College, '28.

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*American Petroleum Institute.
**Radiological Research Institute.
***Henry Laws Fellow.

Norton Bartlett Moore . . . . Aeronautics
A.B., Univ. of California, '29; M.S., Purdue Univ., '31.

Ross Elliott Morris . . . . Chemistry
B.S., California Institute, '31.

Stanley Aber Morse . . . . Physics
A.B., Kalamazoo College, '31.

James Carlisle Mouzon* . . . . Physics
A.B., Southern Methodist Univ., '27.

George Clarkson Munro . . . . Physics
A.B., Univ. of California at Los Angeles, '29.

Philip Griffis Murdock . . . . Chemistry
B.S., California Institute, '29.

Albert Edward Myers . . . . Chemistry
B.S., California Institute, '29.

John Melville Nordquist* . . . . Physics
A.B., Park College, '29; M.S., Univ. of Oklahoma, '31.

Dwight Olcott North . . . . Physics
B.S., Wesleyan Univ., '30.

W. Bailey Oswald . . . . Aeronautics
B.A., Univ. of California at Los Angeles, '27.

George Herman Otto . . . . Geology
S.B.. Univ. of Chicago, '31.

Raymond Alfred Peterson . . . . Geology
B.S., California Institute, '31.

John Gibson Pleasants** . . . . Electrical Engineering
B.S., Univ. of Southern California, '29; M.S., California Institute, '30.

Albert Roberts Poole . . . . Mathematics
B.A., Univ. of British Columbia, '29; M.A., '31.

Willis Parkison Popenoe . . . . Geology
B.S., George Washington Univ., '30.

George Wilber Read . . . . Electrical Engineering
B.S., California Institute, '30; M.S., '31.

John Read . . . . Physics
B.Sc., London Univ., '29; B.Sc. (Physics), '31.

Harington Molesworth Anthony Rice . . . . Geology
B.A.Sc., Univ. of British Columbia, '23; M.A.Sc. '31.

Lynn Hamilton Rumbaugh* . . . . Mathematics
A.B., Miami Univ., '28.

*Henry Laws Fellow.
**On exchange fellowship in Germany, 1931-1932.

Bruce Hornbrook Sage* . . . . Chemistry
B.S., New Mexico State College, '29; M.S., California Institute, '31.

Marston Cleaves Sargent . . . . Biology
A.B., Harvard Univ., '28.

David Walter Scharf . . . . Geology
B.S., California Institute, '30.

Hermann Franz Schott . . . . Biology
B.S., California Institute, '26.

Maple Delos Shappell** . . . . Geology
B.S., Univ. of Arizona, '21.

David Sheffet . . . . Electrical Engineering
B.S., California Institute, '30; M.S., '31.

Jack Sherman*** . . . . Chemistry
B.S., University of California, '29.

Selby Millmore Skinner . . . . Physics
B.S., Univ. of Washington, '28.

Hampton Smith . . . . Geology
B.S., California Institute, '28.

Howard Gardner Smits . . . . Engineering
B.S., California Institute, '31.

Joshua Lawrence Soske . . . . Geology
Geological Engineer, Colorado School of Mines, '29.

Carsten Conover Steffens . . . . Chemistry
A.B., Syracuse Univ., '30.

Robert Ingersoll Stirton**** . . . . Chemistry
B.S., California Institute, '30.

George Frederic Taylor . . . . Geology
B.S., California Institute, '29; M.S., '31.

David Boyd Thomas . . . . Physics
B.S., North Carolina State College, '31.

Guy Waddington . . . . Chemistry
B.A., Univ. of British Columbia, '28; M.A., '29.

Frank Christian Walz . . . . Physics
B.S., Univ. of Colorado, '22; M.S., '26.

Ralph Mayhew Watson . . . . Engineering
B.S., California Institute, '27; M.S., '28.

*American Petroleum Institute.
**Storrow Fellow in Geology of the National Research Council.
***E. I. DuPont de Nemours Company.
****Inspiration Copper Company.

Robert James Watson . . . . Geology
B.A., Univ. of Toronto, '25; M.A., '26.

Frank L. Wattendorf* . . . . Aeronautics
B.A., Harvard Univ., '26; M.S., Mass. Institute of Technology, '28.

James Harold Wayland . . . . Mathematics
B.S., Univ. of Idaho, '31.

Sidney Weinbaum . . . . Chemistry
B.S., California Institute, '24.

Merit Penniman White . . . . Engineering
A.B., Dartmouth Coll., '30; C.E., Thayer School of Civil Engineering, '31.

Nathan Davis Whitman, Jr. . . . . Engineering
B.S., California Institute, '30.

Melville Chase Williams . . . . Physics
B.A., Univ. of South Dakota, '31.

Edgar Bright Wilson, Jr. . . . . Chemistry
B.S., Princeton Univ., '30; M.A., '31.

Robert Warren Wilson . . . . Geology
B.S., California Institute, '30.

Georg Friedrich Wislicenus . . . . Engineering
M.E., Staatliche Höhere Maschinenbauschule, Würzburg, Germany, '25; M.S., California Institute, '31.

Karl Morgan Wolfe** . . . . Electrical Engineering
B.S., West Virginia Univ., '25; M.S., California Institute, '29.

Carleton Russell Worth . . . . Mathematics
A.B., Southwest Missouri Teachers College, '25; S.M., Univ. of Chicago, 27.

---

*Daniel Guggenheim Lighter-than-Air Institute.
**Petroleum Rectifying Corporation.

Staff of Instruction and Research Summary

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J. Robert Oppenheimer, Theoretical Physics
William R. Smythe, Physics
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Clyde Wolfe, Mathematics

INSTRUCTOR

Francis W. Maxstadt, Electrical Engineering

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Alfred Faessler, Rockefeller Foundation
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Laurence E. Lefevre
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Carl D. Anderson
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Sterling Beckwith
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Arnold M. Kuethe
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Lynn H. Rumbaugh
David Sheffet
Selby M. Skinner
David B. Thomas
Frank C. Walz
James H. Wayland
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Carleton R. Worth

*On leave of absence, 1931-1932.

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*American Potash and Chemical Corp.
**American Petroleum Institute.
‡duPont Fellow.
†Inspiration Copper Company.

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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: F. C. Austin, John Willis Baer, R. R. Blacker, Mrs. Norman Bridge, E. P. Clark, Elmer W. Clark, Frank P. Flint, Mrs. Eldridge M. Fowler, Herbert J. Goudge, F. A. Hardy, Frank P. Hixon, Henry E. Huntington, William G. Kerckhoff, Samuel Mather, Eugene A. Merrill, Edgar G. Miller, Seeley W. Mudd, Benjamin E. Page, George S. Patton, Charles H. Ruddock, Douglas Smith, Frederick H. Stevens, William L. Stewart, Joseph E. Tilt.

Educational Policies

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

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

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

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

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

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

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

(6) Throughout the period of undergraduate study every effort shall be made to develop the character, ideals, breadth of view, general culture, and physical well-being of the students of the Institute. To this end the literary, historical, economic, and general scientific subjects shall continue to be taught by a permanent staff of men of mature judgment and broad experience; the regular work in these subjects shall be supplemented by courses of lectures given each year by men of distinction from other institutions; and the weekly assemblies, addressed by leading men in the fields of education, literature, art, science, engi-

neering, public service, commerce, and industry, shall be maintained as effectively as possible. Moderate participation of all students in student activities of a social, literary, or artistic character, such as student publications, debating and dramatic clubs, and musical clubs, shall be encouraged; and students shall be required to take regular exercise, preferably in the form of intramural games or contests affording recreation.

(7) In all the scientific and engineering departments of the Institute research shall be strongly emphasized, not only because of the importance of contributing to the advancement of science and thus to the intellectual and material welfare of mankind, but also because research work adds vitality to the educational work of the Institute and develops originality and creativeness in its students.

(8) In order that the policies already stated may be made fully effective as quickly as possible, and in order that the available funds may not be consumed merely by increase in the student body, the registration of students at any period shall be strictly limited to that number which can be satisfactorily provided for with the facilities and funds available. And students shall be admitted, not on the basis of priority of application, but on that of a careful study of the merits of individual applicants, so that the limitation may have the highly important result of giving a select body of students of more than ordinary ability. A standard of scholarship shall also be maintained which rapidly eliminates from the Institute those who, from lack of ability or industry, are not fitted to pursue its work to the best advantage.

Educational Buildings and Facilities

THROOP HALL

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

NORMAN BRIDGE LABORATORY OF PHYSICS

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

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

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

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

THE HIGH-POTENTIAL RESEARCH LABORATORY

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

GATES CHEMICAL LABORATORY

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

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

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

RESEARCH LABORATORY OF APPLIED CHEMISTRY

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

ENGINEERING RESEARCH LABORATORY AND HEATING PLANT

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

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

STEAM, GAS ENGINE, AND HYDRAULIC LABORATORIES

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

DANIEL GUGGENHEIM AERONAUTICAL LABORATORY

Funds for the construction of the Daniel Guggenheim Aeronautical Laboratory 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 considerably more than 200 miles per hour has been produced. A complete set of aerodynamical balances permit testing and research work of all kinds to be performed in the wind tunnel. A large structures laboratory has recently been equipped with specially designed testing machines with which a series of researches are now in progress, dealing chiefly with the problems connected with the modern use of stressed skin or monocoque structures. On the first floor are the observation room of the wind tunnel, a wood shop large enough for the building of complete airplanes, and the structures laboratory. On the second floor are offices and a group of six small laboratories for research. The third floor contains the balance room in which the wind tunnel measurements are made, a seminar room, library, drafting room, 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 about two and one-half miles west of the Institute on a granite ridge affording firm bedrock foundation for the instrument piers. The investigations at the laboratory relate mainly to earth movements originating within a radius of about two hundred miles. The seismograms from six branch stations, built and maintained with the aid of cooperating agencies in Southern California, contribute greatly to these studies.

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

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

THE WILLIAM G. KERCKHOFF LABORATORIES OF THE BIOLOGICAL SCIENCES

The first 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 has also been established at Corona del Mar. 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 50 miles) will make it possible to supply the biological laboratories with living materials for research and teaching. The fauna at Corona and at Laguna Beach, which is near-by, is exceptionally rich and varied, and is easily accessible.

W. K. KELLOGG LABORATORY OF RADIATION

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

LIBRARIES

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

Athenaeum

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

The purpose of the Athenæum is to provide a place and opportunity for contact between the distinguished foreign scientists and men of letters temporarily in residence from time to time at the California Institute, the Mount Wilson Observatory and the Henry E. Huntington Library and Art Gallery, the staffs and graduate students of those institutions, and the patrons and friends of science and education in Southern California making up the California Institute Associates.

The Athenæum building contains on the first floor a large and beautiful lounge, a library, a main dining-room, three small dining-rooms, and, adjoining the main dining-room—and planned so that the two rooms can be thrown together for large banquets—a room for scientific and other lectures, known as the "Hall of the Associates," in addition to a completely-equipped kitchen and the necessary service rooms. On the upper floors are very attractively furnished rooms and suites, each with private bath, for visiting professors, members of the staffs and graduate students of the three institutions named, and other members of the Athenæum who may desire to make use of these accommodations either for themselves or for their guests. An attractive writing room and lounge are provided on a mezzanine floor for the exclusive use of women.

Undergraduate Student Houses

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

These four houses in Mediterranean style harmonizing with the Athenæum, were, like the latter building, designed by Gordon B. Kaufmann. While built in a unified group, each house is a separate unit providing accommodations for about seventy-five students; each has its own dining-room, reading room, and lounge, but all are served from a common kitchen.

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

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

The Institute's plans contemplate that with the completion of these student houses all undergraduate students, except those living at home, shall be in residence on the campus.

Extra-Curriculum Opportunities

LECTURE AND CONCERT COURSES

Through a cooperative arrangement with the Pasadena Lecture Course Committee there are given at the Institute assemblies a number of lectures on science, literature, current events, and other subjects of general interest, by speakers of national and international note brought to Pasadena by the Committee. Weekly public lectures in science, illustrated by experiments, are given by the members of the Institute faculty in the lecture rooms of the Norman Bridge Laboratory of Physics and the Gates Chemical Laboratory. 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.

The forensic interests of the Institute include also membership in the Southern California Public Speaking Association.

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

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

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

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

Student Health and Physical Education

In 1929 the Institute inaugurated a student health program consisting of three principal features. The first is a thorough physical examination of all students entering the Institute by specialists on the staff of the Pasadena Hospital. The second feature of the program is the appointment of a consulting physician, Dr. E. D. Kremers, who is in his office on the campus in the William G. Kerckhoff Laboratory of Biological Sciences one hour each day, and may be consulted by the students without charge. The third is a provision for the students to obtain various services at the Pasadena Hospital at special rates.

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

Requirements for Admission to Undergraduate Standing

ADMISSION TO THE FRESHMAN CLASS

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

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

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

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

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

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

Regular entrance examinations will be held at the Institute Friday, May 6th, and Saturday, May 7th. Applicants should report in the Lounge of Dabney Hall May 6th at 8:30 A.M.

Students living at a distance from Pasadena may, upon request, be allowed to take the entrance examinations under the supervision of their local school authorities*; or they may, if they prefer, take the New Plan (Plan B) College Board examinations in Comprehensive English, Comprehensive Mathematics (Elementary and Advanced), Physics, and Chemistry. No candidate will be registered by the College Entrance Examination Board under this plan unless he is at the end of his high school course and unless also the Board has notice from the Institute that the candidate has its permission to take his examinations under the New Plan (Plan B).

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notebooks at the time of the examination. The schedule for 1932 is as follows: Wednesday, September 21, 9:00 A.M., Mathematics; 2:00 P.M., English. Thursday, September 22, 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 20-25, 1932. 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 23, 1932.

*Arrangements for examinations in absentia should include a letter to the Registrar from the individual directing the tests stating that the required supervision will be given.

Each applicant must pass a physical examination showing that he is able to do the work of the Institute. These examinations will be conducted for the Institute by the staff of the Pasadena Hospital on September 19-21. 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 doing so by the first of April, or even earlier. This enables the Institute to make full use of all information available from high school sources. Applicants whose preparatory work is 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 expect to complete their preparatory work at the close of the year will be admitted to the examinations if such a request is received from their principals. 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.

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 June 25th will be notified by the Registrar as to their acceptance on or about July 1st.

Upon receipt of the registration fee of $10.00 (which will be deducted from the first-term tuition), each accepted applicant will be sent a registration card which will entitle him to register, provided his physical examination is satisfactory. The registration card should be presented at the Dabney Lounge September 22nd at 8:30 A.M.

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

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

ADMISSION TO UPPER CLASSES

For admission to the upper classes of the Institute applicants who have been students at other institutions of collegiate rank must present letters of honorable dismissal, together with statements showing in detail the character of their previous training, and the grades which have been received. It is advisable for students planning to transfer to send their credentials to the registrar at an early date. A personal interview is desirable; during the summer months it is well to arrange for this in advance. These students take examinations in Mathematics, Physics, and Chemistry; except that the examination in Chemistry is required only of those desiring to pursue the course in Science. Students must offer courses, both professional and general, substantially the same as those required in the various years at the Institute (see pages 131-145) 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 classification will be determined by the committee on the basis of the results of all the examinations taken.

The examinations may be taken either in June or in September. The schedule for 1932 is as follows: Thursday, June 9, 9 A.M., Chemistry; Friday, June 10, 9 A.M., Mathematics; Saturday, June 11, 9 A.M., Physics; Friday, September 16, 9 A.M., Mathematics; Saturday, September 17, 9 A.M., Physics; 1:00 P.M., Chemistry.

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

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

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

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 loss of time and difficulty in the pursuit of the more advanced subjects. Students intending to complete the Institute courses are therefore recommended, as far as possible, to take their freshman and sophomore work also at the Institute.

Expenses

TUITION

The tuition fee for undergraduate students is three hundred dollars ($300) a year, payable in three installments of $100 each at the beginning of each term.

Students who attain honor standing at the end of their Freshman or Sophomore years are awarded prize scholarships carrying half tuition for the ensuing year, as described on page 80 of this Catalogue.

For graduate students, see page 102.

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.

Registration and General Regulations

Registration for the second term, 1931-1932, will take place January 4, 1932 (9 A.M. to 3 P.M.); for the third term, March 28, 1932 (9 A.M. to 3 P.M.). Registration for the first term, 1932-1933, will take place, for freshmen, September 22, 1932 (8:30 A.M.), for transfers from other colleges September 22-23, 1932 (9 A.M. to 3 P.M.), and for other students, September 23, 1932 (9 A.M. to 3 P.M.). A special fee of two dollars is charged for registration after these dates.

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

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

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

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

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

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. The balance of the work should be completed during the next term in residence by the date fixed for the removal of conditions and the grade of incomplete, unless an extension of time is granted by the Dean. When thus completed the record of incomplete shall not be considered a deficiency on the student's record.

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

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

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

A condition in any term's work must be removed during the next term in residence on the date fixed for the removal of conditions. 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. For fulfilling scholastic requirements set *forth in the following paragraphs, not less than 90 per cent of the credits required must be received in subjects other than Assembly and Physical Education.*

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

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

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

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

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

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

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

5. 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. At the close of each school-year the Committee on Honor Students awards *honor standing* to approximately 16 students who have completed the freshman year, and to 12-16 students who have completed the sophomore year. To each of these students is also awarded a *prize scholarship* carrying half tuition. These awards are based primarily on the scholastic records of the students.

Any holder of such a scholarship who in any subsequent term fails to maintain a scholastic standard set by the Committee automatically loses his honor standing and scholarship for the remainder of the school-year.

Honor standing entitles the student to special privileges and opportunities, such as excuse from some of the more routine work, instruction in "honor sections," and admittance to more advanced subjects and to research work. But a student in honor standing may not be admitted to an honor section in a particular subject unless he has obtained a grade of 3 or better in the work prerequisite to that subject.

Students of the class graduating in 1932 will be awarded honor standing and honor graduation as outlined on pages 77 and 78 of the 1929 catalogue.

If for any reason a student is carrying less than 40 units, the credits required (as stated in paragraphs 1 and 2 on pages 77-78) shall be prorated on the basis of 40 as a minimum. 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

Sixteen freshmen scholarships carrying $150 or $300 are awarded by the Institute upon the basis of a competition open to properly qualified male students in the senior classes of high schools or college preparatory schools.

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 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 competitior, while retaining the scholarship as an honorary recognition. The winners of these scholarships will be designated Blacker Scholars or Drake Scholars, in recognition of the donors, Robert Roe Blacker and Nellie Canfield Blacker, or Mr. and Mrs. A. M. Drake.

DRAKE SCHOLARSHIPS

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

SOPHOMORE AND JUNIOR PRIZE SCHOLARSHIPS

With the aid of funds recently received the Institute has established about thirty new scholarships known as the Sophomore and Junior Prize Scholarships. These scholarships, which carry half tuition, are awarded at the end of each school-year to those students who as the result of their work, during the freshman and sophomore years, were granted honor standing on the basis described in paragraph 6 on page 78 of this Catalogue. In addition the Committee on Honor Students may award a smaller number of tuition grants to students of high standing who are in need of financial assistance.

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.

COMPETITION FOR THE TRAVEL PRIZES

Qualifying for the Travel Prizes—At the end of each year the Committee on Honor Students will designate twelve to sixteen students to receive honor standing at the end of their sophomore year as described in paragraph 6 on page 78 of this Catalogue. The students so designated shall be considered to have qualified for the competition for the Travel Prize of the ensuing year.

Competition for the Travel Prizes—The competitors qualifying for the Travel Prizes in the way just stated 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.

Award of the Travel Prizes—These prizes will be awarded at the end of the second term of the junior year to those students who, having qualified in the way above stated, are given the highest rating by the members of the Committee on Honor Students in consultation with instructors who have close contact with the competitors. This rating will be based upon:

(a) Previous scholastic records.

(b) Acquaintance with European geography, politics, social problems, and recent history, with art, with the modern languages, and with other knowledge conducive to the success of a European trip.*

(c) Ability in research and other creative directions.

(d) Power of clear, forceful expression (oral and written).

(e) Personal qualities conducive to fullness of life and success in a scientific or engineering career.

(f) Student activities, outside interests, health, and physical development.

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.

*Students desiring to compete for the Travel Prizes should attend the seminar on "Europe" during the first two terms of their junior year.

Study and Research at the California Institute

PHYSICS

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

Further, since the best education is that which comes from the contact of youth with creative and resourceful minds, the staff of the Norman Bridge Laboratory of Physics has been from the beginning a group of productive physicists rather than merely a group of teachers. The entering freshman makes some contact in his first year with practically all of the members of that staff, and he has the opportunity to maintain that contact throughout his four undergraduate years, and his graduate work as well if he elects to go on to the higher degrees.

It is the combination of a large graduate school of physics and a limited number of undergraduate students which makes the distinctive feature of the work in physics at the Institute. The instruction is done by the small group method, sixteen to a section, save for one rather elaborate demonstration lecture each week throughout the freshman and sophomore years. All of the members of the staff participate in giving 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 fifty to sixty major papers. There are three general seminars per week, which are regularly attended by all research workers, including in general ten or a dozen National and International Research Fellows and all graduate students, numbering from forty to fifty. In addition there is a weekly theoretical seminar conducted for the benefit of those interested primarily in mathematical physics.

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

MATHEMATICS

The Institute is now prepared to offer to 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.

Students intending to take certain of the advanced courses are specially asked to note the foreign language prerequisites.

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 correlated with the newer quantum theories.

ENGINEERING

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

The plan of instruction embodies a four-year course 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 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. These courses provide for advanced work in the application of mathematical analysis and physical laws to mechanical and electrical problems incident to electrical design and research, electric transients including lightning phenomena, high voltage production and transmission, electrical engineering problems involving the use of vacuum tubes, and problems relating to the generation and distribution of electrical power for lighting and industrial purposes.

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

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

AERONAUTICS

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

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

1. A comprehensive series of theoretical courses in aerodynamics, hydrodynamics, and elasticity, with the underlying mathematics and mechanics, taught by Professors Theodor von Kármán, Harry Bateman, Eric T. Bell, Paul S. Epstein, Beno Gutenberg, Clark B. Millikan, and Arthur L. Klein.

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

3. Experimental and theoretical researches on
   - (a) the basic problems of flow in real fluids with regard to the scientific foundations of technical hydro- and aerodynamics;
   - (b) the basic problems of Applied Mechanics which relate to the properties of materials and the theory of elasticity;
   - (c) practical problems in aerodynamics and structures, especially as applied to aeronautics.

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

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

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

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

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

GEOLOGICAL SCIENCES

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

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

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

INSTRUCTION IN GEOLOGY AND PALEONTOLOGY

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

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

OPPORTUNITIES FOR RESEARCH IN GEOLOGY AND PALEONTOLOGY

Within convenient reach of Pasadena occurs an almost unrivaled variety of rock types, geologic structures, and physiographic forms. Field studies can be conducted comfortably throughout the entire year, and this constitutes an important part of the department program.

Stratigraphic and faunal studies may be pursued in the Cenozoic and Mesozoic sedimentary rocks of the Southern Coast Ranges, in which oil fields are located, and in the Mojave Desert region. Thick sections of Paleozoic sediments in southeastern California remain almost unexplored. Structural and physiographic problems in the Coast and Basin Ranges and along the coastal front await critical investigation and frequently involve an interpretation of folding and faulting on a large scale. The presence of many productive oil fields, of large Portland cement plants, and of gem-producing districts in Southern California afford exceptional opportunities to students interested in economic geology. Moreover, the gold, silver, quicksilver, and copper 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 exist for studies in physical and geological seismology. A fully equipped Seismological Research Laboratory is situated on a site west of the Arroyo Seco in Pasadena. The laboratory is devoted to researches conducted both by the Carnegie Institution of Washington and the California Institute of Technology, and graduate students in the

Division of Geology and Paleontology will be received in the Laboratory for the purpose of taking part in the researches or of becoming acquainted with seismological methods.

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

TEACHING AND RESEARCH FELLOWSHIPS

Fellowships are available for properly qualified students who desire to pursue advanced work in geology and paleontology, as in other branches of science; see page 115.

BIOLOGICAL SCIENCES

A Department of Biology, rather than the traditional departments of Botany and Zoölogy, has been established, in order to emphasize the unity of the phenomena of living organisms rather than their manifold diversities. That there are many properties common to the two great branches of the living world has become abundantly manifest in recent years. For example, the same principles of heredity that obtain among flowering plants apply also to human traits, and in their response to light, animals and plants conform to common laws of physics. It is true that, at what may be called the biological level, an immense diversity of form and function manifests itself, but enough insight has already been gained to make evident that this diversity is in large part due to permutations and combinations of relatively few fundamental and common properties. It is in the search for these properties that the zoologist and botanist may profitably pool their interests. 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, with the intention of bringing together in sympathetic union a group of investigators whose interests lie in the fundamental aspects of their subjects, that a department of Biology has been organized.

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

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

ASTROPHYSICS

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, structure and motion 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, motion, and nature of remote nebulæ; and of many phenomena bearing directly on the constitution of matter.

The new observatory will consist of two main features. One of these will be the 200-inch telescope, with its building, dome, and auxiliary equipment, to be erected on the most favorable high-altitude site that can be found within effective working distance of the associated groups of investigators and their extensive scientific equipment. The other will be an Astrophysical Laboratory located on the Institute campus, which will serve as the headquarters in Pasadena of the Observatory Staff and of the Graduate School of Astrophysics. Its equipment will include instruments and apparatus for the measurement of photographs, the reduction and discussion of observations, and for such astrophysical investigations as can be made there to the best advantage. Its instruments for the interpretation of astrophysical phenomena will be designed to supplement those of the laboratories of the Institute and the Pasadena laboratory of the Mount

Wilson Observatory. A well-equipped shop for the development of new instruments has been erected on the campus, and the Astrophysical Laboratory is under construction.

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

An Observatory Council, consisting of four members of the Executive Council of the Institute, has been placed by the trustees in full charge of the design, construction, and operation of the Astrophysical Observatory and Laboratory. With the approval of the Carnegie Institution of Washington, Dr. John A. Anderson, of the Mount Wilson Observatory, has been appointed by the Observatory Council as its Executive Officer, in direct charge of design and construction. An Advisory Committee, including the Director and Assistant Director of the Mount Wilson Observatory and many other prominent astronomers and physicists, aid the Observatory Council in determining matters of policy. The organization of the Observatory Council and the personnel of its Advisory Committee are shown on page 52 of this Catalogue.

Any great increase in the size of telescopes requires a long study of the most promising methods of making large paraboloidal mirrors. Two substances for mirror disks are especially suitable because of their low coefficients of expansion: fused silica and Pyrex glass. Both are under investigation and the probability of obtaining a good 200-inch disk of one of these materials is very high.

The extensive investigation of primary and auxiliary instruments, which forms such a vital part of the general scheme, has also made marked progress, through the active cooperation of the Warner & Swasey Company, Dr. Frank E. Ross, the Bausch & Lomb Optical Company, Sir Herbert Jackson, Sir Charles Parsons, the Philips Lamp Works, Professor Joel Stebbins, and others. The Research Laboratory of the Eastman Kodak Company has generously agreed to deal with many of the special photographic problems. A Zeiss recording microphotometer has been obtained, and is being used in a comparative study of various forms of this instrument. The radiometer recently used very successfully by Dr. C. G. Abbot, of the Smithsonian Institution, in measuring the distribution of energy in the spectra of stars of several types has been 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, after the Astrophysical Laboratory on the campus has been completed 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.

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

THE HUMANITIES

One of the distinctive features of the California Institute is its emphasis upon the humanistic side of the curriculum. In the degree and genuineness of this emphasis the Institute has differentiated itself from other American schools of science, most of which accord little more than a gesture of recognition to the liberal arts. As a rule, in schools of engineering, the professional studies monopolize nearly all the available time and money, leaving the humanities to take what is left, which usually turns out to be very little.

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

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

One of the largest and most attractive buildings on the Institute campus is devoted to the work in Literature, Languages, Philosophy, Economics, History, and Government. This Hall of the Humanities, erected in 1928, was given by Mr. and Mrs. Joseph B. Dabney, of Los Angeles. In connection with the 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 Professor O. A. Craven, of the University of Chicago, Professor Godfrey Davies, formerly of the same institution, and Professor Louis B. Wright of the University of North Carolina. For a part of the present year, also, Dr. Charles A. Beard of New York comes to the Institute as Associate in History and Government, and Dr. Jacob Gould Schurman, formerly President of Cornell University and American Ambassador to Germany, will be Special Lecturer in International Relations. It is anticipated that with the opportunities for research in English Literature and American History which are afforded by the proximity of the Huntington Library, the instruction given at the Institute in these fields will be steadily strengthened by the association of visiting scholars.

Information and Regulations
for the Guidance of Graduate Students

A. GENERAL REGULATIONS

I. REQUIREMENTS FOR ADMISSION TO GRADUATE STANDING

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

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

3. Admission to graduate standing does not of itself admit to candidacy for the degree of Master of Science or Doctor of Philosophy. As to this, see pages 103, 105, 108.

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 hereafter 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 therefor.

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.

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

I. GENERAL REQUIREMENTS

To receive the degree of Master of Science, the student must complete in a satisfactory way the work indicated in the schedule of one of the Fifth-Year Courses, as well as in the schedule of the Four-Year Course in Science or in Engineering (see pages 131-144), except that in the case of students transferring from other institutions equivalents will be accepted in subjects in which the student shows by examination or otherwise that he is proficient, and except in so far as substitutions may be approved by special vote of the Committee in charge.

Senior students at the Institute desiring to return for a fifth year will file an application with the representative of the department in which they expect to do their major work, and such application will be passed upon by the Engineering or the Science

Course Committee. Such students will be expected to present satisfactory scholarship qualifications, and to have demonstrated a capacity for doing advanced work.

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

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

II. REGISTRATION

1. The regulations governing registration and student responsibilities as given for undergraduate students on page 75 of the Catalogue apply also to Fifth-Year students.

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

3. A student will not receive credit for a course unless he is properly registered, and at the first meeting of each class should

furnish the instructor with a regular assignment card for the course, obtained from the Registrar's office.

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

III. SCHOLASTIC REQUIREMENTS

1. Scholastic Requirements given on page 77 of the Catalogue for undergraduate students, with the exception of paragraph 6, also apply to Fifth-Year students.

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

IV. THESIS

1. In the Division of Geology and Paleontology, a finished draft of theses presented in partial fulfillment of the requirements for the degree of Master of Science must be submitted to the supervising instructor by the first of May.

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

I. GENERAL REGULATIONS

The degree of Doctor of Philosophy is conferred by the Institute in recognition of breadth of scientific attainment and of power to investigate scientific problems independently and efficiently, rather than for the completion of definite courses of study through a stated term of residence. The work for the degree must consist of scientific research and the preparation of a thesis describing it, and of systematic studies of an advanced character in science or engineering. In addition, the candidate must have acquired the power of expressing himself clearly and forcefully both orally and in written language, and he must have a good reading knowledge of French and German.

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

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

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

With the approval of the Committee on Graduate Study, students are admitted to graduate standing by the department in which they choose their major work toward the Doctor's degree. In the case of insufficient preparation, applicants for the Doctor's degree may be required to register for the Master's degree first. The Master's degree, however, is in no sense a prerequisite for the Doctor's degree.

III. REGISTRATION

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

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

3. A student will not receive credit for a course unless he is properly registered, and at the first meeting of each class should furnish the instructor with a regular assignment card for the course, obtained from the Registrar's office. *The student himself is charged with the responsibility of making certain that all grades to which he is entitled have been recorded.*

4. One term of residence shall consist of one term's work of not less than 45 units in which a passing grade is recorded. If less than 45 units are successfully carried the residence will be regarded as shortened in the same ratio, but the completion of a larger number of units in any one term will not be regarded as increasing the residence. Students who are permitted to carry on research during the summer will be allowed credit, but in order to obtain such credit they must register therefor in advance.

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

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

7. Graduate students studying for the Doctor's degree who are devoting their whole time to their studies will be allowed to register for not more than 60 units in any one term. Students

on part time teaching appointments will not be allowed to register for so many units. Teaching Fellows and Assistants will be allowed to register for not more than 45 units.

IV. GRADES IN GRADUATE COURSES

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

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

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

V. REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

1. *Major and Minor Subjects.* The work for the Doctor's degree must consist of scientific research and advanced studies in some branch of science or engineering, which will be termed the "major subject" of the candidate. In addition, as "minor subject" (or subjects), studies which will give a fundamental knowledge and research point of view must be pursued in at least one other branch of science or engineering.

The choice and scope of the minor subject must be approved by the departments in charge both of the major and minor subjects, and must involve not less than 45 units of advanced study.

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

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

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

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

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

3. *Admission to Candidacy:* Any student admitted to work for the Doctor's degree who has been in residence one term or more, who has satisfied the several departments concerned by written or oral examination or otherwise that he has a comprehensive grasp of his major and minor subjects as well as of subjects fundamental to them, who has satisfied the department of modern languages that he can read scientific German and French with reasonable facility, who has shown ability in carrying on research and whose research subject has been approved

by the chairman of the division concerned, and whose program of study has been approved by both his major and minor departments may, on recommendation of the chairman of the division in which he is working, be admitted by the Committee on Graduate Study to candidacy for the degree of Doctor of Philosophy. Members of the permanent Institute staff of rank higher than that of Assistant Professor are not admitted to candidacy for a higher degree.

A regular 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.*

4. *Examinations:* 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 who have taken regular language classes in the Institute, and have 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.

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

A final examination in their major and minor subjects 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 into parts or given all at one time at the discretion of the departments concerned. The student must petition for this examination on a form obtained from the chairman of the Committee on Graduate Study after consultation with the division chairman.

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

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.*

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

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

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

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

Modern Algebra, Ma. 101 a, b, c, including the Galois Theory; Algebraic Geometry, Ma. 102 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. 101 a, b, c, or Ph. 103 a, b, c.

b. To be recommended for candidacy for the Doctor's degree in Physics the applicant must pass the following courses with a grade of 2 or better: Electricity and Magnetism, Ph. 101 a, b, c, Analytical Mechanics, Ph. 103 a, b, c, Optics, Ph. 105 a, b, and Atomic Physics, Ph. 107 a, b, c. In case the applicant's minor is in Mathematics he must also pass with a grade of 2 or better one of the following courses: Advanced Calculus, Ma. 8 a, b, c, Differential Equations, Ma. 10 a, b, c, or Mathematical Analysis, Ma. 109 a, b, c. In case the applicant's minor is in Chemistry he must also pass with a grade of 2 or better: Chemical Principles, Ch. 21 a, b, c.

c. To be recommended for candidacy for the Doctor's degree in Electrical Engineering the applicant must pass the following courses with a grade of 2 or better: Analytical Mechanics, Ph. 103 a, b, c, or Applied Mechanics, AM. 1 a, b, and Strength of Materials, AM. 1 c; Electricity and Magnetism, Ph. 101 a, b, c, or

Electricity and Magnetism, Ph. 7 a, b, and Theory of Electricity and Magnetism, Ph. 222; Advanced Calculus, Ma. 8 a, b, and Differential Equations, Ma. 11; Alternating Current Analysis, EE. 120; Advanced Alternating Current Machinery, EE. 122; Transmission Lines, EE. 144; Dielectrics, EE. 152.

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

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

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

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

A student in Electrical Engineering will, in general, be 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 the end of each term.

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

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

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

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

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

7. The Doctor's degree is not awarded in Chemical Engineer-

ing at the present time, but students interested in this field may offer a minor in Chemical Engineering in connection with a major in Chemistry.

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.

4. The Ph.D. thesis must be submitted to the professor in charge not later than February 1st. This should be a finished draft with data and maps or illustrations complete. In the interval between February and June it is expected that the candidate will prepare a paper for publication embodying the results of his research in whole or in part.

D. OPPORTUNITIES FOR GRADUATE AND SCIENTIFIC WORK AT THE INSTITUTE

I. 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 they are 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 the basic sciences, 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 men and the character of the work which they pursue. 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.

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

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

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

5. The American Potash and Chemical Corporation has provided a fellowship for the study of problems relating to the utilization of inorganic salts.

6. The E. I. duPont de Nemours Company of Wilmington has for several years provided a fellowship of $750 at the Institute for graduate study and research in chemistry.

7. The Radiological Research Institute has provided a fellowship for work in X-rays.

8. The Petroleum Rectifying Corporation of Los Angeles has established a research fellowship for investigation of oil dehydration.

III. INSTITUTE GUESTS

Members of the faculties of other educational institutions and Research Fellows who have already received their Doctor's degree and desire to carry on special investigations may be granted the privileges of the facilities of the Institute, without payment of fees. Arrangement should be made in advance with the Chairman of the 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.

IV. GRADUATE LIFE

The Athenæum (see page 61) affords opportunity for contact between the Associates of the Institute, distinguished foreign visitors, and members of the staffs and graduate students at the three adjacent institutions, the Mount Wilson Observatory, the Huntington Library, and the California Institute. It also provides living quarters for a limited number of men associated with the foregoing institutions, including specially economical sleeping quarters for about a dozen graduate students.

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Description of the Undergraduate and Fifth-Year Courses

THE COURSES IN ENGINEERING

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

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

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

THE COURSES IN SCIENCE

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

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

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

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

The Biology Option and the Graduate Course in Biology prepare for teaching and research in colleges and universities, for government service in agriculture and public health, and for field studies and laboratory research in connection with museums. The Option of the Undergraduate Course affords a preliminary training, with emphasis on the fundamental sciences, for those who desire to pursue graduate studies in medicine, sanitation, and the public health.

Schedules of the Undergraduate Courses

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

The subject numbers correspond to those given in the Description of Subjects on pages 146-222. The abbreviations denote the various branches of instruction as follows:

Aeronautical Engineering	AE
Applied Mechanics	AM
Assembly	As
Astronomy	Ay
Biology	Bi
Chemistry	Ch
Civil Engineering	CE
Drawing	D
Economics	Ec
Electrical Engineering	EE
English	En
Geology	Ge
History and Government	H
Hydraulics	Hy
Languages	L
Mathematics	Ma
Mechanical Engineering	ME
Philosophy	Pl
Physical Education	PE
Physics	Ph
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 4, 12 a b	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

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

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

†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
§ Structural Drawing	D 9	0	6	0	20	20
§ Descriptive Geometry	D 12 c or d	0	3	0		
§ Surveying	CE 1	3	4	4		
§ Machine Drawing	D 6	0	6	0		
§ Descriptive Geometry	D 12 c or d	0	3	0		
§ Engineering Chemistry	Ch 6	4	0	7		
§ Materials and Processes	ME 3	3	3	5		
§ Mechanism	ME 1	3	3	3		
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.

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

§Each student takes one of these groups 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	..	..
Geology†	Ge 1 a	3	3	3	9	..	..
Biology†	Bi 1	3	3	3	..	9	..
Paleontology† or	Ge 1 b	4	1	4			
Biology† or	Bi 2	3	4	2	..	..	9
Astronomy†**	Ay 1	3	1	5			
Accounting†	Ec 17	3	0	6	9 or	9 or	9
Applied Mechanics	AM 1 a b c	4	3	7	14	14	14
Direct Currents*	EE 2, 3	3	3	6			
Alternating Currents*	EE 4, 5	3	3	6	12	12	12
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.

†Engineering students take two terms of Nature Science and one term of Accounting.

**Not offered in 1931-1932.

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	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. Students are required to take one term of Philosophy or Evolution of Morality, and choose two terms from the other electives as follows:

American Literature, En. 9 (MacMinn)

Modern Drama, En. 10 (Huse, Stanton)

Contemporary Literature, En. 8 (Judy, Eagleson)

German Literature, L. 40 (Macarthur)

Literature of the Bible, En. 11 (MacMinn)

Sociology, Pl. 5 (Untereiner) (Not offered in 1931-1932)

‡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.

FOURTH YEAR (Continued)

SUBJECTS	SUBJECT NUMBER	HOURS PER WEEK			UNITS		
		Class	Lab.	Prep.	1st Term	2nd Term	3rd Term
Mechanical Engineering Option:							
Structures	CE 9	3	3	6		12	..
Machine Design	ME 5a	2	3	4	9		
Machine Design	ME 5b	3	3	4	.	10	.
Machine Design	ME 5c	0	9	0			9
Metallurgy	ME 10	3	0	6	9	..	
Heat Engineering	ME 16	4	0	8	12	..	..
Heat Engineering	ME 17	3	3	3	..	.	9
Heat Eng. Lab. or Elective (see below)	ME 26	0	3	3	..	6	..
Electrical Engineering Option I:							
Structures, or	CE 9	3	3	6	..	..	12
Vacuum Tubes	EE 162	4	0	8	..	..	12
Diff. Equations	Ma 11	3	0	6	9	..	..
Heat Engineering	ME 16	4	0	8	..	12	..
Electrical Eng. Lab.	EE 7	0	3	3	..	..	6
Elect. and Magnetism	Ph 7 a b c	2	0	4	6	6	6
Elect. Measurements	Ph 9 a b	0	3	1	4	4	..
Electrical Machinery	EE 6 a b	2	0	4	..	6	6
*Electrical Engineering Option II:**							
Civil Engineering Option:							
Advanced Surveying	CE 2	3	6	3	12	.	..
Railway Engineering	CE 8 a b c	.	..	..	6	6	6
Theory of Structures	CE 10a b c	3	3	6	12	12	12
Highway Engineering	CE 4	3	0	3	..	..	6
Reinforced Concrete	CE 12	2	0	4	..	..	6
Aeronautics Option:							
Advanced Calculus	Ma 8 a b c	4	0	8	12	12	12
Aeronautics	AE 1	3	0	6	.	9	..
Metallurgy	ME 11	2	0	4	6	..	.
Machine Design	ME 8	3	3	6	12		..
Structures	CE 11 a b	..	..	..	..	9	6
General Electives:							
Advanced Calculus	Ma 8 a b c	4	0	8	12	12	12
Advanced Calculus	Ma 9 a b c	3	0	6	9	9	9
Indust. Accounting	Ec 18	..	..	..	6	..	..
Indust. Statistics	Ec 19	..	..	..	..	..	9

*Same as Option I, except that EE 6 a, b is taken in the first and second terms, AM 3 is taken in the second term, and Ph 5 a, b, c is substituted for Hy 2, ME 16, ME 25, and Ma 11.

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	Ch12 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
Options:							
Chemistry and Chemical Engineering							
Analytical Chem.	Ch 12 c	2	6	2	..	..	10
Physics or Biology							
Organic Chemistry	Ch 43	2	6	2	..	..	10
Mathematics or Physics							
Theory of Equations	Ma 3	3	0	7	..	..	10
*Geology****							
Surveying	CE 1	3	4	4	..	..	11
Descriptive Geometry	D 14	0	3	0	..	..	3
Crystallography	Ge 3 a	1	3	2	..	..	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.

**Not offered in 1931-1932.

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

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							
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
Applied Physics Option:							
Introduction to Math. Physics....	Ph 5 a b c	4	0	8	12	12	12
Electricity and Mag.	Ph 7 a b c	2	0	4	6	6	6
Electrical Meas.....	Ph 9 a b c	0	3	1	4	4	4
Physics or Astronomy Option:							
Introduction to Math. Physics....	Ph 5 a b c	4	0	8	12	12	12
Differ. Equations...	Ma 10 a b c	3	0	6	9	9	9
Chemistry Option:							
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 {0	6 3	2} 1}	..	8	4
A. Inorganic Chem....	Ch 13 a b	2	0	2	4	4	..
Inorg. Chem. Lab...	Ch 14 a b c	0	9	0	9	9	9
B. Introduction to Math. Physics....	Ph 5 a b c	4	0	8	12	12	12
Options: (Cont'd next page)							

*Students taking the Mathematics Option substitute in the second and third terms Analytic Geometry (Ma 4 a b) for Chemical Principles. Students taking the Geology Option substitute in the third term Plane Table Surveying (CE 3) for Chemical Principles.

THIRD YEAR (Continued)

SUBJECTS	SUBJECT NUMBER	HOURS PER WEEK			UNITS		
		Class	Lab.	Prep.	First Term	Second Term	Third Term
Chemical Engineering Option:							
Applied Mechanics..	AM 2 a b	4	0	8	12	12	..
Heat Engineering...	ME 15	3	3	6	..	..	12
Economics.........	Ec 2, 3, 4	3	0	3	..	6	6
Physico-Chem. Lab..	Ch 26 a b	0	3	1	..	4	4
Instrument. Analysis	Ch 16	0	6	2	8	..	..
Mathematics Option:							
Analytical Geom....	Ma 4 a b	3	0	7	..	10	10
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
Geology Option‡:							
Mineralogy........	Ge 3 b c	..	..	..	8	10	..
Drawing...........	D 15, 16	..	..	..	6	..	6
Petrology..........	Ge 4 a b	..	..	..	..	10	8
Field Geology......	Ge 7 a	..	..	..	..	..	10
Historical Geology..	Ge 1 c	3	1	4	8	..	..
Plane Table Surv...	CE 3	1	6	1	..	..	8
Biology Option:							
Physico-Chem. Lab.	Ch 26 a b	0	3	1	..	4	4
Colloid and Surface Chemistry.......	Ch 29	3	0	5	..	..	8
General Botany....	Bi 3	{2 1	4 3	2 2}	8	6	..
General Zoölogy....	Bi 4	3	4	3	10	..	..
Physiology........	Bi 5 b c	{2 2	4 4	2 3}	..	8	9
Histology.........	Bi 6 a b	0	3	0	3	3	..

‡Summer Field Geology required after Junior year.

COURSE IN SCIENCE

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	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							
Applied Physics Option:							
German...........	L 35 a b c	..	..	..	10	6*	6*
Applied Mechanics..	AM 1 a b c	4	3	7	14	14	14
Direct Currents....	EE 2,3	3	3	6			
Alter. Currents.....	EE 4, 5	3	3	6	12	12	12
Heat Engineering...	ME 16	3	3	6			
Physics Option:							
German...........	L 35 a	4	0	6	10	..	..
French............	L 1 a b	4	0	6	..	10	10
Advanced Calculus.	Ma 9 a b c	3	0	6	9	9	9
Prob. and Lt. Sq....	Ma 12	2	0	4	6	..	..
Electricity and Magnetism.......	Ph 101abc	3	0	6	9	9	9
Elec. Measurements.	Ph 9 a b c	0	3	1	4	4	4
Chemistry Option:							
German...........	L 35 a b c	..	..	..	10	6*	6*
Organic Chemistry..	Ch 41 a b c	{3, 2}	0, 0	{5, 4}	8	8	6
Organic Chem. Lab..	Ch 46 a b	0	9	0	9	9	..
Thermodynamic Ch.	Ch 22 a b	2	0	4	6	6	..
Industrial Chem....	Ch 61 a b c	{2, 2}	0, 0	{4, 2}	6	4	4
Chemical Engineering Option:							
German	L 35 a b c	..	..	..	10	6*	6*
Organic Chemistry.	Ch 41 a b c	{3, 2}	0, 0	{5, 4}	8	8	6
Organic Chem. Lab.	Ch 46 a b	0	9	0	9	9	..
Thermodynamic Ch.	Ch 22 a	2	0	4	6	..	..
Industrial Chem ..	Ch 61 a b c	{2, 2}	0, 0	{4, 2}	6	4	4
Direct Currents	EE 2, 3	3	3	6	..	12	..
Alternating Currents	EE 4, 5	3	3	6	..	..	12

*See page 134.
†Omit in Chemical Engineering Option (taken in the third year).
*Students may, with the approval of the language department and of the Registrar, substitute French (L 1 a, b) 10 units, for German (L 35 b, c) in the second and third terms.

FOURTH YEAR (Continued)

SUBJECTS	SUBJECT NUMBER	HOURS PER WEEK Class	Lab.	Prep.	UNITS First Term	Second Term	Third Term
Mathematics Option:							
German	L 35 a	4	0	6	10	..	..
French	L 1 a b	4	0	6	..	10	10
Complex Variable	Ma 107	3	0	6	9	..	..
Modern Algebra	Ma 101 abc	{3 / 4}	0 / 0	{6 / 8}	9	12	12
Differ. Geometry	Ma 103 abc	3	0	6	9	9	9
Astronomy Option:							
German	L 35 a	4	0	6	10	..	..
French	L 1 a b	4	0	6	..	10	10
Diff. Equations	Ma 10 a b c	3	0	6	9	9	9
Prob. and Lt. Sq.	Ma 12	2	0	4	6	..	..
Astronomy†	Ay 5 a b c	4	1	7	12	12	12
*Geology Option**:*							
German	L 35 a b c	..	..	..	10	6*	6*
Field Geology	Ge 7 b	..	..	..	..	..	8
Structural Geology	Ge 9	..	..	..	10	..	..
Invertebrate Pale'n.‡	Ge 11 a b	..	..	..	8	10	..
Vertebrate Paleon.‡	Ge 12 a b	..	..	..	..	10	8
Optical Mineralogy‡	Ge 5	..	..	..	10	..	..
Petrography‡	Ge 6 a b	..	..	..	..	10	10
Thesis	Ge 21, 22	..	..	..	8‡	6	8‡
Biology Option:							
German	L 35 a	4	0	6	10	..	..
French	L 1 a b	4	0	6	..	10	10
Embryology	Bi 7	3	4	3	..	10	..
Biochemistry	Bi 8	3	6	3	12	..	..
Research	Bi 15	..	..	..	..	..	18
Foreign Journals	Bi 16	..	..	..	..	4	4
A. Cytology	Bi 9	3	4	3	10	..	..
Genetics	Bi 10 a b	..	..	..	6	8	..
B. Physiology	Bi 11	..	..	..	..	..	10
Bio-Organic Chem.	Ch	3	0	3	6	..	..

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

**Summer Field Geology required after Senior Year.

†Not offered in 1931-1932.

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

Schedules of the Fifth-Year Courses

SUBJECTS COMMON TO ALL COURSES, ALL TERMS	NUMBER OF UNITS
Seminar in American History and Government / *or* English Literature / *or* Philosophy	9
Engineering or Research Seminars	2
Professional Subjects	42
	53

PHYSICS OR INDUSTRIAL PHYSICS

SUBJECT	SUBJECT NUMBER	NUMBER OF UNITS		
		1st Term	2nd Term	3rd Term
Electives as follows:				
Kinetic Theory	Ph 110 a b	12	12	. .
Atomic Physics	Ph 107 abc	9	9	9
Spectroscopy Lab.	Ph 108	. .	3	. .
Analytical Mechanics	Ph 103 abc	12	12	12
Optics	Ph 105 ab	9	9	. .
Optics Lab.	Ph 106 ab	3	3	. .
Vacuum Tubes	EE 162	. .	. .	12
Mathematical Analysis	Ma 109 abc	15	15	15
Research		15	15	15

MATHEMATICS

Electives as follows:				
Modern Algebra	Ma 101 abc	9	12	12
Differential Geometry	Ma 103 abc	9	9	9
Algebraic Geometry	Ma 102 abc	9	9	9
Relativity	Ma 205			15
Analytical Mechanics	Ph 103 abc	12	12	12
Electricity	Ph 9, 101	12	12	12
Research	. . . .	6	6	6
Subjects in fifth-year Physics Course				

FIFTH-YEAR COURSES

ELECTRICAL ENGINEERING

PROFESSIONAL SUBJECTS	SUBJECT NUMBER	NUMBER OF UNITS		
		1st Term	2nd Term	3rd Term
Alternating Current Analysis	EE 120	12	..	..
Advanced A. C. Machinery	EE 122	..	12	..
Transmission Lines	EE 144	..	..	12
Alternating Current Laboratory	EE 121 a b c	6	6	6
Specifications and Design	EE 148	6	..	..
Electric Transients	EE 160	..	6	..
Dielectrics	EE 152	..	..	6
Research or Thesis	....	12	12	12
Electives, as below	....	6	6	6
		42	42	42
Electives:				
Vacuum Tubes	EE 162	..	..	12
Electric Traction	EE 128	6	..	..
Electrical Communication	EE 156	6	..	..
Light and Power Distribution	EE 130	..	.	6

CHEMISTRY OR CHEMICAL ENGINEERING

Electives from Four-Year Course in Science or Fifth-Year Course in Physics				
Other Electives as follows:				
Thermodynamic Chemistry	Ch 153	8	8	..
Photochemistry	Ch 158	6	..	..
Crystal Structure	Ch 177 abc	2	2	2
Organic Chemistry (special topics)	Ch 161 abc	..	6	6
Organic Chemical Analysis	Ch 162	9	..	..
Chemical Engineering*	Ch 166 ab	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

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		9	12	12
Electives or Research		..	..	9
		42	42	42
Supplementary Professional Subjects				
Water Power Plant Design	CE 101 a b	10	10	..
Arched Dams	CE 103 a b	5	5	..
Statically Indeterminate Structures	CE 105 b c	..	15	15
Geodesy and Precise Surveying	CE 107 a b c	6	6	6
Highway Problems	CE 108	..	..	..
Sewage Treatment Plant Design	CE 110 b c	..	10	10
Sanitation Research	CE 112	..	..	..
Analysis of Earthquake Effects upon Structures	CE 114	..	..	..

MECHANICAL ENGINEERING

Power Plant Engineering	ME 121, 122	..	12	12
Thermodynamics	ME 120	15	..	..
Heat Engineering Laboratory	ME 130	15	..	..
Research or Thesis	ME 100	..	18	18
Elective as below	......	12	12	12
Mechanical Engineering Seminar	ME 150 a b c	2	2	2
		44	44	44
Electives:				
Science of Metals	ME 110 a b c	12	12	12
Advance Machine Design	ME 101 a b c	12	12	12

FIFTH-YEAR COURSES

GEOLOGY AND PALEONTOLOGY

PROFESSIONAL SUBJECTS	SUBJECT NUMBER	NUMBER OF UNITS 1st Term	2nd Term	3rd Term
Ore Deposits	Ge 195	..	10	..
Non-Metalliferous Deposits	Ge 196	..	..	10
Geomorphology† *or*	Ge 186	10	..	..
Seismology‡	Ge 183	6	..	..
Optical Mineralogy*	Ge 5	10	..	..
Petrography*	Ge 6 a b	..	10	10
Invertebrate Paleontology*	Ge 11 a b	8	10	..
Vertebrate Paleontology*	Ge 12 a b	..	10	8
Electives as follows:				
Mineragraphy	Ge 200	9	..	..
Applied Geophysics‡	Ge 207, 205, 206	5	5	5
Physics of the Atmosphere† *or*	Ge 202	..	6	..
Physics of the Earth‡	Ge 203	..	6	..
Physical Geology (Seminar)	Ge 189 a b	5	..	5
Invertebrate Paleon. (Seminar)	Ge 191 a b	5	5	..
Vertebrate Paleon. (Seminar)	Ge 190 a b	..	5	5
Mineralogy (Seminar)	Ge 199	5	..	..
Advanced Petrology	Ge 210	..	5–12	..
Petrology (Seminar)	Ge 211	..	..	5
Economic Geology (Seminar)	Ge 198 a b	..	5	5
Geophysics (Seminar)	Ge 208 a b	5	..	5
Advanced Study	Ge 188	..	..	..
Research	Ge 187	..	..	..

AERONAUTICAL ENGINEERING

PROFESSIONAL SUBJECTS	SUBJECT NUMBER	NUMBER OF UNITS 1st Term	2nd Term	3rd Term
Aerodynamics of the Airplane	AE 251 a b c	9	9	9
Elementary Airplane Design	AE 252 a b c	11	15	20
Mathematical Analysis	Ma 109 a b	15	15	..
Vector Analysis	Ma 14	..	..	12
Lab. Meth. in Aero.	AE 257	6	..	..
Research or Electives				

*The starred course not completed during the senior year is to be taken
†Odd-numbered years.
‡Even-numbered years.

SIXTH-YEAR COURSE

AERONAUTICAL ENGINEERING

PROFESSIONAL SUBJECTS	SUBJECT NUMBER	NUMBER OF UNITS		
		1st Term	2nd Term	3rd Term
Advanced Problems in Airplane Design	AE 253 a b c	9	9	9
Theoretical Aerodynamics I	AE 266 a b	15	9	..
Theoretical Aerodynamics II	AE 267	..	12	..
Hydrodynamics of a Compressible Fluid	AE 268	..	..	12
Aero. Power Plants	AE 256	..	6	..
Research and Electives		..	..	..

Subjects of Instruction

DIVISION OF PHYSICS, MATHEMATICS, AND ELECTRICAL ENGINEERING

PHYSICS

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

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

ASSISTANT PROFESSORS: J. ROBERT OPPENHEIMER, WILLIAM R. SMYTHE

RESEARCH FELLOWS: CARL D. ANDERSON, OTTO BEECK, H. VICTOR NEHER

TEACHING FELLOWS AND GRADUATE ASSISTANTS: LUCAS A. ALDEN, RAYMOND BEELER, WILLIAM M. BLEAKNEY, RICHARD H. BRANDON, EVERETT F. COX, CLYDE B. CRAWLEY, CHARLES E. HABLUTZEL, MAURICE F. HASLER, WALTER H. JORDAN, LAWRENCE E. KINSLER, STANLEY A. MORSE, J. CARLISLE MOUZON, GEORGE C. MUNRO, JOHN M. NORDQUIST, DWIGHT O. NORTH, GEORGE W. READ, JOHN READ, SELBY M. SKINNER, DAVID B. THOMAS

UNDERGRADUATE SUBJECTS

Ph. 1 a, b, c. MECHANICS, MOLECULAR PHYSICS, AND HEAT. 12 units (3-3-6); first, second and third terms.

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

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

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

Instructors: Watson, Bleakney, Crawley, Hablutzel, Jordan, Kinsler, Munro, Neher, Nordquist, North.

Ph. 2 a, b, c. Electricity, Sound, and Light. 12 units (3-3-6), first and second terms; 8 units, third term.

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

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

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

Instructors: Anderson, Beeck, Beeler, Brandon, Lauritsen, Mouzon, John Read, Skinner.

Ph. 2 d. Physics Review. 4 units; last three weeks of sophomore year.

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

Ph. 3. Modern Physics. 12 units (2-6-4); third term.

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

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

Instructor: Bowen.

Ph. 5 a, b, c. Introduction to Mathematical Physics. 12 units (4-0-8); first, second and third terms.

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

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

Instructor: Houston.

Ph. 7 a, b, c. Electricity and Magnetism. 6 units (2-0-4); first, second and third terms.

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

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

Text: Electrodynamics for Engineers, Bennett and Crothers.

Instructor: Mackeown.

Ph. 9 a, b, c. Electrical Measurements. 4 units (0-3-1).

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

A laboratory course in advanced electrical measurements.

Text: Advanced Electrical Measurements, Smythe and Michels.

Instructors: Smythe, G. W. Read, Alden.

UNDERGRADUATE OR GRADUATE SUBJECTS

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

Prerequisites: Ph. 5 a, b, c; Ma. 9 a, b, c, or 10 a, b, c.

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

Text: Electricity and Magnetism, Jeans.

Instructor: Smythe.

Ph. 103 a, b, c. ANALYTICAL MECHANICS. 12 units (4-0-8); first, second and third terms.

Prerequisites: Ph. 5 a, b, c; Ma. 9 a, b, c, or 10 a, b, c, reading knowledge of French.

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

Texts: Painlevé Cours de Mécanique, Vols. I and II.

Instructor: Zwicky.

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

Prerequisites: Ph. 5 a, b, c; Ma. 9 a, b, c, or 10 a, b, c.

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

Text: Theory of Optics, Drude.

Instructor: Bowen.

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

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

Text: Manual of Advanced Optics, Taylor.

Instructors: Bowen and Cox.

Ph. 107 a, b, c. Atomic Physics. 9 units; first, second and third terms.

Prerequisites: Ph. 5 a, b, c; Ma. 9 a, b, c, or 10 a, b, c.

An outline of the experimental and theoretical basis of modern atomic physics, which covers electron theory, spectroscopy and the elementary principles of quantum mechanics.

Instructors: Millikan, Bowen, Houston.

Ph. 108. Spectroscopy Laboratory. 3 units; second term.

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

Instructor: Bowen.

Ph. 110 a, b. Kinetic Theory of Matter. 12 units; first and second terms.

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

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

Instructor: Goetz.

Ph. 142. Research in Physics. Units in accordance with the work accomplished.

GRADUATE SUBJECTS

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

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

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

Instructor: Epstein.

Ph. 221. Potential Theory. 15 units; third term.

Prerequisites: Ma. 9 a, b, c, 10 a, b, c.

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

(Not given in 1931-1932.)

Instructor: Bateman.

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

Prerequisites: Ph. 101 a, b, c; Ma. 9 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 1931-1932.)

Instructor: Epstein.

Ph. 223. Theory of Electromagnetic Waves. 12 units; second term.

Prerequisites: Ph. 101 a, b, c; Ma. 9 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 1931-1932.)

Instructor: Epstein.

Ph. 224. Theory of Sound. 9 units; second term.

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

Vibrations of strings, rods, plates and of the larynx. Resonators, horns and musical instruments. Theories of hearing. The acoustics of an auditorium. The propagation of sound. Reflection, refraction and absorption of sound.

(Not given in 1931-1932.)

Instructor: Bateman.

Ph. 226. Heat Radiation and Quantum Theory. 12 units; second term.

Prerequisites: Ph. 101 a, b, c, 103 a, b, c, 211; Ma. 9 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. 227. Physical Optics and Quantum Theory of Spectral Lines. 12 units; third term.

Prerequisites: Ph. 103 a, b, c, 105 a, b, 107 a, b, c; Ma. 9 a, b, c, 10 a, b, c.

Treatment of dispersion and optical activity on the basis of the classical theory. Fundamentals of quantum theory and wave mechanics. Action of magnetic and electric fields on the emission of spectral lines. X-ray spectra and the structure of atoms.

(Not given in 1931-1932.)

Instructor: Epstein.

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

Prerequisites: Ph. 103 a, b, c, 107 a, b, c, 226, 227; Ma. 9 a, b, c, 10 a, b, c.

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

Instructor: Epstein.

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

Prerequisites: Ph. 101 a, b, c, 103 a, b, c, 107 a, b, c; Ma. 9 a, b, c, 10 a, b, c. Matrices and tensors. Schroedinger's partial differential equation. Dirac's transformation theory. Applications to the structure of atoms.

(Not given in 1931-1932.)

Instructor: Epstein.

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

Prerequisites: Ph. 101 a, b, c, 103 a, b, c, 107 a, b, c; Ma. 9 a, b, c, 10 a, b, c.

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

Instructor: Oppenheimer.

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

Prerequisites: Ph. 101 a, b, c, 103 a, b, c, 107 a, b, c; Ma. 9 a, b, c, 10 a, b, c.

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

(Not given in 1931-1932.)

Instructor: Oppenheimer.

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

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

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

Instructor: Tolman.

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

Recent developments in theoretical physics for specialists in mathematical physics.

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

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

This seminar discusses the current literature on the physics of solids, together with the problems that turn up in the research at the Institute in this field. Only advanced students working in experimental and theoretical research in the physics of solids should register for this seminar.

Instructors: Goetz in collaboration with other members of the staff.

Ph. 240. SEMINAR ON X-RADIATION. 4 units; first, second, and third terms.

Meets once a week for reports and discussions of problems in X-Radiations. "X-Rays" by de Broglie is followed in the first term as an outline only; the reports being amplifications and additions to the material of the text as drawn from the original papers of workers in the field. During the second and third terms advanced reports are made on current problems in the field of X-Rays and on fundamental classical work.

Instructors: Lauritsen and DuMond.

Ph. 241. Research Conferences in Physics. 4 units; first, second and third terms.

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

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

Ph. 242. Research in Physics. Units in accordance with the work accomplished.

Astronomy and Physics Club.

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

MATHEMATICS

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

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

ASSISTANT PROFESSORS: WILLIAM N. BIRCHBY, MORGAN WARD, CLYDE WOLFE

NATIONAL RESEARCH FELLOW: ARNOLD E. ROSS

TEACHING FELLOWS AND ASSISTANTS: J. LAWRENCE BOTSFORD, VINTON A. BROWN, ARNOLD M. KUETHE, HARRY MATISON, ROBERT S. MARTIN, ALBERT R. POOLE, LYNN H. RUMBAUGH, FRANK C. WALZ, JAMES H. WAYLAND, MERLE C. WILLIAMS, CARLTON R. WORTH

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 and Calculus, Woods and Bailey.

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

Prerequisite: Ma. 1 a, b, c.

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

Text: Analytic Geometry and Calculus, Words and Bailey.

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

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

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

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

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

Instructor: Wear.

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

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

Instructor: Birchby.

Ma. 8 a, b, c. Advanced Calculus. 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, Poole.

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

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

An abridged course in Advanced Calculus for students in Theoretical Physics.

Text: Advanced Calculus, Wood.

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

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

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

Texts: Differential Equations, Piaggio, Woods.

Instructor: Martin.

Ma. 11. Differential Equations. 9 units (3-0-6); first 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. 6 units (2-0-4); first term.

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

A study of the fundamental principles of probability and their application to statistical data, adjustment of observations, and precision of measurements.

Text: Theory of Errors and Least Squares, Bartlett.
Instructor: Wolfe.

Ma. 14. VECTOR ANALYSIS. 12 units (4-0-8); third term.
Prerequisites: Ma. 2 a, b, c, d.
Elementary vector operations (addition, multiplication) and their application to problems of geometry and physics are treated.
Text: Coffin's Vector Analysis.
Instructor: Ward.

UNDERGRADUATE OR GRADUATE SUBJECTS

Ma. 101 a, b, c. MODERN ALGEBRA. 9 units first term; 12 units second and third terms.
Prerequisite: Ma. 8 or 9, reading knowledge of German.
Introduction to algebraic invariants, matrices and bilinear forms, substitution groups and their simpler applications.
Instructor: Bell.

Ma. 102 a, b, c. ALGEBRAIC GEOMETRY. 9 units; first, second and third terms.
Prerequisites: Ma. 1 a, b, c, 2 a, b, c, d, 4 a, b.
A course in the modern methods of analytic geometry.
Instructor: Wear.

Ma. 103 a, b, c. DIFFERENTIAL GEOMETRY. 9 units; first, second and third terms.
Prerequisites: Ma. 8 or 9, 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. 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 or 9, 10, 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 1931-1932.)

Text: Whittaker, Calculus of Observations.

Instructors: Bateman, Wolfe.

Ma. 106 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, Lebesque integration, infinite series, implicit functions, Fourier series.

(Not given in 1931-1932.)

Instructor: Ward.

Ma. 107. Complex Variable. 9 units (3-0-6); first term.

Prerequisites: Ma. 8 or 9, 10.

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.

Text: Bieberbach, Functiontheorie.

(Not given in 1931-1932.)

Instructor: Ward.

Ma. 108 a, b, c. Infinite Series. 15 units; first, second and third terms.

Prerequisites: Ma. 8 or 9, 10.

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

Instructor: Bell.

Ma. 109 a, b, c. Mathematical Analysis. 15 units; first, second and third terms.

Prerequisites: Ma. 8 or 9, 10.

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.

Instructor: Ward.

Ma. 110 a, b, c. Introduction to Theory of Numbers. 6 units; first, second, and third terms.

Prerequisite (third term): Reading knowledge of German.

This course will cover selected topics in elementary number theory.

Texts: Dickson's Introduction to Theory of Numbers; Landau's Vorlesungen.

Instructor: Ward.

Ma. 111. Elementary Theory of Tensors. 9 units.

Prerequisites: Ma. 8 or 9, 10.

Fundamental properties of tensors, differential forms, covariant differentiation, geodesic coordinates, Riemannian differential geometries.

Instructor: Michal.

Ma. 112 a, b, c. Theory of Numbers. 9 units; first, second and third terms.

Elementary theory of numbers.

Text: Dickson, Introduction to the Theory of Numbers; assigned readings.

Instructor: Ross.

GRADUATE SUBJECTS

Ma. 201. Modern Analysis. 15 units; first, second, and third terms.

Prerequisites: Ma. 8 or 9, 10.

Theory of convergence, integration and residues, expansions of functions in infinite series, asymptotic and divergent series. Fourier series. Differential equations and function theory, integral equations, the gamma function and the zeta function, the hypergeometric function and related functions of mathematical physics, elliptic functions, ellipsoidal harmonics.

Text: Whittaker and Watson, Modern Analysis.

Instructor: Bateman.

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

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

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

Instructor: Ward.

Ma. 203 a, b, c. Partial Differential Equations and Tensor Analysis. 12 units; first, second, and third terms.

Prerequisites: Ma. 8 or 9, 10.

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.

(Not given in 1931-1932.)

Instructor: Michal.

Ma. 204 a, b, c. Geometrical Transformations and Invariants. 15 units; first, second, and third terms.

Prerequisite: Graduate standing.

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

Instructor: Bateman.

Ma. 205. Relativity. 15 units; third term.

Prerequisites: Ma. 8 or 9, 10; Ph. 1, 2.

Tensor analysis; the general theory of relativity and gravitation.

(Not given in 1931-1932.)

Instructor: Bell.

Ma. 206 a, b. Modern Theories of Differential Invariants. 9 units; second and third terms.

Prerequisite: Ma. 111 and a course in analysis.

Differential invariants of symmetric and asymmetric connections, projective and conformal differential invariants. Modern differential geometries. Continuous groups and their invariants.

Instructor: Michal.

Ma. 207. Calculus of Variations. 15 units; first term.

Prerequisites: Ma. 8 or 9, 10.

Solutions of geometrical and physical problems involving the variation of a definite integral by both direct and indirect methods. Derivation of the equations of Euler and Lagrange. Conditions for a maximum or minimum.

Instructor: Bateman.

Ma. 208. INTEGRAL EQUATIONS. 9 units; third term.

Prerequisites: Ma. 8 or 9, 10.

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

Instructor: Bateman.

Ma. 209 a, b, c. FUNCTIONALS AND FUNCTIONAL EQUATIONS. 15 units; first, second, and third terms.

Prerequisite: Graduate standing in Mathematics, including a course in Analysis.

Functional operations; permutable functions, functions of composition; integral equations, integro-differential equations, partial differential equations of the second order; differentials of functionals, functional equations with functional derivatives; infinite matrices.

(Not given in 1931-1932.)

Instructor: Michal.

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

Prerequisite: Graduate standing.

The Dedekind theory of algebraic numbers, Kronecker's theory of modular systems with applications to algebraic functions; comparison of recent theories of algebraic numbers.

Instructor: Bell.

Ma. 251 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. 252 a, b, c. SEMINAR IN CONTINUOUS GROUPS. 9 units; first, second, and third terms.

Prerequisite: Graduate standing in Mathematics.

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

Instructor: Michal.

Ma. 253 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.

(Not given in 1931-1932.)

Instructor: Michal.

Ma. 254 a, b, c. SEMINAR IN MODERN THEORIES OF INTEGRATION. 6 units; first, second and third terms.

Prerequisite: Graduate standing in Mathematics, including a course in Function Theory.

Stieltzes and Lebesgue integrals with applications to the algebra and geometry of functionals.

Instructor: Michal.

Ma. 255 a, b, c. DIFFERENTIAL AND INTEGRAL EQUATIONS OF MATHEMATICAL PHYSICS. 15 units; first, second and third terms.

Prerequisites: Ma. 8 or 9, 10.

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

Instructor: Bateman.

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

Prerequisite: Graduate standing.

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

Instructor: Michal.

One or two of courses Ma. 203, 209, 252, 253, will be given according to demand.

ELECTRICAL ENGINEERING

PROFESSOR: ROYAL W. SORENSEN

ASSOCIATE PROFESSOR: S. STUART MACKEOWN

ASSISTANT PROFESSOR: FREDERICK C. LINDVALL

INSTRUCTOR: FRANCIS W. MAXSTADT

TEACHING FELLOWS AND ASSISTANTS: RAYMOND AGER, STERLING BECKWITH, MELVIN E. GAINDER, ANDREW V. HAEFF, GEORGE T. HARNESS, GIBSON PLEASANTS, GEORGE W. READ, DAVID SHEFFET, 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, Harness.

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, Beckwith, Gainder, Sheffet, 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, Harness.

EE. 5. Alternating Current Laboratory. 5 units (0-3-2); second or third term.

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

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

Text: Laboratory Notes.

Instructors: Maxstadt, Beckwith, Gainder, Sheffet, Wolfe.

EE. 6 a, b. Electrical Machinery. 6 units (2-0-4); first and second terms, or second and third terms.

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

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

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

Instructor: Lindvall.

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

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

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

Text: Laboratory Notes.

Instructors: Maxstadt, Beckwith, Gainder.

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.

FIFTH-YEAR SUBJECTS

EE. 120. Alternating Current Analysis. 12 units (5-0-7); first term.

Prerequisites: EE. 7 and preceding courses.

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

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

Instructor: Sorensen.

EE. 121 a, b, c. Alternating Current Laboratory. 6 units (0-3-3); first, second and third terms.

Prerequisites: EE. 7 and preceding courses.

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

Text: Advanced Laboratory Notes.

Instructors: Maxstadt, Haeff.

EE. 122. 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. 128. Electric Traction. 6 units (2-0-4); first term.

Prerequisites: EE. 2, 4, 6.

The electric railway, traffic studies and schedules, 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: Railway Engineering, Harding.

Instructor: Maxstadt.

EE. 130. Electric Lighting and Power Distribution. 6 units (2-0-4); third term.

Prerequisites: EE. 2, 4, 6.

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

Text: Electrical Equipment, Lloyd.

Instructor: Ager.

EE. 144. Transmission Lines. 12 units (4-0-8); third term.

Prerequisites: EE. 122 and preceding courses.

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

Instructor: Lindvall.

EE. 148. Specifications and Design of Electrical Machinery. 6 units (4-0-2); first term.

Prerequisites: EE. 7 and preceding courses.

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

Text: Electrical Machine Design, Gray.

Instructor: Sorensen.

EE. 152. Dielectrics. 6 units (2-0-4); third term.

Prerequisites: EE. 122 and preceding courses.

A study of electric fields in insulations, particularly air, and the effects on sparking voltage of the sparking distance, atmospheric pressure and humidity; corona phenomena; high frequency voltages; characteristics of commercial insulations.

Text: Dielectric Phenomena in High Voltage Engineering, Peek.

Instructors: Sorensen, Ager.

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

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

A study of modern means of communication with special emphasis on recent developments.

Instructor: Mackeown.

EE. 160. Electric Transients. 6 units (2-0-4); second term.

Prerequisites: EE. 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.

Instructor: Mackeown.

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

Prerequisites: EE. 6 and preceding courses.

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

Instructor: Mackeown.

ADVANCED SUBJECTS

EE. 200. Advanced Work in Electrical Engineering.

Special problems relating to electrical engineering will be arranged to meet the needs of students wishing to do advanced work in the field of electricity. The Institute is equipped to an unusual degree for the following lines of work: Theory of Electrical Machine Design, Electric Transients, and High Voltage Engineering Problems, under the direction of 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 Dr. F. W. Maxstadt.

EE. 220. Research Conferences in Electrical Engineering. 2 units required; additional units based on work done. First, second, and third terms.

Meets once a week for discussion of work appearing in the literature and in progress at the Institute. All advanced students in Electrical Engineering and members of the Electrical Engineering staff are expected to take part.

Instructors: Sorensen, Mackeown, Maxstadt, and Lindvall.

EE. 221 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.

EE. 226. ENGINEERING MATHEMATICAL PHYSICS. 15 units (3-0-12); first, second, and third terms.

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

This course is designed to develop the correlation of mathematics and physics with problems in engineering design and application. The following subjects will be treated in detail: mechanical vibrations, oscillations in electro-mechanical systems, short circuit forces, power system transients, electric motors applied to variable or pulsating loads, heat transfer and transient heat flow. The principle of constant flux linkage in electrical transient analysis; solution of mechanical problems by electrical methods; application of Heaviside operational calculus to mechanical and thermal problems.

Instructor: Lindvall.

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

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

Instructor: Mackeown.

DIVISION OF CHEMISTRY AND CHEMICAL ENGINEERING

CHEMISTRY

PROFESSORS: ARTHUR A. NOYES, STUART J. BATES, JAMES E. BELL, WILLIAM N. LACEY, LINUS C. PAULING, RICHARD C. TOLMAN

ASSOCIATE PROFESSORS: ROSCOE G. DICKINSON, HOWARD J. LUCAS

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

RESEARCH FELLOWS: EDWARD W. NEUMAN, JAMES H. STURDIVANT

TEACHING FELLOWS AND GRADUATE ASSISTANTS: ROBERT C. BARTON, PHILIP D. BRASS, LAWRENCE BROCKWAY, BERNARD M. DICKINSON, WILLIAM F. EBERZ, EMORY L. ELLIS, NORMAN R. GUNDERSON, EARL S. HILL, JAMES L. HOARD, RALPH R. HULTGREN, CECIL E. P. JEFFREYS, CHARLES E. KIRCHER, JOHN A. LEERMAKERS, WILLIAM B. LEWIS, ERNEST H. LYONS, JOHN McMORRIS, ROSS E. MORRIS, PHILIP G. MURDOCH, ALBERT MYERS, BRUCE H. SAGE, JACK SHERMAN, CARSTON C. STEFFENS, ROBERT I. STIRTON, GUY WADDINGTON, SIDNEY WEINBAUM, E. BRIGHT WILSON, JR.

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: Smith-Kendall, Chemistry; A. A. Noyes, Qualitative Analysis.

Instructors: Bell, Beckman, and Teaching Fellows.

Ch. 6. ENGINEERING CHEMISTRY. 11 units (4-0-7); 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 (2-0-2); 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, c. Inorganic Chemistry Laboratory. 9 units; first, second and third 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.

Prerequisite: Ch. 12 c.

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

Text: Lacey, Instrumental Methods of Chemical Analysis.

Instructor: Lacey.

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

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

Conferences and recitations dealing with the general principles of chemistry from an exact, quantitative standpoint, and including studies on the elements of thermodynamics; the pressure-volume relations of gases; on vapor-pressure, boiling point, freezing point, and osmotic pressure of solutions; on the molecular and ionic theories; on electrical transference and conduction; on chemical and phase equilibria; on thermochemistry, and the elements of thermodynamic chemistry and of electrochemistry. A large number of problems are assigned to be solved by the student.

Text: Noyes and Sherrill, Chemical Principles.

Instructors: Bates, Dickinson.

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

A continuation of subject Ch. 21, given in much the same way. The topics considered include reaction rate and a further study of 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 mimeographs.

Instructor: Bates.

Ch. 26 a, b. PHYSICAL CHEMISTRY LABORATORY. 8 units (0-6-2) or 4 units (0-3-1) second term; and 4 units (0-3-1) third term.

Laboratory exercises to accompany Ch. 21.

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

Instructors: Bates, Dickinson, Badger.

Ch. 29. COLLOID AND SURFACE CHEMISTRY. 8 units (3-0-5); third term.

Prerequisite: Ch. 22.

Class-room exercises with outside reading and problems, devoted to surface tension, adsorption, contact catalysis, and the general principles relating to disperse systems with particular reference to the colloidal state. Supplementary laboratory work can be provided if desired.

Text: Kruyt, Colloids, and mimeographed notes.

Instructor: Badger.

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

Prerequisite: Ch. 12.

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

Text: Lucas, Mimeographed Notes.

Instructor: Lucas.

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

Prerequisites: Ch. 1 a, b, c.

Lectures and recitations, accompanied by laboratory exercises, dealing with the synthesis and the physical and chemical properties of the more important compounds of carbon.

Text: Porter, The Carbon Compounds.

Instructor: Ramsperger.

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. The preparation and purification of carbon compounds and the study of their characteristic properties. Qualified students may pursue research work.

Text: Lucas, Mimeographed Notes.

Instructor: Lucas.

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

Prerequisites: Ch. 21, a, b.

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

Text: Badger and Baker, Inorganic Chemical Technology.

Instructor: Lacey.

Ch. 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. 8 units; first and second terms.

This course is the same as Ch. 22, a, b. See page 170.

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

Instructor: Bates.

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

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

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

Instructor: Tolman.

Ch. 156 a, b. 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.

Instructor: Pauling.

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

This topic is divided into two parts.

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

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

Instructor: Pauling.

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

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

Instructor: Dickinson.

Ch. 159. THERMODYNAMICS (Seminar). 6 units, first term.

A discussion of the fundamental principles and methods of thermodynamics.

Instructor: Dickinson.

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

Selected groups of inorganic compounds (e.g., the various compounds of nitrogen with hydrogen and with oxygen) will be considered from modern physico-chemical view-points; thus with reference to their physical properties, their thermodynamic constants (their heat-contents, free-energies, and entropies); their rates of conversion into one another (including effects of catalysis and energy radiations), the ionization of those that are weak acids or bases, and their electron structure and valence relations.

Instructors: Noyes, Yost.

Ch. 161 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. 9 units; first term.

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

Instructor: Lucas.

Ch. 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. 169. Research Manipulations. 3 units; first term.

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

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

Instructor: Beckman.

Ch. 170-173. Chemical Research.

Opportunities for research are offered to graduate students in all the main branches of chemistry, namely, in analytical or inorganic chemistry (170), physical chemistry (171), organic chemistry (172), and applied chemistry (173).

The main lines of research now in progress are:

Ionized substances in relation to the ion attraction theory.
Free-energies, equilibria, and electrode-potentials of reactions.
Study of crystal structure and molecular structure by diffraction of X-rays and electron waves.
Determination of the distribution of electrons in crystals.
Rates of chemical reactions in relation to the quantum theory.
Application of quantum mechanics to chemical problems.
Mechanism of homogenous reactions.
Chemical reactions produced by atoms and molecules excited by radiations.
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.
Solubility of gases in liquids at high pressures.
Equilibria in saturated salt solutions.
Electrolysis of copper leading solutions.
Recovery steps in paper pulp process.

For a fuller survey of the researches in progress, see Publications of the Gates Chemical Laboratory, pages 122-123.

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, Ramsperger, Alles.

Ch. 175. Chemical Applications of Spectral Data (Seminar). 6 units; third term.

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 a, b, c. RESEARCH CONFERENCES IN PHOTOCHEMISTRY. 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 a, b, c. RESEARCH CONFERENCES IN CRYSTAL STRUCTURE AND MOLECULAR STRUCTURE. 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 a, b, c. 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

Ch. 179 a, b, c. RESEARCH CONFERENCES IN APPLIED CHEMISTRY. 2 units; first, second and third terms.

Reports on researches and recent developments in the fields of Applied Chemistry and Chemical Engineering.

Instructor: Lacey.

DIVISION OF CIVIL AND MECHANICAL ENGINEERING*

CIVIL ENGINEERING

PROFESSORS: FRANKLIN THOMAS, ROMEO R. MARTEL

ASSOCIATE PROFESSOR: WILLIAM W. MICHAEL

INSTRUCTOR: FRED J. CONVERSE

TEACHING FELLOWS AND ASSISTANTS: J. H. A. BRAHTZ, CHARLES K. LEWIS, HARLAN B. ROBINSON, MERIT P. WHITE

UNDERGRADUATE SUBJECTS

CE. 1. SURVEYING. 11 units (3-4-4); 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.

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*See Division of Physics, Mathematics and Electrical Engineering pages 162-167, 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.
Prerequisite: CE. 1.
The theory of railway, highway and ditch location and surveys; problems relating to curves, grades, earthwork and track layout, including a study of the mass diagram as applied to railway and highway earthwork.
Text: Railway Curves and Earthwork, Allen.
Instructor: Michael.

CE. 8 c. Railway Surveying. 6 units (0-6-0); third term.
Prerequisite: CE. 8 b.
The class devotes one entire day a week to field surveys of a railroad location, applying the principles as outlined under course CE. 8 b.
Text: Railway Curves and Earthwork, Allen.
Instructor: Michael.

CE. 9. Elements of Structures. 12 units (3-3-6); second term for Mechanical Engineering students; third term for students in Electrical Engineering.
Prerequisite: AM. 1 c.
An abridged course in design of simple structures of timber, steel, masonry, and reinforced concrete. Emphasis is placed upon methods and computations in numerous typical examples.
Text: Structural Design, Thomas.
Instructors: Thomas, Michael, Converse.

CE. 10 a. Theory of Structures. 12 units (3-3-6); first term.
Prerequisite: AM. 1 c.

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

Text: Structural Theory, Sutherland and Boman.

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: Design of Steel Structures, Urquhart and O'Rourke.

Instructors: Thomas, Martel.

CE. 11 a, b,. STRUCTURES. 9 units (2-3-4), second term and 6 units third term.

Prerequisite: AM. 1 c.

A brief course adapted for aeronautical engineering students in the analysis of forces by analytical and graphical methods and the calculation of stresses in beams, girders, columns and simple trusses of timber, steel, and light alloys. The third term is devoted to a study of continuous beams and trusses, trusses with redundant members, effect of flexure and direct stress, deflections in beams and trusses.

Text: Airplane Structures, Niles and Newell.

Instructor: Brahtz.

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.

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

FIFTH-YEAR SUBJECTS

CE. 15. Irrigation and Water Supply. 12 units (5-0-7); second term.

Prerequisite: Hy. 1.

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

Text: Water Supply and Utilization, Baker and Conkling.

Instructor: Thomas.

CE. 16. Masonry Structures. 9 units (2-3-4); second term.

Prerequisite: CE. 12.

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

Text: 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 and Eddy.

Instructor: Thomas.

CE. 21 a. Structural Design. 9 units (0-9-0); first term.

Prerequisites: CE. 10 a, b, c.

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

Instructors: Thomas, Brahtz.

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, Brahtz.

CE. 21 c. Civil Engineering Design. 12 units (0-12-0); third term.

Prerequisites: CE. 15, 21 a, b.

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

Instructors: Thomas, Brahtz.

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: Elastic Energy Theory, Van den Broeck.

Instructor: Martel.

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

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

ADVANCED SUBJECTS

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

CE. 101 a, b. Water Power Plant Design. 10 units; first and second terms.

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

Instructor: Thomas.

CE. 103 a, b. Arched Dams. 5 units; first and second terms.

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

Instructor: Martel.

CE. 105 b, c. Statically Indeterminate Structures. 15 units; second and third terms.

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

Text: 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.

Instructor: Martel.

MECHANICAL ENGINEERING

PROFESSORS: ROBERT L. DAUGHERTY, W. HOWARD CLAPP
ASSISTANT PROFESSOR: ROBERT T. KNAPP
INSTRUCTOR: ERNEST E. SECHLER
TEACHING FELLOWS AND ASSISTANTS: DONALD S. CLARK, RICHARD G. FOLSOM, BRUCE H. SAGE, RALPH M. WATSON, GEORG WISLICENUS

UNDERGRADUATE SUBJECTS

ME. 1. MECHANISM. 9 units (3-3-3); first, second or third term.

Prerequisites: Ma. 1 a, b, c, d; Ph. 1 a, b, c, d; D. 1, 4, 12 a, b.

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

Text: Mechanism, Clapp and Ogier.

Instructor: Watson.

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

A study of the materials of engineering and of the processes by which these materials are made and fabricated. The fields of usefulness and the limitations of alloys and other engineering materials are studied, and also the fields of usefulness and limitations of the various methods of fabrication and of processing machines.

The class work is combined with inspection trips to many industrial plants. The student is not only made acquainted with the technique of processes but of their relative importance industrially and with the competition for survival which these materials and processes continually undergo.

Instructors: Clapp and Clark.

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

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

Applications of mechanics of machinery and mechanics of materials to practical design and construction. Riveting and welding; boilers and plate vessels; bolts and screws; force and shrink fits; hydraulic cylinders; cylinders and cylinder heads for steam and gas engines; stuffing boxes and packing; pistons and piston rings; leaf springs, coil springs; piston pins; connecting rods and cross heads; cranks and crank-shafts; flywheels; spur gears; helical gears; bevel gears; worm gears; spiral gears; belting; pulleys; rope driving; chains; friction drives; wire rope and hoisting; plain bearings; ball bearings; roller bearings; shafts and couplings; clutches; brakes; high speed disks; piping. Also a study of manufacturing processes with especial reference to the economics of design.

Text: Norman, Machine Design; Marks, Mechanical Engineers Handbook.

Instructor: Clapp, Wislicenus.

ME. 8. Machine Design. 12 units (3-3-6); first term.

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

An abbreviated course in machine design for aeronautical engineers. The energy and force problem; relations of stress and strain to failure and the determination of proper safety factors; straining actions in machines; stresses with complex loading; screws and screw fastenings; axles, shafting, and couplings; friction and lubrication; journals and bearings.

Text: Machine Design, Kimball and Barr. Lectures and problems.

Instructor: Sechler.

ME. 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, Clark.

ME. 11. Metallurgy. 6 units (2-0-4), first term.

Prerequisite: Ch. 6.

Same as ME. 10, but abbreviated for students in Aeronautics.

Instructor: Clark.

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: Knapp, Folsom.

ME. 16. Heat Engineering. 12 units (4-0-8); first term for students in Mechanical Engineering, second term for students in Electrical Engineering.

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 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: Knapp, 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.

Instructors: Knapp, 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 industry. Review of current literature.

Instructors: Daugherty, Loosley.

FIFTH-YEAR AND ADVANCED SUBJECTS

ME. 100. ADVANCED WORK IN ENGINEERING.

In addition to the regular fifth-year and other advanced courses which are here outlined, the staff of the mechanical engineering department will arrange special courses or problems to meet the needs of advanced students.

ME. 101 a, b, c. ADVANCED MACHINE DESIGN. 12 units, each term.

Prerequisites: ME. 5, 10.

The student must possess a comprehensive knowledge of mechanics, of materials, and also of the physical properties of the more common materials of construction. Strength of material formulae are studied as to their authority and limitations, and their application is extended to cover such cases as curved bars, thin plates, energy loads, stress concentration around holes, key seats, etc.; dynamic stresses as in rotating disks and flywheels; critical speeds of shafting; bending of bars on elastic foundations. Many examples of evolved designs are studied to determine the considerations which have led to the design. Theory of strengths and their application to the study of designs which have failed in service.

Instructor: Clapp.

ME. 110 a, b, c. SCIENCE OF METALS. 12 units, each term.

Prerequisite: ME. 10.

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

Instructors: Clapp, Clark.

ME. 120. THERMODYNAMICS. 15 units; first term.

Prerequisite: ME. 17.

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

Instructor: Daugherty.

ME. 121 and 122. Power Plant Engineering. 12 units (1-9-2); second and third terms.

Prerequisite: ME. 120.

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

Instructor: Daugherty.

ME. 125. Refrigeration Plants. Units to be based on work done; any term.

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

Instructors: Daugherty, Knapp.

ME. 130. Heat Engineering Laboratory. 15 units (1-9-5); first term.

Prerequisites: ME. 17, 26.

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

Instructor: Knapp.

ME. 132. Engine Laboratory. 15 units; first, second and third terms.

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

ME. 150 a, b, c. Mechanical Engineering Seminar. 2 units each term.

Attendance required of graduate students in mechanical engineering. Conference on research work and reviews of new developments in engineering.

AERONAUTICS

PROFESSORS: HARRY BATEMAN, THEODOR VON KARMAN

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

RESEARCH FELLOWS: LLOYD H. DONNELL, WALTER TOLLMIEN, R. SEIFERTH

TEACHING FELLOWS AND GRADUATE ASSISTANTS: W. BAILEY OSWALD, FRANK WATTENDORF

UNDERGRADUATE SUBJECTS

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

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

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

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

See also Courses CE. 11 and ME. 8.

FIFTH-YEAR AND ADVANCED SUBJECTS

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

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

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

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

Instructor: Millikan.

AE. 252 a, b, c. 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 with or subsequently to 251.

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

Instructors: Klein, Raymond.

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

Prerequisite: AE. 251.

Instructor: Raymond.

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

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

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

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

Instructor: Klein.

AE. 257. LABORATORY METHODS IN AERONAUTICS. 6 units, first term.

Wind channel devices, velocity and pressure measurement, water channel, free flight apparatus, laws of similarity and scale effect.

Instructor: Klein.

AE. 258 a, b, c. AERONAUTICAL PROBLEMS. 3 units (1-0-2), first, second and third terms.

Open to students in aeronautical engineering.

Instructor: Hoover.

AE. 266 a, b. THEORETICAL AERODYNAMICS I. PERFECT FLUIDS. 15 units, first term; 9 units, second term.

Prerequisite: Ma. 14, 109 a, b.

Hydrodynamics of perfect fluids as applied to aeronautics, potential motion, circulation, laws of vortex motion, elements of conformal transformation, streamline bodies, airfoils, three dimensional wing theory, monoplanes, biplanes, interference.

Texts: Glauert, The Elements of Aerofoil and Airscrew Theory; Prandtl, Applications of Modern Hydrodynamics to Aeronautics.

Instructor: Kármán or Millikan.

AE. 267. THEORETICAL AERODYNAMICS II. REAL FLUIDS. 12 units, second term.

Prerequisite: AE. 266 a.

Hydrodynamics of viscous fluids, laminar motion in pipes and channels, turbulence and Reynolds' criterion, similarity laws, theory of drag, discontinuous flow and vortex streets, theory of skin-friction, boundary layer, general theory of turbulence.

Instructor: Kármán or Millikan.

AE. 268. Hydrodynamics of a Compressible Fluid. 12 units, third term.

Prerequisites: AE. 266 a, b.

Relation of the equations to the kinetic theory of gases, theory of jets and of the Venturi tube, motion with a velocity exceeding the velocity of sound, shock waves, cavitation.

Instructor: Bateman.

AE. 270. Elasticity Applied to Aeronautics I. 12 units, first term.

Prerequisites: Ma. 109 a, b, AM. 1 a, b, c, 3.

Analysis of stress and strain. Hookes law. Theory of bending and torsion. Stresses in thin shells. Theory of elastic stability.

Instructor: Kármán.

AE. 271. Elasticity Applied to Aeronautics II. 12 units, first term.

Prerequisites: Ma. 109 a, b, AM. 1 a, b, c, 3.

Theory of elastic vibrations, critical speed with particular reference to airplane engines, wing and tail flutter, strength and vibration of propeller blades.

(Not given in 1932-1933.)

Instructor: Kármán.

AE. 281. Elements of Meteorology and Aerology. 9 units, one term.

Physical properties of the atmosphere, general circulation of the atmosphere, prevailing winds, world's air routes.

Instructor: Gutenberg.

AE. 290 a, b, c. Aeronautical Seminar. 2 units; first, second and third terms.

Study and critical discussion of current contributions to aerodynamics and aeronautical engineering.

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: LLOYD H. DONNELL, LAVERNE LEEPER, HOWARD G. SMITS, NATHAN D. WHITMAN, JR.

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: Applied Mechanics, Poorman.

Instructors: Hinrichs, Converse, Donnell, Smits, Whitman.

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: Properties and Mechanics of Materials, Laurson and Cox, and Steel Construction, A. I. S. C.

Instructors: Hinrichs, Converse, Donnell, Smits, Whitman.

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: Properties and Mechanics of Materials, Laurson and Cox, and Steel Construction, A. I. S. C.

Instructor: Whitman.

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.

Text: Hinrichs' and Martel's Laboratory Manual for Testing Materials.

Instructors: Converse and Leeper.

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

INSTRUCTOR: ERNEST E. SECHLER

TEACHING FELLOWS AND ASSISTANTS: RAYMOND C. BINDER, PERRY M. BOOTHE, JOHN H. A. BRAHTZ, JACK F. MCGARRY, JOSEPH B. GROSE, BRUCE H. SAGE

UNDERGRADUATE ASSISTANTS: CLIFFORD C. CAWLEY, MILLS S. HODGE

D. 1. ELEMENTARY FREEHAND DRAWING. 3 units (0-3-0); first term.

The study of geometrical forms and their representation by means of freehand perspective. Careful observation, accurate draftsmanship and correct proportions will be emphasized. The course also includes the making of lettering plates.

D. 2. ADVANCED FREEHAND DRAWING. 3 units (0-3-0); elective any term.

Prerequisite: D. 1.

Similar to D. 1, but with advanced subject matter.

D. 4. ELEMENTARY MECHANICAL DRAWING. 3 units (0-3-0); first term.

The study of shape and size, description by means of mechanical drawing, and the care and use of drawing instruments. The study and use of single stroke lettering. Accuracy and precision are required.

Text: Svensen, Drafting for Engineers.

Machine drawing, D. 6 and D. 7, are planned to prepare all engineering students for the drawing required in the professional work of the engineering departments. Accuracy, neatness and good lettering are required.

D. 6. MACHINE DRAWING AND LETTERING. 6 units (0-6-0); second and third terms.

Prerequisite: D. 4.

The study of the general principles of working drawings of machinery. The work covers conventional representations and dimensioning, the making of simple working drawings, the making of dimensioned freehand sketches and complete detail and assembly drawings made from the sketches. It also includes lettering plates.

Text: Svensen, Machine Drawing. Drafting for Engineers.

D. 7. Advanced Machine Drawing. 6 units (0-6-0); elective any term.

Prerequisite: D. 6.

The study and execution of design drawings for various mechanisms.

Instructor: Sechler.

Structural Drawing, D. 9 and D. 10, are planned to acquaint students with the technique of structural drawing. Accuracy, neatness, and good lettering are required.

D. 9. Structural Drawing and Lettering. 6 units (0-6-0); first and second terms.

Prerequisite: D. 4.

The study of the general principles of working drawings of structural steel and reinforced concrete, covering conventional representations, dimensioning and billing. The work includes the making of simple working drawings of structural steel trusses, members and details. It also includes lettering plates.

Texts: Bishop, Structural Drafting; A. I. S. C. Handbook.

Instructors: Sechler, Brahtz, Binder, Sage.

D. 10. Advanced Structural Drawing. 6 units (0-6-0), elective any term.

Prerequisite: D. 9.

The study and execution of drawings of structural steel or reinforced concrete for structures designed by upper class students in civil engineering.

Descriptive Geometry, D. 12 a, b, c, d and D. 13 are planned to cover a thorough study of shape description and representation. Especial emphasis will be placed upon the visualization of problems in order to develop three dimensional observation. The work will include practical as well as purely geometrical problems.

D. 12 a. Elementary Descriptive Geometry. 3 units (0-3-0); second term.

The study of the graphical representation of three dimensional geometrical constructions by means of orthographic projection. The work includes principle, auxiliary and oblique views.

Text: Hood, Geometry of Engineering Drawing.

D. 12 b. Descriptive Geometry. 3 units (0-3-0); third term.

Prerequisite: D. 12 a.

A continuation of D. 12 a, covering the "Analysis of Structures" and straight and curved line constructions.

Text: Hood, Geometry of Engineering Drawing.

D. 12 c. Descriptive Geometry. 3 units (0-3-0); first and second terms.

Prerequisite: D. 12 b.

A continuation of D. 12 b, covering problems involving the relationship of lines and planes and the intersection and development of surfaces.

Text: Hood, Geometry of Engineering Drawing.

D. 12 d. Descriptive Geometry. 3 units (0-3-0); second and third terms.

Prerequisite: D. 12 c.

A continuation of D. 12 c, covering more complicated problems involving single curved surfaces, warped and double curved surfaces.

Text: Hood, Geometry of Engineering Drawing.

D. 13. Advanced Descriptive Geometry. 6 units (0-6-0); elective any term.

Prerequisite: D. 12 a, b, c, d.

The study of lineal perspective and the execution of mechanical perspective drawings of machines, bridges, and other structures.

D. 14. Descriptive Geometry. 3 units (0-3-0); third term.

This course is planned primarily for geology students, and includes practical problems in mining and earth structures.

D. 15. Block Diagrams and Land Forms 6 units (0-6-0); first term.

The graphical representation of land forms and geological structure by means of pictorial drawings. The work, which will be mainly freehand, includes the drawing of block diagrams of various land forms in perspective, and of "isometric diagrams and problems in structural geology."

Text: Lobeck, Block Diagrams.

D. 16. Physiographic Sketching. 6 units (0-6-0); third term.

Freehand sketching from landscape forms and details of geological structure. Sketches will be made in both the drawing room and the field, and by means of various mediums. Required of geology students; elective for students of other courses.

Text: Lobeck, Block Diagrams.

HYDRAULICS

PROFESSOR: ROBERT L. DAUGHERTY

ASSISTANT PROFESSOR: ROBERT T. KNAPP

TEACHING FELLOWS: RICHARD G. FOLSOM, GEORG WISLICENUS

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, Knapp, Folsom.

Hy. 2. HYDRAULIC LABORATORY. 6 units (0-3-3); first, second or third term.

Prerequisite: AM. 1 a, b.

Experiments on the flow of water through orifices and nozzles, through pipes and Venturi meters, over weirs; use of Pitot tube; tests of impulse and reaction turbines, centrifugal pumps, and other hydraulic apparatus.

Instructors: Knapp, Folsom, Wislicenus.

ADVANCED SUBJECTS

Hy. 101. HYDRAULIC MACHINERY. Units to be based on work done; any term.

A study of such machines as the hydraulic turbine and the centrifugal pump and their design to meet specified conditions.

Instructor: Daugherty.

Hy. 200. ADVANCED WORK IN HYDRAULIC ENGINEERING.

Special problems in hydraulics will be arranged to meet the needs of students wishing to do advanced work in this field.

DIVISION OF GEOLOGY AND PALEONTOLOGY

PROFESSORS: JOHN P. BUWALDA, WILLIAM MORRIS DAVIS, BENO GUTENBERG, F. L. RANSOME, CHESTER STOCK

ASSISTANT PROFESSOR: IAN CAMPBELL

INSTRUCTORS: RENE ENGEL, JOHN H. MAXSON

CURATOR IN VERTEBRATE PALEONTOLOGY: EUSTACE L. FURLONG

CURATOR IN INVERTEBRATE PALEONTOLOGY: W. P. POPENOE

SCIENTIFIC ILLUSTRATOR: JOHN L. RIDGWAY

COMMONWEALTH FUND FELLOW: H. V. WARREN

TEACHING FELLOWS AND GRADUATE ASSISTANTS: GEORGE H. ANDERSON, FRANK W. BELL, F. D. BODE, LAWRENCE W. BOLLES, WILLIAM M. COGEN, M. G. DONNELLY, BENJAMIN HOLZMAN, GEORGE H. OTTO, RAYMOND A. PETERSON, HARINGTON M. A. RICE, D. W. SCHARF, M. D. SHAPPELL, HAMPTON SMITH, J. L. SOSKE, G. F. TAYLOR, ROBERT J. WATSON, R. W. WILSON

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, Maxson, Bell, Peterson, Smith, Taylor.

Ge. 1 b. ELEMENTARY PALEONTOLOGY. 9 units (4-1-4); third term.

Prerequisite: Ge. 1 a.

A discussion of the principles on which the history of life is based. Illustrations of evolution taken from certain groups of animals of which the fossil record is essentially complete. Occasional field trips.

Text: Lull, Organic Evolution.

Instructors: Stock, Bode, Bell, Smith.

Ge. 1 c. HISTORICAL GEOLOGY. 8 units (3-1-4); first term.

Prerequisite: Ge. 1 b.

A consideration of the geologic history of the earth, as shown by the changing patterns of land and sea and by the succession of faunas and floras. Conferences, lectures, and occasional field trips.

Text: Schuchert, Outlines of Historical Geology.

Reference: Grabau, Textbook of Geology, Part II, Historical Geology.

Instructor: Maxson.

Ge. 3 a. Crystallography. 6 units (1-3-2); third term.

Prerequisites: Ch. 1 a-c; Ph. 1 and 2.

A study of crystal systems and forms, not only from the classical geometric view-point, but also in light of the modern atomic conceptions of crystal structure; also, the physical properties characteristic of crystals.

Text: Dana's Text-book of Mineralogy.

Instructors: Campbell, Donnelly.

Ge. 3 b. c. Mineralogy. 8 units (1-6-1), first term; 10 units (2-6-2), second term.

Prerequisite: Ge. 3 a.

Lectures and laboratory work devoted to the study of the physical and chemical properties of minerals, of their associations and modes of occurrence, and to their identification.

Text: Dana's Text-book of Mineralogy.

Instructors: Engel, Taylor, Donnelly.

Ge. 4 a. Petrology. 10 units (2-6-2), second term.

Prerequisites: Ge. 3 a, b, c.

The origin, properties, and megascopic identification of the common igneous rocks.

Text: Rocks and Rock Minerals, Pirsson-Knopf.

Instructors: Engel, Watson.

Ge. 4 b. Petrology. 8 units (1-6-1), third term.

Prerequisite: Ge. 4 a.

Study and identification of the common sedimentary and metamorphic rocks.

Instructors: Campbell, Watson.

Ge. 5. Optical Mineralogy. 10 units, first term.

Prerequisites: Ge. 1, 3, 4.

Study of optical mineralogy and use of the petrographic microscope in the identification of minerals.

Text: Winchel, Elements of Optical Mineralogy, Part I.

Instructors: Engel, Taylor.

Ge. 6 a, b. Petrography. 10 units, second and third terms.

Prerequisites: Ge. 1, 3, 4, 5.

Application of optical mineralogy to the study of mineral aggregates.

The study of the petrographic characteristics of certain important types of rocks.

Instructors: Campbell, Otto.

Ge. 7 a, b. Field Geology. 10 units, third term, third year; 8 units, third term, fourth year.

Prerequisites: Ge. 1 a-c; 3 a, b; 4 a, b.

During the first term students acquire a knowledge of technical field methods of mapping the distribution of rocks, determining structure, and deciphering the geological history of a region. A representative Coast Range area is mapped in detail and a report is prepared on its stratigraphy, structure and history. The field work and selected text-book assignments are discussed in weekly class meetings.

The second half of the course consists of brief studies of several different localities in the Southwest exemplifying a wide range of geological formations and structures. The trips vary from one to three days in length; often an expedition of about one week is arranged for the spring vacation. Indoor exercises relate to the interpretation of map data in the solution of geologic problems.

Students will be called upon to expend small sums for traveling expenses.

Text: Field Geology, Lahee.

Instructors: Buwalda, Maxson.

Ge. 9. Structural Geology. 10 units first term.

Prerequisite: Ge. 7 a.

A consideration of the structural features of the Earth's crust; folds, faults, joints, foliation. Computation of thicknesses and depths. Determination of the nature and amount of displacements on faults by use of descriptive geometry.

Instructor: Buwalda.

Ge. 11 a, b. Invertebrate Paleontology. 8 units first term, 10 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: Popenoe.

Ge. 12 a, b. VERTEBRATE PALEONTOLOGY. 10 units 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 first or third terms, 6 units second term.

Prerequisite: Ge. 7 a.

The student investigates a limited geologic problem, preferably of his own choosing, under direction, in the field or laboratory. Individual initiative is developed, principles of research are acquired, and practice gained in technical methods. The student prepares a thesis setting forth the results of the research and their meaning. Last date for acceptance of thesis, May 31.

Ge. 22. THESIS PROBLEM IN PALEONTOLOGY. 8 units first or third terms, 6 units second term.

Prerequisites: Ge. 11 a, b, or Ge. 12 a, b; may be taken concurrently.

Special investigations in either invertebrate or vertebrate paleontology. Research on a limited problem involving either field relationships of fossil assemblages or consideration in the laboratory of the structural characters and relations of fossil forms. Preparation of a thesis.

Ge. 23. SUMMER FIELD GEOLOGY. 12 units.

Intensive field mapping of a selected area from a centrally located field camp. Determination of the stratigraphy, fossil content, structure, and geologic history. The area chosen will probably lie in the California Coast Ranges in even-numbered years and in the Great Basin in odd-numbered years. As an occasional alternative in odd-numbered years an expedition will be conducted to localities important in California geology. The interpretations of classical localities afforded in the literature will be studied in the field. The course begins immediately after Commencement (about June 12th). Required at the end of both the Junior and the Senior year for the Bachelor's degree in the Geology and Paleontology course. Tuition, $15.

Instructors: Buwalda, Maxson.

FIFTH-YEAR AND ADVANCED SUBJECTS

Ge. 183. Seismology. 6 units; first term of even-numbered years.

Study and conferences on the principles of physical and geological seismology.

Text: Davison, Manual of Seismology; and Gutenberg, Grundlagen der Erdbebenkunde.

Instructor: Gutenberg.

Ge. 184. Laboratory Studies in Seismology. First, second or third term.

Laboratory practice in the measurement and interpretation of instrumental earthquake records; investigation of specific seismologic problems.

Instructor: Gutenberg.

Ge. 186. Geomorphology. 10 units; first term of odd-numbered years.

Prerequisite: Ge. 9.

Nature and origin of the physiographic features of the earth. Geologic processes involved in their development. Use of physiography in elucidating the later geologic history of regions.

Instructor: Buwalda.

Ge. 187. Research.

Original investigation, designed to give training in methods of research, to serve as theses for higher degrees, and to yield contributions to scientific knowledge. These may be carried on in the following fields: (m) mineralogy, (n) general areal geology, (o) stratigraphic geology, (p) structural geology, (q) physiography, (r) petrology, (s) vertebrate paleontology, (t) invertebrate paleontology, (u) seismology, (v) economic geology, (w) geophysics, (x) geophysical prospecting, (y) meteorology and climatology.

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, b. Physical Geology (Seminar). 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. Vertebrate Paleontology (Seminar). 5 units; second and third terms.

Discussion of progress and results of research in vertebrate paleontology. Critical review of current literature.

Instructor: Stock.

Ge. 191 a, b. Invertebrate Paleontology (Seminar). 5 units; first and second terms.

Conferences on research in invertebrate paleontology and reviews of literature. Discussions of particular aspects of invertebrate paleontology with special reference to the Pacific Coast.

Instructor: Popenoe.

Ge. 195. Ore Deposits. 10 units; second term.

Prerequisites: Ge. 1, 3, 4, 5, 6, 7.

A study of metalliferous deposits with particular reference to their geological relations and origins. Lectures, recitations, and field trips.

Text: Not prescribed, but either Tarr's Introductory Economic Geology or Emmons' Principles of Economic Geology is suggested, with Lindgren's Mineral Deposits as collateral reading.

Instructor: Ransome.

Ge. 196. Non-Metalliferous Deposits. 10 units; third term.

Prerequisites: Ge. 1, 3, 4, 5, 6, 7.

Modes of occurrence, distribution, and origin of the principal non-metallic mineral products, including mineral fuels, building materials, etc.

Text: Not prescribed, but Ries' Economic Geology or an equivalent text will be found useful.

Instructor: Ransome.

Ge. 197 a, b. Advanced Economic Geology. 8 units; second and third terms.

Prerequisites: Ge. 195, 196.

A more thorough and comprehensive study of some of the important mineral deposits of the world than is practicable in courses 195 and 196. Particular attention will be given to deposits in the western United States, Mexico, and Africa.

Instructor: Ransome.

Ge. 198 a, b. Economic Geology (Seminar). 5 units; second and third terms.

Prerequisites: Ge. 195, 196, or equivalents.

Discussion of current literature and special problems. The seminar work may be varied by occasional lectures.

Instructor: Ransome.

Ge. 199. Mineralogy (Seminar). 5 units; first term.

Prerequisite: Ge. 3, 4, 5, 6.

Discussion of current literature and recent advances in this field.

Instructor: Engel.

Ge. 200. Mineragraphy. 9 units; first term.

Prerequisites: Ge. 3, 4, 5, 6, 195.

Investigation of ores in polished surfaces by microscopic and other laboratory methods.

Instructor: Anderson.

Ge. 201. Geomorphology. 6-10 units; second and third terms (1931-1932).

Investigation of an individually selected problem or topic in Geomorphology. Seminar, reports, and conferences.

Instructor: Davis.

Ge. 202. Physics of the Atmosphere. 6 units; second term of odd-numbered years.

Study and conferences on the structure of the atmosphere; sound waves in the atmosphere; optics of the atmosphere; meteorology.

Instructor: Gutenberg.

Ge. 203. Physics of the Earth. 6 units; second term of even-numbered years.

Structure of the earth; gravity and isostasy; tides; movement of the poles; elastic properties, temperature; density.

Text: Jeffries, The Earth.

Instructor: Gutenberg.

Ge. 205. Applied Geophysics I. Measurements of gravity and earth magnetism applied to geological problems and prospecting. 5 units; second term of even-numbered years.

Instructor: Soske.

Ge. 206. Applied Geophysics II. Methods of seismology applied to geological problems and prospecting. 5 units; third term of even-numbered years.

Instructor: Gutenberg.

Ge. 207. Applied Geophysics III. Electricity and heat measurements applied to geological problems and prospecting. 5 units; first term of even-numbered years.

Instructor: Watson.

Ge. 208 a, b. Geophysics (Seminar). 5 units; first and third terms.

Structure of the earth; gravity and isostasy; tides; movement of the poles; elastic properties; temperature; density; changes in the earth's crust; earthquakes; applied geophysics.

Instructors: Gutenberg, Buwalda.

Ge. 209. Meteorology (Seminar). 5 units; second term.

Instructors: Gutenberg, von Karman, Klein, Hoover.

Ge. 210. Advanced Petrology. 5-12 units; second term.

Devoted to class and laboratory study of the sedimentary rocks during odd-numbered years, and to metamorphic and igneous rocks during even-numbered years.

Instructor: Campbell.

Ge. 211. Petrology (Seminar). 5 units; third term.

Discussion of classic and current literature with consideration of recent advances in the field of petrology. Occasional conferences on research problems are included.

Instructor: Campbell.

DIVISION OF BIOLOGY

PROFESSORS: THOMAS HUNT MORGAN, ALFRED H. STURTEVANT

ASSOCIATE PROFESSOR: ERNEST G. ANDERSON

ASSISTANT PROFESSORS: HENRY BORSOOK, THEODOSIUS DOBZHANSKY, HERMAN E. DOLK, ROBERT EMERSON, STERLING H. EMERSON, HUGH M. HUFFMAN

INSTRUCTORS: KENNETH V. THIMANN, ALBERT TYLER

RESEARCH FELLOWS: HANS GAFFRON, K. LINDERSTRÖM-LANG

TEACHING FELLOWS AND ASSISTANTS: JAMES F. BONNER, EMORY L. ELLIS, GEOFFREY L. KEIGHLEY, CARL C. LINDEGREN, MARSTON C. SARGENT, HERMAN F. SCHOTT

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

An introductory course including some work in cytology as a necessary basis.

Bi. 3 a, b. GENERAL BOTANY. 8 units (2-4-2), first term; 6 units (1-3-2), second term.

A course in the structure and physiology of plants.

Bi. 4. General Zoology. 10 units (3-4-3), first term.

A general survey of the animal kingdom, including dissection of representatives of the main groups.

Bi. 5 b, c. Physiology. 8 units (2-4-2), second term; 9 units (2-4-3), third term.

Physiology of animals and plants, each term dealing primarily with one of these two divisions.

Bi. 6 a, b. Histology. 3 units (0-3-0), first and second terms.

A laboratory and demonstration course in the microscopic structure of animal tissues.

Bi. 7. Embryology. 10 units (3-4-3), second term.

A course in descriptive and experimental embryology. As far as possible some of the work will be done at the marine laboratory at Corona del Mar.

Bi. 8. Biochemistry. 12 units, first term.

Lecture, laboratory and seminar courses.

Bi. 9. Cytology. 10 units (3-4-3), first term.

A course in the structure of the cell, with special reference to the chromosomes. The laboratory work will include the technique of preparing microscopical material.

Bi. 10 a, b. Genetics. 6 units, first term; 8 units, second term.

An advanced course, including the study of individual problems in the second term.

Bi. 11. Physiology. 10 units, third term.

A course in physiology designed to follow Bi. 150.

Instructor: Emerson.

Bi. 15. Research. 18 units, third term.

Special problems will be assigned to seniors in their final term, the subject being determined by the major interest of the student.

Bi. 16. Foreign Journals. 4 units, second and third terms.

This course is designed to familiarize the student with the original literature of his chosen field, and to train him in the finding and abstracting of literature.

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. 150. PLANT PHYSIOLOGY. Second term. 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: Hardin Craig, Louis B. Wright
Associate Professor: George R. MacMinn
Assistant Professors: Harvey Eagleson, William Huse, Jr., Roger Stanton
Instructor: L. Winchester Jones

A course in English composition is prescribed for all students in the Freshman year, and a course in the survey of English literature is prescribed for all students in the Junior year. In the Senior year the students are offered a number of options in English, American, and European literature.

The instruction in composition is intended to give a thorough training in both written and spoken English. The instruction in literature is intended to provide an appreciative acquaintance with the chief works of those authors, past and present, who are most significant in the development of modern civilization, and to foster the habit of self-cultivation in books.

The regular courses in English do not exhaust the attention given at the Institute to the student's use of the language; all writing, in whatever department of study, is subject to correction with regard to English composition.

UNDERGRADUATE SUBJECTS

En. 1 a, b, c. English Composition and Reading. 6 units (3-0-3); first, second and third terms.

This course is designed to give the student a thorough review of the principles of composition, with much practice in writing and speaking, and a broad introduction to good reading. The student is offered every inducement to self-cultivation, and is allowed ample opportunity for the exercise of special talents or the pursuit of special intellectual interests.

The work of the honor section is directed toward the stimulation of intellectual initiative. The members of the section are held to high standards of excellence in writing and speaking, and are expected to undertake a considerable amount of cultural reading.

Texts: The Art of Writing Prose, Loomis; Contemporary Thought, Taft, McDermott, and Jensen; Webster's Collegiate Dictionary.

Instructors: Eagleson, Huse, Jones, MacMinn, Stanton.

All students are required to pass a comprehensive examination in English and History at the end of the Sophomore year. This examination is not confined to specific courses, but covers the general attainments of the students in their humanistic work throughout the first two years.

En. 7 a, b, c. Survey of English Literature. 8 units (3-0-5); first, second and third terms.

Prerequisite: En. 1 a, b, c.

A selective study of English literature from the beginnings to the end of the 19th century, focused on the most distinguished works of the greater writers in poetry, drama, the novel, and the essay. Special attention is given to the social background of the works assigned for reading, and to the chief cultural movements of the modern world. In the first term the emphasis is placed on Shakespeare and the English Renaissance; in the second term on the life and literature of the 18th century; in the third on the Victorian Era.

Texts: The Oxford Shakespeare; British Poetry and Prose, Lieder, Lovett and Root.

Instructors: Eagleson, Huse, Jones, Judy, MacMinn, Stanton.

En. 8. Contemporary English and European Literature. 9 units (3-0-6); first, second or third term.

Prerequisite: En. 7 a, b, c.

A continuation of the survey of English literature to cover the period from 1890 to the present, with some extension into Continental literature. Wide reading is required.

Text: Tradition and Experiment in Present-day Literature.

Instructors: Eagleson, Judy.

En. 9. Contemporary American Literature. 9 units (3-0-6); first, second or third term.

Prerequisite: En. 7 a, b, c.

A survey of the literature of the United States during the past half-century, with emphasis upon the chief writers of the present time. 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, second or third term.

Prerequisite: En. 7 a, b, c.

A study of the leading European and British dramatists, from Ibsen to the writers of the present time. Special attention may be given to new movements in the theatre, to stage decoration and production. Wide reading of plays is required.

Text: Chief Contemporary Dramatists, first series, Dickinson.

Instructors: Huse, Stanton.

En. 11. Literature of the Bible. 9 units (3-0-6); third term.

Prerequisite: En. 7 a, b, c.

A study of the Old and New Testaments, exclusively from the point of view of literary interest. Special attention is given to the history of the English Bible. Opportunity is offered for reading modern literature based on Biblical subjects.

Text: The Modern Reader's Bible, Moulton.

Instructor: MacMinn.

En. 12 a, b, c. Debating. 4 units (2-0-2).

Elective, with the approval of the Registration Committee, for upper classmen in the first and second terms. Study of the principles of argumentation; systematic practice in debating; preparation for intercollegiate debates.

Elective, with the approval of the Freshman Registration Committee, for Freshmen, 2 units (1-0-1) in the second term, and 4 units (2-0-2) in the third term. Lectures on the principles of formal logic and the theory of argumentation and debate.

Instructor: Loosley.

En. 13 a, b, c. Reading in English. Units to be determined for the individual by the Department.

Elective, with the approval of the Registration Committee, in any term.

Collateral reading in literature and related subjects, done in connection with regular courses in English, or independently of any course, but under the direction of members of the department.

En. 14. Special Composition. 2 units (1-0-1); any term.

This course may be prescribed for any student whose work in composition, general or technical, is unsatisfactory.

En. 15 a, b, c. Journalism. 3 units (1-0-2).

Elective, with the approval of the Registration Committee.

A study of the principles and practice of newspaper writing, editing, and publishing, especially as applied to student publications at the Institute.

Instructor: MacMinn.

En. 16. Spelling. No credit.

This course may be prescribed for any student whose spelling is unsatisfactory.

En. 20. Summer Reading. Maximum, 16 credits.

Credits are allowed to the maximum number of 16 for vacation reading from a selected list of books in various subjects, and written report thereon.

FIFTH-YEAR AND ADVANCED SUBJECTS

En. 100. Literature. 9 units; first, second and third terms.

A study of some selected period, or type, or author, or group of authors in American, English or European literature, with an introduction to the methods of research and criticism applicable thereto.

Instructors: Craig, Eagleson, Judy, Wright.

LANGUAGES

PROFESSOR: JOHN R. MACARTHUR

INSTRUCTOR: MARTIN L. BUNGE

The courses in this department are arranged primarily to meet the needs of scientific students who find it necessary to read books, treatises, and articles in French, German, and Italian. In these languages correct pronunciation and the elements of grammar are taught, but the emphasis is laid upon the ability to translate from them into English. An elective course in Greek is offered to students interested in that language.

UNDERGRADUATE SUBJECTS

L. 1 a, b. ELEMENTARY FRENCH. 10 units (4-0-6); second and third terms.

A course in grammar, pronunciation, and reading that will provide the student with a vocabulary of extent and with a knowledge of grammatical structure sufficient to enable him to read at sight French scientific prose of average difficulty. Accuracy and facility will be insisted upon in the final tests of proficiency in this subject.

Texts: An Introduction to the Study of French, Bond; Technical and Scientific French, Williams.

Instructor: Macarthur.

L. 11. ELEMENTARY ITALIAN. 9 units (3-0-6); one term, as required.

A course designed to give the student who has already some acquaintance with Latin or with another Romance language sufficient knowledge of the forms and vocabulary of Italian to enable him to read scientific Italian, especially in the field of Mathematics.

Text: Elementary Italian, Marinoni and Passarelli.

Instructor: Macarthur.

L. 32 a, b, c. ELEMENTARY GERMAN. 10 units (4-0-6); first, second and third terms.

This subject is presented in the same manner as the Elementary French.

Texts: First German Course for Science Students, Fiedler and Sandbach; Technical and Scientific French, Greenfield.

Instructors: Macarthur and Bunge.

L. 35 a, b, c. SCIENTIFIC GERMAN. 10 units (4-0-6) first term; 6 units (3-0-3) second and third terms.

Prerequisite: L. 32 a, b, c, or one year of college German.

This is a continuation of L. 32 a, b, c, with special emphasis on the reading of scientific literature.

Texts: Aus der Werkstatt grosser Forscher, Danneman; Die Radioaktivitat, Fajans; Technical and Scientific French, Greenfield.

Instructors: Macarthur and Bunge.

L. 39 a, b, c. READING IN FRENCH, ITALIAN, OR GERMAN. Units to be determined for the individual by the department. Elective, with the approval of the Registration Committee, in any term.

Reading in scientific or literary French, Italian, or German, done under direction of the department.

L. 40. GERMAN LITERATURE. 9 units (3-0-6), third term.

Prerequisites: L. 32 a, b, c; L. 35.

The reading of selected German classics, poetry and drama, accompanied by lectures on the development of German literature. Elective and offered only to students whose work in the prerequisites has been above average.

Instructor: Macarthur.

L. 51 a, b, c. GREEK. 6 units (3-0-3).

This is a course in the elements of the classical Greek language. Special reference is made to scientific nomenclature. Outside reading upon topics drawn from Greek literature, art, philosophy, and science is reported on in term papers. The course is elective.

Texts: Alpha, Frost; Xenophon's Anabasis; The Study of Greek Words in English, Including Scientific Terms, Hoffman.

Instructor: Macarthur.

HISTORY AND GOVERNMENT

PROFESSORS: JOHN R. MACARTHUR, WILLIAM B. MUNRO
ASSOCIATES: CHARLES A. BEARD, GODFREY DAVIES, MAX FARRAND
ASSISTANT PROFESSOR: E. L. HARVEY
INSTRUCTOR: WILLIAM BEARD
ASSISTANTS: ROBLEY D. EVANS, ROBERT B. JACOBS

UNDERGRADUATE SUBJECTS

H. 1 a, b, c. ANCIENT AND MEDIEVAL HISTORY. 5 units (3-0-2); first, second and third terms.

Lectures and discussions upon the early civilizations out of which modern Europe developed, and upon the institutions of the Middle Ages. The students are referred to original sources in the library.

Texts: Ancient Times, Breasted; History of Western Europe, Vol. I, Robinson.

Instructors: Macarthur, Jacobs.

All students are required to pass a comprehensive examination in English and History at the end of the Sophomore year. This examination does not cover specific courses, but the general attainments of the students in their systematic work throughout the first two years.

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: Harvey, Munro.

H. 5 a, b. CURRENT TOPICS. 2 units (1-0-1); first and second terms.

This course is given collaterally with senior humanities electives, and is articulated with a selected weekly journal of general information and opinion.

H. 10. THE CONSTITUTION OF THE UNITED STATES. 2 units (1-0-1); third term.

A study of the principles and provisions of the national constitution in the light of present-day interpretation by the courts. Required of all seniors.

Instructor: Munro.

FIFTH-YEAR AND ADVANCED SUBJECTS

H. 100. Seminar in American History and Government. 9 units (1-0-8); first, second and third terms.

Open only to fifth-year students and seniors who have attained honor grades.

First term: English History in the Nineteenth Century.
Instructor: Davies.
Second term: American History, 1876-1896.
Instructor: Craven.
Third term: American History since 1896.
Instructor: Munro.

H. 101. Technology and Government. 9 units (1-0-8); second and third terms.

Open only to fifth-year students and seniors who have attained honor grades.

Instructor: William Beard.

H. 102. Representative Government in a Technological Age. 1 unit (1-0-0); second term.

Open only to fifth-year students and seniors who have attained honor grades.

Instructor: Charles A. Beard.

ECONOMICS

PROFESSOR: GRAHAM A. LAING
ASSOCIATE PROFESSOR: HORACE N. GILBERT
ASSISTANT PROFESSORS: PHILIP S. FOGG, CLYDE WOLFE
INSTRUCTORS: HERBERT HOOVER, JR., ALLYN C. LOOSLEY

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); second 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, Atkins, Economic Behavior.

Instructors: Laing, Loosley.

Ec. 3. ECONOMIC HISTORY. 2 units (1-0-1); third 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); third 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, Atkins, Economic Behavior.

Instructors: Laing, Loosley.

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. 17. Accounting. 9 units (3-0-6); first, second or third term. Open only to engineering students in their Junior year.

This is a course in the interpretation of the financial statements with which engineering students who enter business will come in contact. A description of bookkeeping methods is presented, but not in sufficient detail to enable the average student to keep a set of business books. Emphasis is placed upon the study of actual business problems involving the executive interpretation of accounting reports. A liberal amount of descriptive material regarding business activities accompanies the instruction.

Text: Problems in Accounting Principles, Walker.

Instructor: Fogg.

Ec. 18. Industrial Accounting. 6 units, first term.

Prerequisite: Ec. 17.

Open only to third, fourth, and fifth year engineering students. The course covers the essential principles of cost accounting as applied to industrial enterprises. The theoretical background of cost accumulation and distribution is supplemented by case studies of actual industrial accounting experience.

Instructor: Fogg.

Ec. 19. Industrial Statistics. 9 units, third term.

Open only to fourth and fifth year engineering students. The object of this course is to introduce students who contemplate going into the administrative side of industry to the essentials of statistical method, especially as it is applied to, and utilized by, business. Consideration is given both to statistical devices for internal control of operations and to methods of analyzing external business conditions.

Instructor: Fogg.

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); first 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: Loosley.

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. 9 units (3-0-6); first, second, and third terms. Open to graduate students. Concurrent registration is required in one of the problem study groups listed as Ec. 101, 102, and 103.

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 with technical training; (b) a study of scientific management methods, statistical technique, and of the use of accounting records; (c) some principles of business economics, representing deduced generalizations based upon an observation of a 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.

Ec. 101 a, b, c. Manufacturing Problems. 3 units (1-0-2); first, second and third terms.

Open only to students registered in Ec. 100. Companies and industries are studied to give the student an acquaintance with industrial undertakings, together with their positions in the field, an understanding of some of the special problems which confront various industries, and an idea of the opportunities for technically trained men in certain leading industries.

Instructor: Gilbert.

Ec. 102 a, b, c. COMMUNICATIONS PROBLEMS. 3 units (1-0-2); first, second and third terms.

Open to students registered in Ec. 100.

Instructor: Hoover.

Ec. 103 a, b, c. AERONAUTICAL PROBLEMS. 3 units (1-0-2); first, second and third terms.

Open to students registered in Ec. 100.

Instructor: Hoover.

PHILOSOPHY, ETHICS AND SOCIOLOGY

Professor: Theodore G. Soares
Assistant Professor: Ray E. Untereiner

UNDERGRADUATE SUBJECTS

Pl. 1. Introduction to Philosophy. 9 units (3-0-6); first and second terms.

An endeavor to see how the most fundamental questions have been answered by typical thinkers in the past, and how the modern student may arrive at a philosophy.

Text: Types of Philosophy, Hocking.

Instructor: Soares.

Pl. 4. Ethics. 9 units (3-0-6); third term.

The fundamental ethical concepts and theories that have emerged in the process of human thought. The major social problems of modern life.

Text: Urban, Fundamentals of 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.

(Not given in 1931-1932.)

FIFTH-YEAR AND ADVANCED SUBJECTS

Pl. 100. A Study of Some Aspects of Philosophical, Ethical or Social Development. 9 units; first, second and third terms.

Instructor: Soares.

DIVISION OF PHYSICAL EDUCATION

PHYSICAL DIRECTOR: WILLIAM L. STANTON
INSTRUCTOR AND MANAGER OF ATHLETICS: HAROLD Z. MUSSELMAN
ASSISTANTS: LAYTON STANTON, STUART L. SEYMOUR (football), EDWIN F. GREEN (baseball), WILLIAM M. COGEN (boxing and wrestling)
CONSULTING PHYSICIAN: DR. E. D. KREMERS
PHYSICIAN TO ATHLETES: DR. FLOYD L. HANES

PE. 1, 2, 3, 4. PHYSICAL EDUCATION. 3 units; first, second and third terms.

All students during all four undergraduate years are required to participate either in the intramural or intercollegiate sports on which the physical education programme is based. The intramural sports comprise competition between student houses, classes, clubs, in all sports, including football, cross-country running, track and field events, baseball, basketball, swimming, boxing, wrestling, tennis, handball, etc., and is required of all students not taking part in intercollegiate sports. The 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 for its social and physical values, and as a foundation for genuine college spirit. During the freshman and sophomore years, all students are given physical strength and skill tests in the first and third terms. These tests are used as a basis of comparison with other men of the same weight and height. Corrective or special exercises are prescribed throughout the four years for those who cannot compete in intramural or intercollegiate sports.

Degrees Conferred, June 12, 1931

Doctor of Philosophy

Russell Lee Biddle, B.S., University of Pittsburgh; M.A., Columbia University

John Stuart Campbell, B.S., California Institute of Technology; M.A., Rice Institute

Rudolph Clemens Hergenrother, B.S., Cornell University; M.S., Pennsylvania State College

Vaino Alexander Hoover, B.S. and M.S., California Institute of Technology

Archer Hoyt, B.A., Whitman College

Lorenz Ditmar Huff, A.B. and M.S., University of Oklahoma

Cecil Edward Pruitt Jeffreys, B.A. and M.A., University of Texas

Lawrence Sanford Kennison, A.B., Dartmouth College; A.M., Brown University

Harry Allister Kirkpatrick, B.S., Occidental College

Charles Coyle Lash, B.S. and M.S., California Institute of Technology

Carl Clarence Lindegren, B.S. and M.S., University of Wisconsin

John Haviland Maxson, B.S. and M.S., California Institute of Technology

Francis William Maxstadt, M.E., Cornell University; M.S., California Institute of Technology

Henry Victor Neher, B.A., Pomona College

Frank Andrew Nickell, B.S. and M.S., California Institute of Technology

Richard Durant Pomeroy, B.S. and M.S., California Institute of Technology

Sol Frederick Ravitz, B.A. and M.A., University of Utah

William Layton Stanton, Jr., B.S., California Institute of Technology

Charles Albert Swartz, B.S., California Institute of Technology

Johannes Archibald Van Den Akker, B.S., California Institute of Technology

Ralph Richter Wenner, B.S., Cooper Union Institute of Technology; M.S., Northwestern University

Howard Merlin Winegarden, B.S. and M.S., California Institute of Technology

Sho-Chow Woo, B.S., National Central University, Nanking, China

Master of Science

PHYSICS

Tseng-Loh Ho, B.S., National Central University, Nanking, China

CHEMICAL ENGINEERING

Clyde L. Blohm, B.S., California Institute of Technology
Earl S. Hill, B.S., Oregon State College
Raymond Winfield Hoeppel, B.S., California Institute of Technology
Bruce Hornbrook Sage, B.S., New Mexico College of Agriculture and Mechanical Arts
Howard Emerson Shirley, B.S., Oklahoma Agricultural and Mechanical College.

GEOLOGY AND PALEONTOLOGY

Francis Dashwood Bode, B.S., California Institute of Technology
John Warlaumont Daly, B.S., California Institute of Technology
Kenneth Elmo Lohman, B.S., California Institute of Technology
George Frederic Taylor, B.S., California Institute of Technology

ELECTRICAL ENGINEERING

Ellis Osmon Erickson, B.S., University of North Dakota
Clinton Eugene Gates, B.S., California Institute of Technoloy
Arthur Behrend Nomann, B.S., California Institute of Technology
George Wilber Read, B.S., California Institute of Technology
George Arthur Ross, B.S., California Institute of Technology
Lloyd Wallace Russell, B.S., California Institute of Technology
David Sheffet, B.S., California Institute of Technology
Austin Webber Strong, B.S., California Institute of Technology
Keith Maple Wilson, B.S., California Institute of Technology

MECHANICAL ENGINEERING

Ernest Arthur Brooks, B.A., Pomona College
Louie Warren Mosley, B.A., University of Texas
Frank Neff Moyers, B.S., California Institute of Technology
Hubert Henry Smith, A.B., University of Redlands
Georg Friedrich Wislicenus, M.E., State Institute of Technology, Wurzberg, Germany

CIVIL ENGINEERING

Deane Edwin Carberry, B.S., California Institute of Technology
Ernest Levine, B.S., California Institute of Technology
Thomas Jefferson Noland, Jr., B.S., California Institute of Technology
Harlan Baird Robinson, B.S., Princeton University

AERONAUTICAL ENGINEERING

George Schild Lufkin, B.S., and M.S. in Mechanical Engineering, California Institute of Technology

Masahiro Howard Nagashi, B.S., and M.S. in Mechanical Engineering, California Institute of Technology

Adam Teodor Zahorski, B.S.E., University of Michigan

Bachelor of Science

(Stars indicate graduation with honor)

Science

Lucas Avery Alden
William Archibald Arnold
Lawrence William Bolles
Charles Emery Buffum
Paul Herman Cate
William Maurice Cogen
Robert Prewitt Coleman
Albert Thomas Crawford
Edward Bishop Crossman
John Struss Detweiler
Stephen Charles Dorman
W. Ferdinand Eberz
Theodore Robert Folsom
Lowell Forrest Green
Carter Holt Gregory
Norman Robert Gunderson
Winton Christoph Hoch
Emmette Rudolph Holman
Benjamin Holzman
*Robert Byron Jacobs
Duroc Albert Jecker
*Lawrence Edward Kinsler
Charles Edmund Kircher, Jr.
Edwin Kuykendall
Alex Herbert Levine
George Edward Liedholm
Harry Matison
John Wilbur Mehl
Ross Elliott Morris
Carl F. J. Overhage
Edward Stephen Peer
*Raymond Alfred Peterson
Leland DeWitt Pratt
Roger Theophilus Robinson
John Townsend Sinnette, Jr.
Willard Palmer Steward
Everett G. Trostel
Glenn Miller Webb
Thomas Robert White
Charles Alfred Wilmot

Engineering

Jack Huber Amann
Maynard Marion Anderson
William Frederick Arndt
Rea Andrew Axline
John Carter Biggers
Perry Mattison Boothe
John Leroy Bovee, Jr.
Arthur Clinton Brooks
George Leland Bussey
*Glenn John Chamberlain
Nelson Myers Cordes
Walter Linnaeous Dickey
Samuel Clare Eastman
Lawrence LaVerne Ferguson
Frank Hubert Ford
Calvin Barton Frye
John Emile Girard
Abraham Jack Grafman
Edwin Francis Green
Robert Hardy Griffin
William Dillon Hacker, Jr.
Marvin William Hall
Francis William Hutchinson
Herbert Smith Ingham
Byron Bethune Johnson
Theodore Waldemar Jurling
James Henry Keeley
Edward Story Kinney, Jr.
Raymond Frary Labory
George Langsner
*Laverne Davidson Leeper
Robert Marshall Lehman
Charles K. Lewis
George Edward Lewis
Edmund Joseph Longyear, Jr.
Jack Felbert McGarry
John Robertson McMillan
William Sterling Merrithew
DeWolfe Murdock
Oscar McMullin Newby
Robert Martin Oaks
Ennis Gunning Olmsted
George Skidmore Rice
Robert Graves Smith
Howard Gardner Smits
Myer Samuel Stein
Charles Klopp Stipp
Thomas Vernon Tarbet
Paul Mitchell Terry
Isadore Thompson
Alvin Carl Tutschulte
Alfred Suter Voak
Carl Arthur Weise
William Textor West
Rubin Widess
Jeffery Andrew Wineland
Carl Kaorn Yoshioka
David Zabaro

Honors, 1931

Junior Travel Prizes: Charles Wright Jones, William Hayward Pickering

Junior Scholars: Harrison Stout Backus, David Fulmer Bender, Eugene Mittell Brunner, Ralph Edward Byrne, Jr., Charles DuBois Coryell, Trent Raysbrook Dames, Rubin Harold Frieman, Gregory Kemenyi Hartmann, James Stanley Johnson, Samuel Yorks Johnson, L. Jackson Laslett, John Dale Mendenhall, William A. Mersman, Wesley Walter Nelson, John Robinson Pierce, Charles Emil Tillman, William Thornton Wheeler, Moses Widess

Sophomore Scholars: Robert Carron Anderson, Robert DeVore Boche, Donald Leroy Cleveland, Edward Bushnell Doll, James Nathaniel Gregory, Howard E. Gulick, Ernest Russel Howard, Robert A. Howard, Ford Lawrence Johnson, Paul Louis Kartzke, Charles Vernon Newton, Nelson Perry Nies, Herbert Spencer Ribner

Blacker Freshman Scholars:

Ward Wilson Beman, Manual Arts High School
Wyche Dean Caldwell, San Diego High School
James Henry Jennison, Pasadena Junior College
Robert Lincoln Kramer, Alhambra High School
Max Millikan, Phillips Academy, Andover, Massachusetts
Edmond F. Shanahan, Hollywood High School

Drake Freshman Scholars:

William Gordon Cox, Trinity College, Ontario Canada
Robert Dourson, Redondo High School
Richard H. Jahns, West Seattle High School
Leonard Searles Patterson, Hollywood High School
Kenneth Pitzer, Pomona High School
John Rudolph Rossum, Central High School, St. Paul, Minnesota
Robert Collett Warner, Chehalis Senior High School, Washington
Victor Wilmer Willits, Eagle Rock High School
Donald Laurence Young, Los Angeles High School

Conger Peace Prize:

Robert Mead, Wesley Nelson

Graduate Students

Abbreviations: Eng., Engineering; Sci., Science; EE, Electrical Engineering; ME, Mechanical Engineering; CE, Civil Engineering; Ch, Chemistry; Ch E, Chemical Engineering; Ph, Physics; Ge, Geology; Ma, Mathematics; AE, Aeronautical Engineering; Bi, Biology.

(†) following a student's name indicates that he has been admitted to candidacy for the degree of Doctor of Philosophy.

Name	Major Subject	Home Address
AGER, RAYMOND WELLINGTON B.S., California Institute, 1922	EE	Pasadena
AGNEW, LEE ALBERT B.S., University of Michigan, 1928	AE	Pasadena
ALDEN, LUCAS AVERY B.S., California Institute, 1931	Ph	Montrose
ALMEN, H. VICTOR B.S., State College of Washington, 1914	Ph	Pasadena
AMANN, JACK HUBER B.S., California Institute, 1931	EE	Pasadena
ANDERSON, ALFRED B. C. (†) A.B., University of California at Los Angeles, 1928	Ph	Los Angeles
ANDERSON, GEORGE HAROLD (†) A.B., Stanford University, 1917; A.M., 1920	Ge	Burbank
AUSSIEKER, RICHARD C. B.S., California Institute, 1928	Bi	Cedar Rapids, Iowa
BARTON, ROBERT C. (†) B.S., Carnegie Institute of Technology, 1929; M.S., 1930	Ch	Pittsburgh, Pennsylvania
BATCHELDER, DEAN EILDERMANN B.S., Massachusetts Institute of Technology, 1928	EE	Melrose, Massachusetts
BECKWITH, STERLING A.B., Stanford University, 1927; M.S., University of Pittsburgh, 1929	EE	Pasadena
BEELER, RAYMOND ARTHUR (†) B.A., Pomona College, 1927	Ph	Pasadena
BELL, FRANK WAGNER B.S., California Institute, 1928	Ge	Pasadena
BERGMAN, EUGENE ELROY B.S., University of Washington, 1921	Ph	Cle Elum, Washington
BINDER, RAYMOND CHARLES B.S., Massachusetts Institute of Technology, 1930	ME	Chicago, Illinois
BLACKBURN, JOHN FRANCIS (†) B.S., University of Chicago, 1926	Ph	Hollywood
BLEAKNEY, WILLIAM MCCHESNEY (†) B.S., Whitman College, 1926	Ph	Pasadena
BODE, FRANCIS DASHWOOD B.S., California Institute, 1930; M.S., 1931	Ge	South Pasadena
BOLLES, LAWRENCE WILLIAM B.S., California Institute, 1931	Ge	Santa Ana
BONNER, JAMES FREDRICK B.A., University of Utah, 1931	Bi	Salt Lake City, Utah
BOOTHE, PERRY MATTISON B.S., California Institute, 1931	CE	Los Angeles
BOTSFORD, JAMES LAWRENCE B.A., University of Washington, 1928	Ma	Seattle, Washington
BOVEE, JOHN LEROY, JR. B.S., California Institute, 1931	ME	Anaheim

Name	Major Subject	Home Address
Bowen, William Harold B.S., University of California, 1928	AE	Pasadena
Brahtz, John Henry Augustus (†) B.S., Royal Technical College, Copenhagen, 1911; M.S., 1914	AE	Copenhagen, Denmark
Brandon, Richard Hoover A.B., Miami University, 1931	Ph	Greenville, Ohio
Brass, Philip Davis (†) B.S., Yale University, 1928	Ch	Elmwood, Connecticut
Breitwieser, Charles John B.S., University of North Dakota, 1931	EE	Grand Forks, North Dakota
Broadwell, Samuel Jonathan B.S., Throop College of Technology, 1918; M.S., University of Chicago, 1920	Ph	Monterey Park
Brockway, Lawrence Olin (†) B.S., University of Nebraska, 1929; M.S., 1930	Ch	Wichita, Kansas
Brown, Vinton Austin B.S., University of Arizona, 1929; M.S., 1931	Ph	Mesa, Arizona
Buffum, Charles Emery B.S., California Institute, 1931	Ph	Long Beach
Butler, Albert B.S., California Institute, 1930	EE	Santa Barbara
Chamberlain, Glenn John B.S., California Institute, 1931	EE	San Diego
Clark, Donald Sherman B.S., California Institute, 1929; M.S., 1930	ME	Bakersfield
Clifford, Alfred Hoblitzelle A.B., Yale University, 1929	Ma	Pasadena
Cobine, James Dillon B.S., University of Wisconsin, 1931	EE	Madison, Wisconsin
Cogen, William Maurice B.S., California Institute, 1931	Ge	Los Angeles
Cox, Everett Franklin A.B., Miami University, 1930	Ph	Eaton, Ohio
Crane, Horace Richard B.S., California Institute, 1930	Ph	Turlock
Crawford, Albert Thomas B.S., California Institute, 1931	Ch E	Santa Ana
Crawley, Clyde Brooks B.A., University of Kentucky, 1930; M.S., 1931	Ph	Henderson, Kentucky
Crossman, Edward Bishop B.S., California Institute, 1931	Ge	Brentwood Heights
Czamanske, Milton Eugene M.E., Marquette University, 1931	AE	Milwaukee, Wisconsin
Delsasso, Leo Peter A.B., University of California at Los Angeles, 1925	Ph	Los Angeles
Delsasso, Lewis A. A.B., University of California at Los Angeles, 1930	Ph	Los Angeles
DeVore, Henry Blythe B.S., Pennsylvania State College, 1926; M.S., 1927	Ph	Monongahela, Pennsylvania
Dickinson, Bernard Neil B.A., University of Oklahoma, 1929; M.S., 1931	Ch	Norman, Oklahoma
Dodge, Richard Mason B.S., California Institute, 1927	EE	Bakersfield
Donnelly, Maurice Ghirarr E.M., Colorado School of Mines, 1929	Ge	Johnsonburg, Pennsylvania
Eberz, William Ferdinand B.S., California Institute, 1931	Ch	Altadena
Edwards, Everett Carlyle (†) A.B., University of Wisconsin, 1918; A.M., 1920	Ge	San Marino

Name	Major Subject	Home Address
ELLIS, EMORY LEON B.S., California Institute, 1930	Bi	San Diego
EVANS, ROBLEY DUNGLISON (†) B.S., California Institute, 1928; M.S., 1929	Ph	Pasadena
FINDLAY, WILLARD ALEXANDER B.S., California Institute, 1929	Ge	Pasadena
FOCKE, ALFRED BOSWORTH B.S., Case School of Applied Science, 1928	Ph	Pasadena
FOLSOM, RICHARD GILMAN (†) B.S., California Institute, 1928; M.S., 1929	ME	Pasadena
FOLSOM, THEODORE ROBERT B.S., California Institute, 1931	Ph	San Diego
FORBUSH, SCOTT ELLSWORTH B.S., Case School of Applied Science, 1925	Ph	Hudson, Ohio
FOULON, FRED B.S., University of California, 1928	EE	Los Angeles
FRAPS, ANTON WENZEL B.S., University of Arizona, 1931	EE	Tucson, Arizona
GABRIEL, VITTALY T. B.S., University of California, 1924	Ph	San Francisco
GAINDER, MELVIN EARNEST B.S., California Institute, 1926; M.S., University of Pittsburgh, 1931	EE	San Diego
GIEBLER, CLYDE EDGAR B.S., California Institute, 1930	EE	Los Angeles
GOTTSCHALK, WINSTON MALCOLM B.S., Princeton University, 1929	Ph	Washington, D. C.
GREEN, EDWIN FRANCIS B.S., California Institute, 1931	ME	Los Angeles
GROSE, JOSEPH BOYD B.S., University of Utah, 1931	ME	Magna, Utah
GUNDERSON, NORMAN ROBERT B.S., California Institute, 1931	Ch E	Randsburg
HABLUTZEL, CHARLES EDWARD, JR. A.B., Stanford University, 1925; A.M., 1926	Ph	San Jose
HAEFF, ANDREW VASILY (†) E. and E.M., Polytechnic Institute, Harbin, China, 1928; M.S., California Institute, 1929	EE	Harbin, China
HARNESS, GEORGE THOMAS, JR. (†) B.S., California Institute, 1928	EE	Glendale
HASLER, MAURICE FRED (†) B.S., California Institute, 1929; M.S., 1930	Ph	Hollywood
HILL, EARL S. B.S., Oregon State College, 1930	ME	Pasadena
HILL, JON DILLARD B.A., University of California at Los Angeles, 1930	Ma	Los Angeles
HO, TSENG-LOH B.S., National Central University, Nanking, China, 1927; M.S., California Institute, 1931	Ph	Chuki, Chekiang, China
HOARD, JAMES LYNN (†) B.S., University of Washington, 1927; M.S., 1929	Ch	Seattle, Washington
HOLZMAN, BENJAMIN B.S., California Institute, 1931	Ge	Los Angeles
HOOPER, DUNCAN LEVERICH B.S., Yale University, 1930	Ch E	Pasadena
HOWSE, SAMUEL ERIC B.S., California Institute, 1930	EE	Hollywood
HULTGREN, RALPH RAYMOND (†) B.S., University of California, 1928; M.S., University of Utah, 1929	Ch	Los Angeles

Name	Major Subject	Home Address
JACOBS, ROBERT BYRON B.S., California Institute, 1931	Ph	Santa Monica
JOHNSON, WALTER LEE M.E., Cornell University, 1918	EE	San Marino
JORDAN, WALTER HARRISON A.B., University of Oklahoma, 1930; M.S., 1931	Ph	Hillsboro, Oregon
JURLING, THEODORE WALDEMAR B.S., California Institute, 1931	ME	Los Angeles
KELLEY, VINCENT COOPER B.A., University of California at Los Angeles, 1931	Ge	Hollywood
KEYES, EDWIN FRANK B.S., Washington State College, 1909	EE	Sunnyside, Washington
KINSLER, LAWRENCE EDWARD B.S., California Institute, 1931	Ph	Los Angeles
KIRCHER, CHARLES EDMUND, JR. B.S., California Institute, 1931	Ch	El Paso, Texas
KRICK, IRVING PARKHURST A.B., University of California, 1928	Ge	Hollywood
KUETHE, ARNOLD MARTIN Ph.B., Ripon College, 1926	Ph	Marshfield, Wisconsin
KUHN, JACKSON G. B.S., California Institute, 1928	EE	Pasadena
LAUNER, HERBERT FRANZ B.A., University of California at Los Angeles, 1929	Ch	Los Angeles
LEEPER, LAVERNE DAVIDSON B.S., California Institute, 1931	CE	San Bernardino
LEERMAKERS, JOHN ANDREW (†) B.S., Iowa State College, 1928; M.S., 1929	Ch	Omaha, Nebraska
LEWIS, CHARLES K. B.S., California Institute, 1931	CE	Santa Ana
LEWIS, CHARLTON MINER (†) B.A., Yale University, 1929	Ph	New Haven, Connecticut
LEWIS, GEORGE EDWARD B.S., California Institute, 1931	EE	Pasadena
LISSMAN, MARCEL ALFRED A.B., Stanford University, 1925; E.E., 1926	Ph	Alhambra
LIU, YUN-PU B.S., University of Amoy, China, 1927	Ch	Gianyen, Taichow, Kiangsu, China
LLOYD, PAUL EUGENE A.B., Stanford University, 1929	Ph	Hollywood
LOHMAN, KENNETH ELMO B.S., California Institute, 1929; M.S., 1931	Ge	Pasadena
LYONS, ERNEST HERBERT, JR. B.S., Massachusetts Institute of Technology, 1931	Ch	Kenilworth, Illinois
MARSHALL, DONALD E. E.E., University of Iowa, 1925	Ph	Wilkinsburg, Pennsylvania
MARTIN, ROBERT SAMUEL A.B., University of Pittsburgh, 1929	Ma	Gary, Indiana
MATISON, HARRY B.S., California Institute, 1931	Ma	Pasadena
MCGARRY, JOHN FELBERT B.S., California Institute, 1931	ME	Hermosa Beach
MCMORRIS, JOHN (†) A.B., College of Emporia, 1924	Ch	Strong City, Kansas
MILES, ERIC JOHNSTONE B.S., University of Colorado, 1931	EE	Long Beach

Name	Major Subject	Home Address
MILLER, JOHN BURDICK	EE	Coudersport, Pennsylvania
B.S., Bucknell University, 1926; M.S., 1927		
MILLS, ROSCOE HARLAN	AE	Phoenix, Arizona
B.A., Pomona College, 1928		
MOORE, NORTON BARTLETT	AE	Rocklin
A.B., University of California, 1929; M.S., Purdue University, 1931		
MORGENSTIERNE, CARL CHRISTIAN	EE	Rutland, Vermont
E.E., Institut Electrotechnique de Grenoble, France, 1929		
MORRIS, ROSS ELLIOTT	Ch	Hollywood
B.S., California Institute, 1931		
MORSE, STANLEY ABER	Ph	St. Joseph, Michigan
B.A., Kalamazoo College, 1931		
MOUZON, J. CARLISLE (†)	Ph	Abilene, Texas
A.B., Southern Methodist University, 1927		
MUNRO, GEORGE CLARKSON (†)	Ph	Rifle, Colorado
A.B., University of California at Los Angeles, 1929		
MURDOCH, PHILIP GRIFFIS (†)	Ch	Pasadena
B.S., California Institute, 1929		
MURPHY, FRANKLIN MAC	Ge	Wheaton, Minnesota
B.A., University of California at Los Angeles, 1928		
MYERS, ALBERT EDWARD (†)	Ch	Los Angeles
B.S., California Institute, 1929		
NORDQUIST, JOHN MELVILLE	Ph	Collins, Missouri
A.B., Park College, 1929; M.S., University of Oklahoma, 1931		
NORTH, DWIGHT OLCOTT	Ph	West Hartford, Connecticut
B.S., Wesleyan University, 1930		
OLMSTED, ENNIS GUNNING	EE	Glendale
B.S., California Institute, 1931		
OSWALD, W. BAILEY	AE	Hollywood
B.A., University of California at Los Angeles, 1927		
OTTO, GEORGE HERMAN	Ge	Oak Park, Illinois
S.B., University of Chicago, 1931		
PETERSON, RAYMOND ALFRED	Ge	Denver, Colorado
B.S., California Institute, 1931		
PHLEGER, FRED B., JR.	Ge	Glendale
A.B., University of Southern California, 1931		
POOLE, ALBERT ROBERTS	Ma	Vancouver, B. C., Canada
B.A., University of British Columbia, 1929: M.A., 1931		
POPENOE, WILLIS PARKISON	Ge	Silver Springs, Maryland
B.S., George Washington University, 1929		
PUGH, ROBERT EUGENE, JR.	Ph	Lake Forest, Illinois
B.A., Lake Forest College, 1929		
RAITT, RUSSELL WATSON	Ph	South Pasadena
B.S., California Institute, 1929		
READ, GEORGE WILBER	EE	Glendale
B.S., California Institute, 1930; M.S., 1931		
READ, JOHN	Ph	Littleover, Derby, England
B.S., London University, 1931		
RICE, HARINGTON MOLESWORTH ANTHONY	Ge	Duncan, B. C., Canada
B.A., University of British Columbia, 1923; M.A., 1931		
RICH, LESTER J.	Ph.	Los Angeles
B.S., University of California, 1919		
RITZIUS, DEVAUN ERVIN	Ge	Los Angeles
B.A., Occidental College, 1931		
ROBINSON, ROGER THEOPHILUS	Ch	La Verne
B.S., California Institute, 1931		

Name	Major Subject	Home Address
Romer, Alfred (†) B.A., Williams College, 1928	Ph	Brooklyn, New York
Rose, Robert Selden (†) A.B., Harvard University, 1930	Ch	Marquette, Michigan
Ross, Roland Case B.A., University of California at Los Angeles, 1931	Ge	South Pasadena
Rumbaugh, Lynn Hamilton (†) A.B., Miami University, 1928	Ph	Carthage, Missouri
Sage, Bruce Hornbrook B.S., New Mexico College of Agriculture and Mechanical Arts, 1929; M.S., California Institute, 1931	ME	State College, New Mexico
Sargent, Marston Cleaves (†) A.B., Harvard College, 1928	Bi	Somerville, Massachusetts
Scharf, David Walter B.S., California Institute, 1930	Ge	Los Angeles
Schott, Herman Franz (†) B.S., California Institute, 1926	Bi	Pasadena
Schroder, Lawrence Druce B.S., University of Utah, 1931	EE	Salt Lake City, Utah
Sechler, Ernest Edwin B.S., California Institute, 1928; M.S., 1929; M.S. (AE), 1930.	AE	Pasadena
Shappell, Maple Delos (†) B.S., University of Arizona, 1921	Ge	Pasadena
Sheffet, David B.S., California Institute, 1930; M.S., 1931	EE	Venice
Sherman, Jack Henry (†) B.S., University of California, 1929	Ch	San Francisco
Sinnette, John Townsend, Jr. B.S., California Institute, 1931	Ch	Pasadena
Skinner, Selby Millmore (†) B.S., University of Washington, 1928	Ph	Seattle, Washington
Smith, Hampton (†) B.S., California Institute, 1928	Ge	Monrovia
Smits, Howard Gardner B.S., California Institute, 1931	CE	Glendale
Smythe, Donald DeCou B.S., University of Oregon, 1919; M.S., Cornell University, 1921	Ge	Santa Cruz
Soske, Joshua Lawrence G.E., Colorado School of Mines, 1929	Ge	Ardmore, South Dakota
Stavely, Homer E. A.B., University of Redlands, 1929; M.S., University of Arizona, 1931	Ch	Los Angeles
Steffens, Carsten Conover B.A., Syracuse University, 1930	Ch	Elmhurst, New York
Stirton, Robert Ingersoll B.S., California Institute, 1930	Ch	Los Angeles
Swift, Frederick Thayer, Jr. B.S., California Institute, 1930	EE	Altadena
Tarbet, Thomas Vernon B.S., California Institute, 1931	EE	Pasadena
Taylor, Daniel Dwight (†) A.B., Colorado College, 1924	Ph	Pasadena
Taylor, George Frederic B.S., California Institute, 1929; M.S., 1931	Ge	Los Angeles
Thomas, David Boyd B.S., North Carolina State College, 1931	Ph	Gibsonville, North Carolina
Urmston, Joseph Winchester B.A., Univ. of California at Los Angeles, 1928; M.S., California Institute, 1930	Ch	San Marino

Name	Major Subject	Home Address
Vanoni, Vito August B.S., California Institute, 1926	CE	Camarillo
Waddington, Guy (†) B.A., University of British Columbia, 1928	Ch	Victoria, B. C., Canada
Walz, Frank Christian B.S., University of Colorado, 1922; M.S., 1926	Ph	Pueblo, Colorado
Watson, Ralph Mayhew B.S., California Institute, 1927; M.S., 1928	ME	Hawthorne
Watson, Robert James B.A., University of Toronto, 1925; M.A., 1926	Ge	Toronto, Ontario, Canada
Wayland, James Harold B.S., University of Idaho, 1931	Ph	Boise, Idaho
Webb, Robert Wallace B.A., University of California at Los Angeles, 1931	Ge	Los Angeles
Weinbaum, Sidney (†) B.S., California Institute, 1924	Ph	Pasadena
Weinstein, David Harold A.B., University of California, 1930	Ph	Pasadena
Welge, Henry B.S., University of Illinois, 1929	Ch E	Long Beach
West, Samuel Stewart B.S., California Institute, 1930	Ph	Pasadena
West, William Textor B.S., California Institute, 1931	AE	Hollywood
White, Merit Pennimann A.B., Dartmouth College, 1930; C.E., Thayer School of Civil Engineering, 1931	CE	Whately, Massachusetts
Whitman, Nathan Davis, Jr. B.S., California Institute, 1930	CE	South Pasadena
Williams, Melville Chase B.A., University of South Dakota, 1931	Ph	Rapid City, South Dakota
Wilson, Edgar Bright, Jr. (†) B.S., Princeton University, 1930; M.A., 1931	Ch	Yonkers, New York
Wilson, Robert Warren B.S., California Institute, 1930	Ge	Los Angeles
Wislicenus, Georg Friedrich (†) M.E., State Institute of Technology, Wurzberg, Germany, 1925; M.S., California Institute, 1931	ME	Strassburg, Alsace
Wolf, Alexander B.S., University of Pennsylvania, 1924	Ph	Philadelphia, Pennsylvania
Wolfe, Karl Morgan (†) B.S., West Virginia University, 1925; M.S., California Institute, 1929	EE	Kingwood, West Virginia
Worrall, George Hobson A.B., Temple University, 1929	Ph	Collingswood, New Jersey
Worth, Carleton Russell A.B., Southwest Missouri Teachers College, 1925; S.M., Univ. of Chicago, 1927	Ma	Kenosha, Wisconsin
Wright, Lowell John B.S., University of Denver, 1930	EE	Denver, Colorado

Undergraduate Students

Students whose names are starred attained honor standing during the preceding year.

SENIOR CLASS

Name	Course	Option	Home Address
Adams, William A.	Eng.	EE	Long Beach
*Anderson, David William	Eng.	ME	Alhambra
Anderson, Thomas Foxen	Sci.	Ch	Glendale
Arnerich, Paul Frank	Eng.	ME	Pasadena
Arnold, Emmer Joseph	Sci.	Ch E	Los Angeles
Atwood, Albert William, Jr.	Eng.	EE	Washington, D. C.
Barton, Millard Vernon	Eng.	ME	Orange
Bascom, John Dwight	Sci.	Ph	Pasadena
Behlow, Lewis Bushnell	Eng.	CE	Alhambra
Bell, Thomas William	Eng.	ME	Whittier
Bennett, Elliott Powell	Eng.	CE	Pasadena
Bergren, William Raymond	Sci.	Ch	Pasadena
Berry, William Ladew	Eng.	EE	Yonkers, New York
Bland, Reginald Barrett	Sci.	Ph	Pasadena
Bowden, Frederick William	Eng.	EE	San Luis Obispo
Bowen, George Henry	Sci.	Ch E	Los Angeles
Bowler, Gordon E.	Eng.	EE	Pomona
Bradburn, James Rupert	Eng.	EE	Los Angeles
Brown, Rupert Arthur	Sci.	Ch E	Pasadena
Bruderlin, Henry H.	Eng.	EE	Los Angeles
Burman, Paul G.	Eng.	ME	San Gabriel
Carey, Robert Van Pelt	Eng.	ME	South Pasadena
*Cawley, Clifford Comer	Eng.	CE	Los Angeles
Chambers, Jack V.	Eng.	CE	Redondo Beach
*Claussen, William H.	Sci.	Ch E	Pasadena
Cox, John L.	Eng.	CE	Alhambra
Crater, Myron Lee	Eng.	ME	Pasadena
*Finney, Howard William	Sci.	Ge	Los Angeles
Fitch, Elliott Bryant	Sci.	Ch E	Napa
Foss, Robert Edwin	Eng.	ME	Rivera
Freeman, Robert B.	Eng.	ME	Pasadena
Goodman, Clark	Sci.	Ch E	Los Angeles
Graff, Donald Badger	Eng.	EE	Pasadena
Gregory, Jackson, Jr.	Sci.	Bi	Pasadena
Griest, Raymond Howard	Eng.	EE	Los Angeles
Hamlin, Charles Frederick	Eng.	CE	San Luis Obispo
Harsh, Charles Maxfield	Sci.	Ch	Eagle Rock
Harshman, Elbert Nelson	Sci.	Ge	Los Angeles
Hatcher, John Burton	Sci.	Ch	Los Angeles
Hayes, Edward	Eng.	EE	El Monte
Haynes, Benarthur Castle	Eng.	ME	Pasadena
Hegardt, Karl Edward	Eng.	EE	Downey
Hibbs, Frank John, Jr.	Eng.	ME	Los Angeles

Name	Course	Option	Home Address
*Hodge, Mills Schuyler	Eng.	EE	Pasadena
Huntley, Walter Palmer	Eng.	EE	Tustin
Hutchison, John A.	Eng.	EE	Abilene, Texas
Iwasaki, Tetsuo	Eng.	EE	Los Angeles
*Jones, Charles Wright	Eng.	ME	Pasadena
Keeley, Kedric V.	Sci.	Ph	El Monte
Kent, William Lyon	Sci.	Ch	Covina
Killgore, Cecil Lloyd	Eng.	EE	Los Angeles
Larsen, Delmar H.	Sci.	Ch	West Hollywood
Lind, Carl Frank	Eng.	EE	Los Angeles
Lipp, James E.	Eng.	ME	Los Angeles
Lyons, Patrick Barbour	Eng.	EE	Los Angeles
Maass, Randal	Sci.	Ch E	Anaheim
Maes, Alvin James	Eng.	CE	Los Angeles
Mathews, Thomas Edwin	Eng.	EE	Glendale
McFadden, William Clyde	Eng.	AE	Fullerton
McLaughlin, James P.	Eng.	EE	Redondo Beach
Miller, Glen W.	Eng.	EE	Glendale
Muller, Victor	Eng.	ME	Los Angeles
*Myers, Glen, Jr.	Eng.	EE	Pasadena
Oelschlager, Ray Troy	Eng.	AE	Kaweah
Oulton, Thomas Dixon	Sci.	Bi	Pasadena
Parsons, Paul Gates	Eng.	CE	Alhambra
*Pickering, William Hayward	Sci.	Ph	Christchurch, New Zealand
Polk, Wendell Robert	Eng.	ME	Los Angeles
Pownall, Henry Bland	Eng.	ME	Santa Monica
Prudames, Edwin Mott	Eng.	CE	Los Angeles
Pruden, Worrell Franzoni	Eng.	CE	Pasadena
Rau, William Charles	Sci.	Ch	Las Vegas, Nevada
Reilly, James Thomas	Sci.	Ge	Pasadena
Ritter, John	Eng.	CE	Whittier
Roach, Harold	Eng.	CE	Los Angeles
Rockefeller, W. Curtis	Eng.	ME	Pasadena
Rule, Bruce Herbert	Eng.	EE	Los Angeles
Sass, Otto	Sci.	Ch	Los Angeles
Saylor, William Henry	Eng.	CE	Covina
Schaafsma, Jan Gerard	Sci.	Ch E	Honolulu, T. H.
Schoeller, Philip	Eng.	CE	Palmdale
Schuhart, Mervin Arno	Eng.	EE	Pasadena
Schultz, Henry William	Eng.	CE	Pasadena
Schultz, William Francis	Eng.	ME	Los Angeles
Searle, Richard Allen	Eng.	EE	Los Angeles
Sheffet, Joseph	Eng.	CE	Venice
Sherman, Robert L.	Eng.	ME	Portland, Oregon
Shockley, William	Sci.	Ph	Los Angeles
*Shuler, William	Eng.	EE	El Monte
Shull, George Orval	Sci.	Ch	Los Angeles
Skaredoff, Nikolai	Eng.	ME	Yokohama, Japan
Skoog, Folke Karl	Sci.	Ch	Alhambra
Solomon, Hyman	Sci.	Ph	Los Angeles

Name	Course	Option	Home Address
Sparks, Brian Orville	Sci.	Ph	Los Angeles
Sparling, Jack Norman	Eng.	CE	Glendale
St. Clair, Robert W.	Eng.	EE	Glendale
*Swart, Kenneth Hayes	Eng.	ME	Riverside
Thiele, Carl Leslie	Sci.	Ph	Hollywood
Thomas, Richard Notley	Eng.	CE	Riverside
Thomas, W. J.	Sci.	Ch E	Los Angeles
Tickner, Alvin James	Sci.	Ph	Pasadena
Van Reed, Mabry	Eng.	ME	San Diego
Venerable, Grant Delbert	Eng.	CE	Los Angeles
Watson, George Gilbert	Eng.	ME	Torrance
Wherritt, Robert C.	Eng.	ME	Los Angeles
White, Wayne Bertrand	Sci.	Ch	Los Angeles
Wilde, Thomas B.	Eng.	ME	Los Angeles
Wilking, Arnold Philip	Sci.	Ch	Pasadena
*Wilson, Chester Eugene	Sci.	Ch	North Hollywood
Wolfe, Halley	Eng.	EE	Porterville
Wong, David Yue-Kwong	Eng.	CE	Tung Shan, Canton, China
Wright, Eldon Emerson	Eng.	EE	Los Angeles
Zuckerman, Herbert S.	Sci.	Ma	Berkeley

JUNIOR CLASS

Name	Course	Home Address
Andrew, Thomas Adelbert	Sci. (Ch E)	Brea
Ashton, Willard Andrew	Eng.	Pasadena
Ayers, John Kimball	Eng.	Boulder City, Nevada
*Backus, Harrison Stout	Sci. (Ch)	Pasadena
Baer, Marcellus Albert	Eng.	Marshfield, Wisconsin
Bamberger, Sidney Francis	Eng.	Venice
Barnett, Earl Edgar	Eng.	Pasadena
*Bender, David Fulmer	Sci. (Ma)	Spokane, Washington
Berkley, Merrill	Eng.	Pasadena
Bernstein, Theodore Isra	Sci. (Bi)	Los Angeles
Bonillas, Ygnacio	Sci. (Ge)	Hollywood
Bower, Evan G.	Eng.	Long Beach
*Brunner, Eugene Mittell	Sci. (Ph)	Monrovia
*Byrne, Ralph Edward, Jr.	Eng.	Kansas City, Missouri
Carleton, Lee Thurston	Sci. (Ph)	Los Angeles
Chesson, George Henry	Eng.	Fair Oaks
Clark, David Lewis	Eng.	Newton, Iowa
Clark, Willis Henry, Jr.	Eng.	Los Angeles
*Coryell, Charles DuBois	Sci. (Ch)	Wilmar
Craig, Philip Henry	Eng.	Burbank
Crawford, Edgar Grenfelle	Eng.	Pasadena
Cripps, Ray Hayward	Eng.	Hollywood
*Dames, Trent Raysbrook	Eng.	San Diego
Davis, Madison T.	Eng.	Pasadena
Dawson, Charles A., Jr.	Sci. (Ge)	Pasadena

Name	Course	Home Address
Dean, Arthur M.	Sci. (Ch E)	Chula Vista
DeMilita, Joseph	Eng.	Los Angeles
Detmers, Fred H.	Eng.	Los Angeles
Doescher, Russell Nimtz	Sci. (Ch)	Santa Monica
Douglass, Paul William	Sci. (Ma)	Pasadena
Efromson, Philip Charles	Eng.	Los Angeles
Eisen, Nathan	Sci (Ph)	Pasadena
Elconin, Victor	Sci. (Ph)	Los Angeles
Fitch, Kenneth S.	Eng.	Los Angeles
Fletcher, Robert Dawson	Eng.	Huntington Park
Fort, Robert Oscar	Eng.	Los Angeles
Franklin, Elmer Sherwood	Sci. (Ge)	Los Angeles
*Frieman, Rubin Harold	Sci. (Ch)	Los Angeles
Getzman, Edwin Samuel, Jr.	Eng.	Claremont
Goss, Louis Harold	Eng.	San Gabriel
Gould, Laurence K.	Eng.	Alhambra
Grossman, Robert B.	Eng.	Beverly Hills
Hallanger, Lawrence	Sci. (Ch E)	Alhambra
Halloran, James Joseph	Eng.	Anaconda, Montana
*Hartmann, Gregory K.	Sci. (Ph)	New York, New York
Herlin, Robert George	Eng.	El Paso, Texas
Hill, James W.	Eng.	Pasadena
Hofmann, Oliver Dimmitt	Eng.	Eagle Rock
Hogan, Robert Charles	Eng.	Durango, Colorado
Holman, Rudolph George	Eng.	Pasadena
Hunter, Francis Robert	Sci. (Bi)	Claremont
*Johnson, James Stanley	Eng.	Pasadena
*Johnson, Samuel Yorks	Eng.	Pasadena
Keenan, J. Stanley	Eng.	Los Angeles
Kennedy, E. Russell	Sci. (Ch)	Los Angeles
Lamel, Arthur Edward	Eng.	Los Angeles
*Laslett, L. Jackson	Sci. (Ph)	Pasadena
Lawrence, Gregory Edson	Eng.	Pasadena
Lewis, Wyatt Hunter	Sci. (Ch E)	Glendora
Libby, Alexander Feller	Eng.	San Bernardino
Lockhart, E. Ray	Eng.	El Paso, Texas
Macdonald, Robert George	Eng.	Hollywood
Marlow, Douglas George	Sci. (Ph)	Newport Beach
Mathewson, Arthur Adelbert, Jr.	Eng.	Coronado
Matson, Edward J.	Eng.	Pasadena
McCleery, Walter Lyde	Eng.	Honolulu, T.H.
Mead, Robert Rufus	Eng.	Pasadena
Mehm, Joseph A.	Eng.	El Monte
*Mendenhall, John Dale	Eng.	Van Nuys
*Mersman, William A.	Sci. (Ma)	Alhambra
Meskell, John Edward	Eng.	Altadena
Miller, Bertram Folger	Eng.	Los Angeles
Mitchel, Theodore Samuel	Eng.	Alhambra
Monning, John Chester, Jr.	Eng.	Los Angeles
Moore, William W.	Eng.	Pasadena

Name	Course	Home Address
Morgan, Wendal Alton	Eng.	Los Angeles
Newcombe, Dennis Arthur	Sci. (Ch)	Los Angeles
Nicholson, Hunter, Jr.	Sci. (Ch E)	Los Angeles
Olds, Earl Mortimer	Sci. (Ch)	Los Angeles
O'Neil, Hugh Michael	Eng.	Pasadena
Osborne, LeRoy Robert	Sci. (Ch)	Los Angeles
Palm, Bernhard Nelson	Eng.	South Pasadena
Palmer, Durward Harry	Eng.	Fullerton
Pauly, William Charles	Eng.	Los Angeles
Pearson, Harold E.	Sci. (Bi)	Fresno
Pelzel, Robert E.	Sci. (Ch)	Los Angeles
Perrine, Charles Dillon	Sci. (Ph)	Hermosa Beach
Pickett, George Henry	Eng.	Pasadena
*Pierce, John Robinson	Eng.	Pasadena
Pipes, Louis Albert	Eng.	South Pasadena
Plank, Dick August	Eng.	Pasadena
Poulson, Donald F.	Sci. (Bi)	Idaho Falls, Idaho
Prior, Christian Henry	Sci. (Ch)	Santa Monica
Randall, John Alden	Eng.	Pasadena
Rice, Winston R.	Eng.	Los Angeles
Robinette, Willard Clement	Eng.	Prescott, Arizona
Roeding, Fred Charles	Eng.	Berkeley
Russell, Richard Lord	Eng.	Long Beach
Sarno, Dante Hector	Sci. (Ch E)	Pasadena
Sauerman, Dean F.	Eng.	Pasadena
Scholtz, Walter	Eng.	Los Angeles
Secord, Grover Marion	Eng.	Alhambra
Sharp, John Wilfred	Eng.	Pasadena
Slavin, Leon	Eng.	Los Angeles
Smallman, Robert Leslie	Eng.	Los Angeles
Smith, Alvin Joseph	Eng.	Pasadena
Smith, Warren Howard	Eng.	Pasadena
Spade, James Clifton	Eng.	Huntington Park
Spicer, Charles B.	Eng.	Los Angeles
Stewart, Harry Edwin	Eng.	Globe, Arizona
Stone, William Ellis	Sci. (Ch)	Colton
Suhr, Henry B.	Sci. (Ch)	Deep Springs
Sullwold, John	Sci. (Ch E)	Pacific Palisades
Sunderland, Robert Croft	Eng.	Los Angeles
Taylor, James	Sci. (Ch)	Wildomar
Terrill, Thomas Starr	Eng.	Pasadena
*Tillman, Charles Emil	Eng.	San Pedro
Van Wingen, Nico	Eng.	Pasadena
Warfel, John Spencer	Eng.	Redondo Beach
Warren, Kenneth P.	Sci. (Ch E)	Orange
Washburn, Dana Ernest	Eng.	Altadena
Weinstein, Nicholas	Eng.	Palms
Wheeler, George	Sci. (Ph)	Oceano
*Wheeler, William Thornton	Eng.	Richgrove
*Widess, Moses	Eng.	Pasadena

SOPHOMORE CLASS

Name	Course	Home Address
Allen, Robert James	Sci.	Fullerton
Anderson, Henry Fredrik	Sci.	Pasadena
*Anderson, Robert Carron	Eng.	Hollywood
Anderson, Walter E.	Sci.	Pasadena
Babcock, Horace W.	Sci.	Pasadena
Bellis, Henry	Sci.	Auburn
Birdsey, William Canvin	Eng.	Pasadena
*Boche, Robert DeVore	Sci.	Seattle, Washington
Boehmer, Harold	Eng.	Los Angeles
Boykin, Robert Owen, Jr.	Eng.	Pasadena
Boyle, John	Eng.	Pasadena
Brockman, Graydon Perry	Eng.	Pasadena
Brown, Robert	Eng.	Los Angeles
Bulnes, Alfonso Carlos	Sci.	Durango, Mexico
Bushnell, David P.	Eng.	Los Angeles
Caldwell, Clyde Conrad	Eng.	San Diego
Carr, Joseph Philip	Eng.	San Pedro
Carrick, Thomas Hallam	Sci.	Los Angeles
Charters, Alexander C. Jr.	Eng.	Portland, Oregon
Childers, Milford Carlson	Eng.	Pasadena
*Cleveland, Donald Leroy	Sci.	Wilmar
Connor, Chandler Harvey	Sci.	Los Angeles
Cortelyou, Jack Taylor	Eng.	Los Angeles
Cox, Herbert Orville	Eng.	Pomona
Craig, Carroll	Eng.	Beverly Hills
Crutchfield, Richard S.	Eng.	Arcadia
Dane, Paul Howard	Eng.	Taft
Desmond, Jack Maxwell	Eng.	Pasadena
Dibble, Barry, Jr.	Sci.	Redlands
Dietrich, Robert Alexander	Eng.	Los Angeles
Dodge, Burnham H.	Eng.	South Pasadena
*Doll, Edward Bushnell	Eng.	Los Angeles
Donahue, Willis Ray	Sci.	Ontario
Douglas, Duncan Howitt	Sci.	Pasadena
Downs, George Wallingford	Sci.	Claremont
Dunbar, Oliver Churchill	Sci.	Canton, Massachusetts
Escherich, Roland Herman	Sci.	Altadena
Etter, Lewis Fort	Eng.	Los Angeles
Everett, Wilhelm Sydow	Sci.	Ventura
Felt, Robert Carlen	Sci.	Gardena
Fomilyant, Anatol Anatol	Sci.	Fallbrook
Forney, Gerard Joseph	Sci.	Hollywood
Gardener, Cornelius Allen	Eng.	Simi
Gertmenian, Norman	Eng.	Pasadena
Gordon, Garford Gailord	Sci.	Pasadena
Graham, Eugene	Eng.	Los Angeles
Gravitt, Bruce Benson	Eng.	Lynwood
*Gregory, James Nathaniel	Sci.	San Marino
Grimes, Joseph Wilbur	Eng.	Glendale

Name	Course	Home Address
*Gulick, Howard E.	Sci.	Glendale
Haex, Joseph Constant E.	*Eng.*	*Maastricht, Holland*
Hannay, Patrick M.	Eng.	La Jolla
Hansen, Henry Jens	Sci.	Copenhagen, Denmark
Hebel, Francis Frederick	Eng.	Carpinteria
Heinrich, Albert	Eng.	Pasadena
Hinshaw, Meral William	Sci.	Pasadena
*Howard, Ernest Russell	Eng.	Pasadena
*Howard, Robert A.	Sci.	Los Angeles
Howland, Walter Lavern	Eng.	Temple City
*Johnson, Ford Lawrence	Sci.	Ephraim, Utah
Judson, Jack Finlay	Sci.	Pasadena
*Kartzke, Paul Louis	Eng.	Pasadena
Kelly, Dunford Austermell	Eng.	Los Angeles
Kidd, Ray Edward	Eng.	Monrovia
Kullberg, John Earl	Sci.	Kingsburg
Kurata, Fred	Sci.	Rialto
Lien, Elvin Bernard	Sci.	Tacoma, Washington
Little, John Robert	Eng.	Xenia, Ohio
Lutes, Wallace	Eng.	La Mesa
Mahr, Andrew R., Jr.	Eng.	Santa Ana
Marmont, George H.	Sci.	Hollywood
Mathewson, Dan Reinert	*Eng.*	*Coronado*
McClain, Franklin James	Eng.	Los Angeles
Michener, Harold David	Sci.	Pasadena
Mitchell, H. Allan	Sci.	Oxnard
Moore, Morton Estes	*Sci.*	*Hollywood*
Morris, Lee Pierce	Eng.	Hollywood
Myers, Bryant Elmer	Eng.	Santa Barbara
Naylor, Ralph Arthur	Sci.	Pasadena
*Newton, Charles Vernon	Eng.	Westwood
Nicolson, Garth Fancher	Eng.	Pasadena
*Nies, Nelson Perry	Sci.	Los Angeles
Ohashi, George Yoshio	Eng.	Los Angeles
Patrick, Charles	Sci.	Huntington Beach
Patton, Warren Lomax	Eng.	San Diego
Pearne, John Frederick	Eng.	Hollywood
Radford, James Croxton	Sci.	South Pasadena
*Ribner, Herbert Spencer	Sci.	Hollywood
Roberts, Paul Clark	Eng.	Long Beach
Romoli, John Albert	Eng.	Los Angeles
Rooke, Donald R.	Eng.	Pasadena
Ross, Robert Lewis	Sci.	South Pasadena
Scheetz, Carlton Frank	Sci.	Los Angeles
Schiller, Harold	Sci.	Venice
Schmidt, W. Malcolm	Sci.	Los Angeles
Schneider, Charles Louis	Sci.	Tujunga
Schreck, J. Robert	Eng.	Los Angeles
Schwien, Nevin	Eng.	Pasadena
Sexton, Louis Perry	Eng.	Los Angeles
Sharp, Robert Phillip	Sci.	Oxnard

Name	Course	Home Address
Sherborne, John Elliott	Sci.	Long Beach
Shipley, William Clapper	Eng.	Los Angeles
Shoemaker, Orin Henderson	Eng.	Anaheim
Shreve, George	Sci.	San Jose
Sieland, Henry Joseph	Eng.	Oxnard
Simmons, Edward E.	Eng.	Los Angeles
Skinner, Davis Ayres	Sci.	Los Angeles
Sluder, Darrell Hayes	Eng.	Los Angeles
Smith, George Sidney	Eng.	Oakland
Stevenson, Arthur Louis	Eng.	Riverside
Switzer, Alfred Ivan	Eng.	San Gabriel
Thomas, Charles Franklin	Eng.	Pasadena
Thompson, Alverdo Earnest	Sci.	Los Angeles
Tracy, Francis Gallatin	Eng.	Carlsbad, New Mexico
Travers, William Albert	Sci.	Los Angeles
Traynor, Raymond William	Eng.	Los Angeles
Van Osdol, George William	Eng.	Los Angeles
Varney, Frederick Merrill	Sci.	Los Angeles
Walley, Bernard	Eng.	Los Angeles
Weaver, Glenn Wakelin	Eng.	Compton
Welch, Charles Luis	Sci.	Los Angeles
Wenzlaff, Edgar	Eng.	Glendale
Wheeler, Edgar James	Eng.	Alhambra
Whistler, Ralph Edward	Eng.	Ontario
White, Charles Edward	Eng.	El Monte
Whittaker, William Robert	Eng.	Los Angeles
Willis, Prentice Fay	Eng.	Pasadena
Woodward, Glen Everett	Sci.	Ontario
Wyatt, Francis W.	Sci.	Moapa, Nevada
Young, Bradley Hobart	Eng.	La Habra

FRESHMAN CLASS

Name	Home Address
Allardt, Frederick H.	Fresno
Atkins, Arthur	San Francisco
Bailey, Jay Richard	Hollywood
Bakeman, Robert Tate	Los Angeles
Baker, Horace White	Glendora
Beck, Melvin Warren	Los Angeles
Becker, Leon Sangamon	Los Angeles
Beerbower, Alan	Warren, Arizona
Beman, Ward Wilson	Los Angeles
Binkley, Jack T.	San Diego
Black, Harold James	Gardena
Browder, Lewis Blakeley	Los Angeles
Browne, James Bell	Hollywood
Caldwell, Wyche Dean	San Diego
Callis, Dale Elwyn	Lompoc
Carlton, Robert Ogden	Portland, Oregon

Name	Home Address
Caward, Olin Mason	Hollywood
Chamberlain, Donald Newton	Glendora
Chivens, Clyde Cuthbertson	Burbank
Condon, John	Beverly Hills
Cox, Sherman Julian	Pasadena
Cox, William Gordon	Los Angeles
Davenport, Horace Willard	Glendale
Davenport, Lind Burnett	Monrovia
Davies, James Allman	Santa Monica
Deahl, Thomas Jay	Long Beach
Dekker, Albert Orno	Glendale
Dennett, Edward H. G.	Modesto
Dewees, Norman Branson	Pasadena
Dickson, John Fraser	Binghamton, New York
Dourson, Robert Henry	Redondo Beach
Draemel, Frederick Clise	Coronado
Drummond, Finlay True	La Jolla
Edwards, Eugene Leroy	Los Angeles
Edwards, Jackson	Pasadena
Ehrenberg, Gustave, Jr.	San Diego
Eley, Frederick Richard	Santa Ana
Elmendorf, Charles Halsey	Westwood Hills
Emmel, Victor Meyer	San Diego
Engelder, Arthur Edward	Warren, Arizona
Estep, Carl Robert	Los Angeles
Estes, Harry De	Compton
Etz, Arthur Nelson	Santa Monica
Evans, Harrison Milton	Los Angeles
Everett, Walter William	Fresno
Field, Frank Payne	Los Angeles
Fleming, Lawrence Thomas	Los Angeles
Foster, Herbert Maxwell	San Dimas
Frazee, John Love	Stockton
Fuhrmann, Hans Hermann	Los Angeles
Gallant, Charles James, Jr.	Los Angeles
Gelzer, John Roswell	St. Louis, Missouri
Gibbs, Charles James	Palos Verdes Estates
Gluckman, Howard Philip	Los Angeles
Gordon, Adrian Hugh	Beverly Hills
Gordon, Albert	Beverly Hills
Green, Emerson Ward	Pasadena
Green, Nathaniel Baldwin	Arcadia
Gregory, Theodore Roy	San Marino
Griffiths, Thomas William	Santa Barbara
Hallanger, Robert John	Alhambra
Hand, Ross Lowell	Burbank
Harris, William Richard	Los Angeles
Hartzell, Wilbur Gaus	Minneapolis, Minnesota
Heinkel, Melvin Charles	Los Angeles
Herrera, Robert Bennett	Wilmar
Higley, John Ball	Pasadena

Name	Home Address
Holt, Grant Herbert	Burlingame
Homann, Ralph E., Jr.	Los Angeles
Hopkins, John Selden	Pasadena
Inman, Byron Noll	Pasadena
Isenhower, Gerald Victor	Modesto
Isham, Arthur Earl, Jr.	Redlands
Jackson, Thomas	Vineyard Haven, Mass.
Jahns, Richard Henry	Seattle, Washington
James, Kenneth Eugene	Hollywood
Jansen, Richard Martin	Pasadena
Jennison, James Henry	Pasadena
Johnson, Wallace J. S.	Fort Dodge, Iowa
Jones, Clyde Branson	Pasadena
Jones, Robert Parry	Inglewood
Kelley, Harold Maxwell	Los Angeles
Ketchum, Milo C.	Kansas City, Missouri
Keyes, William Forrest, Jr.	Los Angeles
King, Fred Charles	Berkeley
Kiplinger, John Ames	Casper, Wyoming
Kramer, Robert Lincoln	Alhambra
Lanham, Arden Keith	Pasadena
La Rue, Robert Orville	Beverly Hills
Lehmicke, David John	Stillwater, Minnesota
Levy, Henri Arthur	Oxnard
Lindsay, Chester William	Los Angeles
Lisol, John	Long Beach
Maescher, Robert Edward	Hollywood
Marsh, Robert Henry	Kalispell, Montana
Martin, Stanley Charles	Hollywood
Maycock, Russel Leslie	San Francisco
McLean, William Burdette	Eagle Rock
McRae, Robert Alex	Los Angeles
Meneghelli, Hugo Antonio	Hollywood
Merralls, Franz Nelson	Los Angeles
Miller, Daniel Harrison	Los Angeles
Miller, Eugene Clair	Glendora
Miller, Mark Trevellick	Greenville
Millikan, Max Franklin	Pasadena
Morse, Nathan L.	Los Angeles
Nethercutt, Jack Boison	Ocean Park
Oliver, Bernard More	Santa Cruz
Olson, Edgar Williams	Glendale
Olson, Eugene Fred	Los Angeles
Osburn, Davidson Gould	Los Angeles
Osman, Francis Kurt	Los Angeles
Palmer, J. Ellsworth	San Jose
Patterson, Leonard Searles	Hollywood
Pehoushek, Frederick	San Fernando
Pitzer, Kenneth Sanborn	Pomona
Polentz, Perry Paul	Whittier
Potter, Warren Thomas, Jr.	Whittier

Name	Home Address
Ray, Albert Allen	Alhambra
Raya, Julian John	Calexico
Reynolds, Edward Henry	Los Angeles
Rice, David Webster	Alhambra
Rivas, Dagoberto	Calexico
Robinson, William Stewart	Los Angeles
Rodriguez, Eugene Manuel	Pasadena
Rosen, Samuel	Los Angeles
Rossum, John Rudolph	St. Paul, Minnesota
Ruge, Neil Marshall	San Pedro
Scherb, Ivan Victor	Beverly Hills
Schwartz, Jack William	Hollywood
Scott, Claude Trick	Pasadena
Seidel, Robert Klensch	Los Angeles
Shanahan, Edmond Francis	Los Angeles
Sheff, Sander David	Pasadena
Sheppard, Dickson Marshall	Los Angeles
Sikes, Robert Davis	Indio
Slater, Alfred	Pasadena
Smith, James Norman	Pasadena
Snow, Neil Worthington	Altadena
Stick, John Chester, Jr.	South Pasadena
Stoddard, James Bates	Los Angeles
Stoll, Henry William	Los Angeles
Stuppy, Laurence J.	Los Angeles
Sugi, Chihiro	Riverside
Swanson, Walfred Earnest	Hollywood
Taylor, Jay Camburn	Pasadena
Tejada, Luis Hernan	La Paz, Bolivia, S. A.
Thomas, Harold Albert	Newport, Oregon
Tonn, Frederick Rudolph	San Diego
Tooby, George J.	Eureka
Vredenburgh, John Culloden	Pasadena
Warne, Archer Hurst	Los Angeles
Warner, Robert Collett	Chehalis, Washington
Webster, Donald Charles	Hollywood
Wiget, Clark Hamilton	Concord
Willits, Victor Wilmer	Eagle Rock
Wilson, Harry	Filer, Idaho
Wood, Reuben Esselstyn	Monrovia
Woodbury, Herbert Lee	Los Angeles
Wright, Richard Carl	Los Angeles
Yata, Charles Masao	Los Angeles
Young, Donald Laurence	Pasadena

UNCLASSIFIED

Schwieso, Charles	Pasadena

SUMMARY

Graduate School			
National Research Fellows		9	
Rockefeller Foundation International Fellows		5	
Commonwealth Fund Fellows		3	
C. R. B. Educational Foundation Fellows		2	
Research Fellows of the Institute		12	
Foreign Exchange Fellow		2	
			33
Graduate Students: Physics		57	
Chemistry		25	
Chemical Engineering		4	
Mathematics		7	
Geology		30	
Biology		5	
Engineering		59	
			187
Undergraduate School			
Seniors—Science: Ph 9; Ch 13; Ch E 9; Ge 3; Ma 1; Bi 2	37		
Engineering: AE 2; CE 20; EE 29; ME 25	76	113	
Juniors—Science: Ph 9; Ch 13; Ch E 8; Ge 3; Ma 3; Bi 4	40		
Engineering	85	125	
Sophomores—Science	55		
Engineering	75	130	
Freshmen		162	
Unclassified		1	
			531
			751

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